The Macroeconomic and Redistributive Effects of Shielding Consumers from Rising Energy Prices: a Real-Time Evaluation of the French Experiment*

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Abstract

The French government implemented an energy tariff shield in 2021 to mitigate the impact of rising energy prices. To assess the macroeconomic and redistributive effects of this policy, we propose a novel methodology for ex-ante evaluations based on the government's forecasts included in the Finance Act and a new Keynesian business cycle model with heterogeneous agents. From a macroeconomic perspective, this policy boosts economic growth and reduces inflation but slightly increases the debt-to-GDP ratio. Regarding redistribution, the policy curtailed the increase in consumption inequality. We compare the outcomes of this policy with those of alternative strategies such as re-indexing wages to prices or implementing 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

Relief from the COVID-19 crisis in 2021 and Russia's incursion into Ukraine in 2022 precipitated an energy shock in Europe unparalleled in the history of the Eurozone. With gas prices surging by a factor of more than five and barrel prices more than doubling since 2021, the magnitude of inflationary shocks has been huge. In 2022, inflation rates surged to 8% in Italy, 8.3% in Germany, and 12% in the Netherlands. By contrast, France demonstrated a comparatively lower inflation rate of 6.2%, distinguishing itself from its European counterparts. Since October 2021, the French government has implemented a "tariff shield" to mitigate the impact of the energy shock.[1] At the end of 2022, the French government decided to extend the tariff shield to 2023. This policy had several important implications. Beyond inflation, it is expected to affect economic growth, public finances, and economic inequality considering the larger proportion of energy expenditure among the most disadvantaged households.[2] The objective of this study is to assess the impact of the tariff shield implemented in France by comparing it with alternative policies. To achieve this, we develop a new method for Heterogeneous-Agent New-Keynesian (HANK) models that involves identifying the shocks that rationalize the data, including forecast data, using the sequence-space method introduced by Auclert et al. (2021a). This original method can be employed in real-time to assist governments in making policy decisions.

Specifically, we examine the effectiveness of the tariff shield over a specific period and at the time of its announcement. What are the expected consequences of this policy on the output, inflation, inequality, and public debt? How does its efficacy compare to that of alternative policies? We require a particular approach to achieve this objective in terms of policy evaluation because some policies alter the structure of the economy, rendering analysis based solely on impulse response functions (IRF) to exogenous shocks ineffective. As these policies modify the responses to all shocks, evaluating their effects requires combining the impacts of all shocks. Moreover, policy evaluation

[1] The tariff shield comprises a freeze on gas prices at their October 2021 levels, a limit on the rise in electricity prices, and the introduction of a discount at the pump starting in April 2022. In retrospect, it seems that this policy has had a notable impact on inflation. According to the French Statistical Institute (INSEE), inflation would have been 3.1 points higher between the second quarters of 2021 and 2022. See the publication INSEE Analysis n^o75 Soaring energy prices: the "tariff shield" cuts inflation in half (in French). For an appraisal of the French policy in comparison with measures implemented in other economies, see the fiscal tracker provided by the think tank Bruegel "National fiscal policy responses to the energy crisis".

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

focuses on a particular period–the period that motivates the policy–that results from the history of shocks. Therefore, it is necessary to identify shocks specific to that period, because the effectiveness of an economic policy depends on the composition of the shocks it faces. Real-time policy evaluation presents additional difficulties because it is necessary to compare the anticipated effects of different policies. This implies the need to identify future shocks that define a relevant environment for comparing the policies studied.

To meet these requirements, we use the information provided by the government in its Finance Act (including spending, taxes, deficits, and debt) as well as its forecasts of GDP growth, inflation, and other relevant economic indicators.[3] Thus, our method integrates historical data and forecasts into a HANK model *(i)* to estimate the sequences of the different shocks that likely hit the French economy so that the government forecasts come true, in the spirit of the conditional forecast methodology presented by Del Negro and Schorfheide (2013)[4,5] and *(ii)* to develop counterfactual scenarios, given these sequences of shocks, providing real-time evaluations of the alternative policies needed for decision-making.

The choice of general equilibrium model is crucial for this method. We use the HANK model because it enables us to study the impact on macroeconomic aggregate variables (such as output, inflation, or public debt) and the dynamics of inequalities across households simultaneously. At the aggregate level, the advantage of the HANK model is that it predicts the observed depressive effect of a positive shock on energy prices, unlike the representative-agent new Keynesian (RANK) model, as shown in Auclert et al. (2023a).[6] From a distributional perspective and since the "yellow vests" protests, the evaluation of an economic policy that changes the price of energy must consider its redistributive impacts, which is possible using a HANK model. To properly capture the greater sensitivity of the poorest to energy price shocks, our model introduces incompressible consumption of energy products. This allows the model to generate a share of energy products in

[3]The forecasts contained in the Finance Act may be considered as robust as possible because they are based on the largest information set, bringing together *(i)* the qualitative expertise of numerous experts from different French ministries and the European Commission, *(ii)* the use of large non-structural econometric models, and *(iii)* statistical analyzes of surveys on French confidence (entrepreneurs and consumers).

[4]Therefore, the shocks estimated for the five-year period of forecasts (2023-2027) can be interpreted as the evolution of the economic conditions necessary to make the government's forecasts consistent within the model's framework.

[5]A challenge for conditional forecasts is that they may be exposed to the Lucas (1976) critique. The Finance Act may also modify decision rules of the government. To address this problem, we implemented a stability test of the policy rules and showed how to incorporate a possible change in policy into the evaluation method.

[6]In the representative agent model, the energy shock leads demand to shift toward the consumption of domestically produced goods, which counterfactually sustains growth.

the consumption basket that decreases with income, as observed in the data. Additionally, it allows for price elasticity, which increases with income, making it difficult for the poorest to avoid energy price increases. Another novelty of our model is that it allows the government to smooth policy financing by issuing new debt. Based on the calibrated parameters for the steady-state, our HANK model for the French economy reproduces government forecasts (output, inflation, and public debt) conditional on government policies (expenditure and revenue) and energy prices. The solutions are obtained through a first-order approximation around the steady state (Reiter (2009), (2010)) and the sequence-space Jacobian approach (Auclert et al. (2021a)). This method enables us to determine the unique sequence of unanticipated shocks that fits a given observed time series. Estimating these shocks reveals the size of the energy shock in France, allowing us to move beyond an IRF analysis and uncover the size of the budget intervention required to cope with the magnitude of this shock. Next, to evaluate an alternative policy, we maintain the paths of all the exogenous variables as given by the benchmark and only change the policy tool under consideration.

Scenario	GDP growth 2022	GDP growth 2023	Inflation rate 2022	Inflation rate 2023	Inequality evolution	Debt-to-GDP 2027
No tariff shield	1.68%	0.94%	7.3%	3.5%	2.09 → 2.28	111.3%
Tariff shield	2.85%	1.00%	6.5%	3.4%	2.09 → 2.24*	112.6%
Tariff shield & Faster wage indexation on prices	2.38%	0.77%	7.4%	4.1%	2.09 → 2.25	114.1%
Transfers	1.97%	1.13%	7.5%	4.4%	2.05 → 2.12	116.1%

* Lecture: the consumption of the top 10% earners is 2.24 times larger in 4Q2024 than those of the bottom 10% earners when the policy was implemented, whereas it was 2.09 times larger before the crisis (1Q2022).

Table 1: Growth, inflation, indebtedness, and inequalities for various policies

We demonstrate that tariff shield played a crucial role during the recent energy crisis. As illustrated in Table 1, the implementation of the tariff shield in 2022 and 2023 supported economic growth, averaging 1.9% per year between 2022 and 2023, while limiting inflation to 5.6% per year during the same period. Additionally, it mitigated the increase in consumption inequality in times of crisis. The fiscal cost, while significant, remains manageable in terms of public finances, as the debt-to-GDP ratio would only be 1.3 points higher compared to a scenario without a tariff shield. Comparatively, this policy outperforms alternative strategies such as faster wage indexation to inflation[7] or targeted redistribution policy.[8] Table 1 indicates that a more rapid wage indexation to

[7]In this scenario, the tariff shield is accompanied by a more rapid wage indexation to inflation, leading nominal wages to be indexed to consumer price inflation in less than a year.

[8]The redistribution scheme provides equal lump sum transfers to all households, covering incompressible energy expenses, and thus benefiting the poorest disproportionately.

inflation (or the implementation of a redistributive policy) would have resulted in an average growth rate of 1.57% (or 1.55%), an inflation rate of 5.74% (or 5.94%), and a larger debt-to-GDP ratio (+4.8 points and +5.8 points respectively). In other words, without a tariff shield, the French economy would have experienced lower economic growth and higher inflation 2022 and 2023, respectively.

Literature. Our study contributes to several strands of literature. Building on the seminal contributions of Aiyagari (1994) and Krusell and Smith (1998), an extensive body of literature has emerged over the past few years that develops models with heterogeneous agents. These models incorporate market frictions such as price and wage rigidities, which are essential for business cycle analysis.[9] Kaplan et al. (2018) and Auclert et al. (2021b) demonstrated the empirical performance of these HANK models and their relevance for policy evaluations. HANK models have been widely used to analyze the business cycle and inequality dynamics of the US economy.

One of our contributions is extending these analyses to the French economy, which is distinctive because of its membership in a monetary union. We adapt the Taylor rule to reflect the fact that the European Central Bank (ECB) responds only partially to French inflation, which is only a part of European inflation. Beyond their ability to reproduce wealth inequalities, Auclert et al. (2023a) demonstrated that HANK models can induce a recession following an energy shock, as observed through real-world data, in contrast to Representative-Agent New Keynesian (RANK) models. By applying the HANK model to French data, we also examine its ability to generate a recession during an energy crisis. Our approach is different from those of Bayer et al. (2023) and Auclert et al. (2023a), who considered a two-country model within a monetary union. By contrast, our approach concentrates on a small open economy model. The benefit of focusing on a small open economy lies in the demand for a limited dataset that facilitates real-time assessments based on historical data and forecasts. However, the approach is limited in that it cannot analyze intercountry interactions. Our third contribution is that this study addresses the unequal impacts of energy price changes by examining them using an estimated model that incorporates business cycle fluctuations and

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

short-term macroeconomic policies. Känzig (2021)[10] revealed that the carbon tax is regressive, affecting the most disadvantaged households more severely owing to their more energy-intensive consumption and/or lower price elasticity. Pieroni (2023) developed a HANK model similar to ours, demonstrating that *(i)* low-income households incur the greatest costs from an energy shock, and *(ii)* monetary and fiscal policies can theoretically mitigate these unevenly distributed costs.

Our study also provides new tools for stochastic debt sustainability analyses (see Bohn (1998) and Blanchard (2019)). It allows us to analyze debt dynamics within a stochastic general equilibrium framework. Therefore, beyond evaluating the direct impact of the tariff shield on the government budget, our general equilibrium analysis incorporates the interactions between debt, inflation, GDP growth, interest rates, and so forth in a stochastic environment, providing new tools for managing new fiscal rules in the EU (see Blanchard et al. (2021)). This approach complements the semi-structural approach of Bouscasse and Hong (2023) based on the method of McKay and Wolf (2023), which identifies the best policy for stabilizing real debt.

Finally, we enrich the literature on policy evaluations based on conditional forecasts, which is particularly useful for developing counterfactual policy scenarios. These forecasts rely on external information to predict the evolution of certain economic variables and derive economic shocks that are consistent with these paths. Conditional forecasts primarily focus on the monetary policy interest rate in Vector Autoregression (VAR) (Waggoner and Zha (1999) and Antolin-Diaz et al. (2021)) and Dynamic Stochastic General Equilibrium (DSGE) models (Leeper and Zha (2003) and Del Negro and Schorfheide (2013)).[11] Our contribution involves estimating conditional forecasts based on the official government's forecasts for public finance and macroeconomic aggregates using the sequence-space Jacobian methodology (Auclert et al. (2021a)), and then evaluating policies using counterfactual scenarios derived from our HANK model.

The remainder of this paper is organized as follows: Section 2 presents the model. Section 3 describes the quantitative methodology used in the study. Section 4 outlines the model calibration and estimation. Section 5 analyzes the quantitative implications of the alternative policies. Section 6 presents the results of several robustness tests. Finally, Section 7 concludes the paper.

[10] Känzig (2021) studied the impacts of the European carbon market reforms on the Euro area.

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

2 Model

The model presented in this section is similar to those in Auclert et al. (2018) (2021b), and (2023a). Additional features are included to account for energy consumption and input.[12] Fiscal tools are introduced to allow the French government to fight the rise in inflation during the energy crisis, and the Taylor rule is adopted to account for the weight of the French economy in the Euro area.

2.1 Households

In each household, the worker's productivity takes the values $e' \in \mathtt{E}$ conditional to a current value $e \in \mathtt{E}$. The transition matrix between the productivity levels is $\mathcal{P}(e, e')$. If $V_t(e, a_-)$ denotes the value function of households, $a_- \in \mathtt{A}$ its asset position at the beginning of period t and $0 < \beta < 1$ the discount rate, the household's decision rules are deduced from

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

c is the consumption basket, n is the number of hours worked (determined by unions), d is the transfer from firms (dividends), and τ is the transfer from the government. τ_c is the consumption tax rate, and τ_l is the labor income tax rate. The rule for the distribution of government transfers $\bar{\tau}(e)$ is $\bar{\tau}'(e) \leq 0$. Dividends are distributed according to rule $\bar{d}(e)$, such that $\bar{d}'(e) \geq 0$. The real wage and real interest rate are w and r, respectively, where $1 + r = \frac{1+i_-}{1+\pi}$, i_- is the pre-determined nominal interest rate, and π is the inflation rate. The subsistence energy level is $\underline{c}_E$ and the rate at which the tariff shield reduces energy prices is s_H. Incompressible consumption $\underline{c}_E$ is bought directly by households at the energy producer, implying that it is not in consumption basket c. Preferences[13] are given by $u(c) = \log(c)$ and $v(n) = \varphi \frac{n^{1+\nu}}{1+\nu}$, where $\varphi > 0$ and $\nu > 0$. The consumption basket $c = \left(\int_0^1 c_i^{\frac{\varepsilon_d - 1}{\varepsilon_d}} \, di \right)^{\frac{\varepsilon_d}{\varepsilon_d - 1}}$ is sold at price P and is composed of imperfectly substitutable goods c_i, with

[12] Appendix A gives a graphical representation of the model structure. Our modeling of the opening of the economy is very limited: France, which does not produce any raw energy, imports raw materials, and the balance of trade is ensured on each date, assuming that these revenues are used by foreigners to finance an export request addressed to French firms. Obviously, this partial vision of the French trade balance prevents us from examining the implications of our model for real exchange rates and trade exchanges.

[13] We restrict our analysis to preferences compatible with a balanced growth path as shown in King et al. (1988). This is consistent with the detrending method used to stationarize the data.

ε_d the elasticity of substitution. The basket c_i is given by

$$c_i = \left(\alpha_E^{\frac{1}{\eta_E}} \left(c_{i,E} - \underline{c}_E\right)^{\frac{\eta_E - 1}{\eta_E}} + (1-\alpha_E)^{\frac{1}{\eta_E}} \left(c_{i,H}\right)^{\frac{\eta_E - 1}{\eta_E}}\right)^{\frac{\eta_E}{\eta_E - 1}} \quad (1)$$

where $c_{i,E}$ is energy consumption, $c_{i,H}$ is the domestically produced consumption good, η_E is the elasticity of substitution between these two goods, and α_E is the share of energy in c_i. The basket c_i satisfies household's preferences if $c = p_H c_H + (1 - s_H) p_E (c_E - \underline{c}_E)$, i.e. $c + (1 - s_H) p_E \underline{c}_E = p_H c_H + (1 - s_H) p_E c_E$ with $p_H = P_H / P$ and $p_E = P_E / P$.[14]

2.2 Supply

Intermediate Goods Y_H are produced with energy E and labor N using technology

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

where σ_f is the elasticity of substitution between E and N and α_f is the share of energy.

Final goods Y_F are produced with intermediate goods Y_H and energy Y_E using the technology

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

which corresponds to the household preferences defined by equation (1). Perfect competition causes the prices of these two goods to equal their marginal costs: $p_j = mc_j$ for $j = H, F$ where $mc_H = Z^{-\frac{1}{\sigma_f}} \left(\alpha_f p_E^{1-\sigma_f} + (1-\alpha_f) w^{1-\sigma_f}\right)^{\frac{1}{1-\sigma_f}}$ and $mc_F = \left(\alpha_E ((1-s_H) p_E)^{1-\eta_E} + (1-\alpha_E)\left(p_H\right)^{1-\eta_E}\right)^{\frac{1}{1-\eta_E}}$.

Retailer i produces consumption goods using final goods according to a linear production function: $Y_i = Y_{i,F}$. Households and the government have the same preferences. Thus, their baskets, c and G, respectively, are defined by $Y = \left(\int_0^1 Y_i^{\frac{\varepsilon_d - 1}{\varepsilon_d}} di\right)^{\frac{\varepsilon_d}{\varepsilon_d - 1}}$ for $Y = c, G$. Under monopolistic competition, retailers obtain markup, but support adjustment costs when they change prices. With ψ_P as the

[14] The intratemporal households' choices are managed by the firms that create final goods by combining home goods and energy services satisfying the households' preferences. This allows us to introduce a Phillips curve on the consumer price index (CPI) via an adjustment cost on price adjustment paid by the retailers.

adjustment cost parameter, the price-setting rule is deduced as follows:

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

This leads to the following New-Keynesian Phillips Curve (NKPC):

$$\pi_t \quad = \quad \kappa_P \left(mc_t - \frac{1}{\mu} \right) + \frac{1}{1+r_{t+1}} \frac{Y_{t+1}}{Y_t} \pi_{t+1} \quad \text{given that } \pi_t = \frac{P_t}{P_{t-1}} - 1$$

where $mc_t = \frac{P_{Ft}}{P_t} = p_{Ft}$, $\kappa_P = \frac{\varepsilon_d}{\psi_P}$ and $\mu = \frac{\varepsilon_d}{\varepsilon_d - 1}$.[15] The dividends distributed to households by firms (their profits) are defined as $d_{Ft} = Y_t - p_{Ft} Y_{Ft} - \frac{\psi_P}{2} \left(\frac{P_t}{P_{t-1}} - 1 \right)^2 Y_t$.

2.3 Unions

For task k, a union sets a wages for all levels of productivity $e \in \mathtt{E}$ and asset $a \in \mathtt{A}$. Assuming that wage adjustments are costly, with ψ_W as the adjustment cost parameter, the program is

$$\begin{aligned} U_t^k(W_{k,-}) \quad &= \quad \max_{W_k} \int_e \int_{a_-} \left[u(c(e,a_-)) - v(n(e,a_-)) \right] d\Gamma(a_-, e) - \frac{\psi_W}{2} \left(\frac{W_k}{W_{k,-}} - 1 \right)^2 + \beta U_{t+1}^k(W_k) \\ \text{s.t. } N_k \quad &= \quad \left(\frac{W_k}{W} \right)^{-\varepsilon} N \quad \text{with } W = \left(\int_0^1 W_k^{1-\varepsilon} dk \right)^{\frac{1}{1-\varepsilon}} \end{aligned}$$

where N_k denotes the quantity of labor in task k, N is the aggregate employment, and ε is the degree of substitution among tasks. The equilibrium distribution of the households satisfies $\int_e \int_{a_-} d\Gamma(a_-, e) = 1$. The income after wage and consumption taxes of household i is

$$\frac{1-\tau_l}{1+\tau_c} e_i w n_i = \frac{1-\tau_l}{1+\tau_c} e_i \int_0^1 \frac{W_k}{P} n_{ik} dk = \frac{1-\tau_l}{1+\tau_c} e_i \int_0^1 \frac{W_k}{P} \left(\frac{W_k}{W} \right)^{-\varepsilon} N dk$$

where the second equality come from $n_{ik} = n_{i'k} \equiv N_k$ as unions consider only a representative worker. After integrating this result into the union's objective, the nominal wage set by the union leads to a new Keynesian Phillips curve for the wage inflation dynamics:

$$\pi_{Wt} \quad = \quad \kappa_w \left(N_t v'(N_t) - \frac{1}{\mu_w} \frac{1-\tau_l}{1+\tau_c} \frac{W_t}{P_t} N_t u'(C_t) \right) + \beta \pi_{Wt+1} \quad \text{where } \mu_w \equiv \frac{\varepsilon}{\varepsilon - 1} \text{ and } \kappa_w \equiv \frac{\varepsilon}{\psi_W}$$

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

2.4 Government

The government collects revenue (R_t) and incurs expenditures (S_t), and the difference between revenue and expenditures is financed by issuing public debt B_t. Therefore, we have

$$\begin{aligned} P_tR_t &= P_t\tau_{lt}w_tN_t + P_t\tau_{ct}(C_t + p_{Et}\underline{c}_E) \\ P_tS_t &= P_tG_t + P_t\tau_t + P_ts_{Ht}(p_{Et}Y_{Et} + (1+\tau_{ct})p_{Et}\underline{c}_E) \\ B_t &= (1+i_{t-1})B_{t-1} - P_tR_t + P_tS_t \quad \Rightarrow \quad b_t = (1+r_t)b_{t-1} - R_t + S_t \end{aligned}$$

where $b = B/P$ is the real public debt and $G_t = \left(\int_0^1 g_{it}^{\frac{\epsilon_d - 1}{\epsilon_d}} di\right)^{\frac{\epsilon_d}{\epsilon_d - 1}}$ is the real government spending. To ensure the stability of the public debt dynamics, the transfers τ_t incorporate a fiscal brake $\theta\left(\frac{b_{t-1}}{b} - 1\right)$ with $\theta > 0$, such that $\tau_t = T_t - \theta\left(\frac{b_{t-1}}{b} - 1\right) + \vartheta_t$, where T_t represents the discretionary part of the transfers and ϑ_t is a measurement error that gives a stochastic dimension at the debt, allowing us to include it in the estimation as an observable variable. As the Finance Act does not entail any revision of tax rates to finance the tariff shield, we assume that this additional expenditure is financed through debt issuance.[16]

2.5 Monetary Policy

The monetary policy of the ECB, is summarized by a Taylor rule $i_t = \rho_r i_{t-1} + (1-\rho_r)\left(r_{ss} + \phi_\pi \pi_t^{EU}\right) + \widetilde{\varepsilon}_t$, where the European inflation is defined as $\pi_t^{EU} = \mu_{FR}\pi_t + (1-\mu_{FR})\pi_t^{REU}$, where π_t^{REU} denotes inflation in the rest of the Euro area and μ_{FR} represents the share of the French economy. Assuming that π_t^{EU} is correlated with French inflation, that is, $\pi_t^{REU} = \rho_\pi \pi_t + \pi_t^{REU*}$, where π_t^{REU*} represents the specific inflation of the rest of the Euro area, and the Taylor rule becomes as follows:

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

with $\varepsilon_t = \widetilde{\varepsilon}_t + \phi_\pi(1-\rho_r)(1-\mu_{FR})\pi_t^{REU*}$. 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.[17]

[16] Alternative financing schemes are presented in section 6.

[17] The output gap is not in the Taylor rule because *(i)* this target is not in the ECB mandate (see Art. 127, Ch. 2, The Treaty on the Functioning of the European Union (2012)) and *(ii)* papers dealing with the same subject, such as Bayer et al. (2023) and Auclert et al. (2023a), also choose this restriction, making it easier to compare the results.

2.6 Energy Market

Energy E_t^s is produced using raw energy $\overline{E}_t$ through technology $E_t^s = \Upsilon \overline{E}_t^{\nu}$, where $0 < \nu \leq 1$ and $\Upsilon > 0$. Raw energy is purchased at an exogenous price $\widetilde{P}_{Et}$, and the quantity of raw energy $\overline{E}_t$ is adjusted to ensure energy market equilibrium. If $\nu < 1$, then the equilibrium energy price P_{Et} is the solution to $E_t^s = \mathcal{E}_t \equiv E_t + Y_{Et} + \underline{c}_E$ and the energy sector distributes dividends $d_{Et} = P_{Et}E_t^s - \widetilde{P}_{Et}\overline{E}_t > 0$. If $\nu = 1$, then the energy price is $P_{Et} = \widetilde{P}_{Et}/\Upsilon$ and $d_{Et} = 0$. Given that France does not produce any raw energy, we assume that revenues from raw energy sales $\mathcal{R}_{Et} = P_{Et}E_t^s$ are earned by a foreign representative agent who use these to purchase goods exported by French firms $\mathcal{R}_{Et} = X_t$. Under this assumption, albeit highly simplistic, the trade balance is always at equilibrium without any financial trade with the rest of the world.[18]

2.7 Equilibrium

The market-clearing conditions used to determine the unknowns $\{r, w, p_E\}$ are:

$$\begin{aligned} \text{asset market:} \quad & b = \mathcal{A} \equiv \int_{a_-}\int_e a(a_-, e)d\Gamma(a_-, e) \\ \text{labor market:} \quad & N = \mathcal{N} \equiv \int_{a_-}\int_e en(a_-, e)d\Gamma(a_-, e) \\ \text{energy market:} \quad & E^s = \mathcal{E} \equiv E + Y_E + \underline{c}_E \end{aligned}$$

Market-clearing on the goods market can be used to check the Walras law, given $d = d_F + d_E$,[19]

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

3 Quantitative Method

This section introduces an original method for "real-time" policy evaluation using HANK models. First, we provide a brief overview of the linearized model solutions. Leveraging this solution and given that any Finance Act commits the government to its expenditures and revenues based on forecasts for future years, we can then identify the shocks that would match the government fore-

[18] A version of the model where the consumption of the foreign representative agent depends only on a fraction of his current income but also on his wealth (the counterpart of international financial exchanges) indicates that our conclusions on policy ranking are not affected. Results are available upon request.

[19] In the case where $\nu = 1$ and thus $d_E = 0$, we have $\overline{E} = \mathcal{E} \equiv E + Y_E + \underline{c}_E$ and $Y\left(1 - \frac{\psi_P}{2}\pi^2\right) = p_E\overline{E} + \mathcal{C} + G$.

casts with model solutions (method of conditional forecasts à la Del Negro and Schorfheide (2013), extended to HANK models). Subsequently, using these identified shocks, we propose a method that allows us to compare the policy announced in the Finance Act with alternatives in exactly the same context. This method transcends traditional IRF analysis by enabling comparisons across scenarios in which the new policy can combine shocks and changes in the model's multipliers. By imposing strong theoretical restrictions, this approach yields causal interpretations, albeit at the expense of focusing on a narrower set of variables than large-scale non-structural approaches.

3.1 Model's Solution

The equilibrium dynamics must satisfy the following conditions.

$$\mathbf{H}_t(\mathbf{Y},\mathbf{Z}) \equiv \begin{pmatrix} \Phi(S_{t+1}, S_t, S_{t-1}) \\ \mathcal{A}_t - b_t \\ \mathcal{N}_t - N_t \\ \mathcal{E}_t - E_t^s \end{pmatrix} = 0 \tag{2}$$

where $\mathbf{Y}$ and $\mathbf{Z}$ are the time series of all the aggregate variables and aggregate shocks, respectively. The system $\Phi(S_{t+1}, S_t, S_{t-1}) = 0$ regroups all equations describing firm, union, government, and central bank behaviors, where S_t is the vector of the aggregate variables controlled by these agents. The solution to Equation (2) was obtained using the approximation method developed by Auclert et al. (2021a). With $[H_Y]_{t,s} \equiv \frac{\partial \mathbf{H}_t}{\partial Y_s}$ and $[H_Z]_{t,s} \equiv \frac{\partial \mathbf{H}_t}{\partial Z_s}$ $\forall s, t$, this is given by

$$0 = \sum_{s=0}^{\infty} [H_Y]_{t,s} dY_s + \sum_{s=0}^{\infty} [H_Z]_{t,s} dZ_s \quad \Rightarrow \quad dY \quad = -H_Y^{-1} H_Z dZ \equiv G dZ$$

where $dZ = Z - \overline{Z}$, $\overline{Z}$ is the steady-state value of Z, and G is the complete Jacobian of the dynamic system. We assume that all shocks in the model have the following MA(∞) representation: $dz_t = \sum_{s=0}^{\infty} \mathbf{m}_s^z \varepsilon_{t-s}^z$ and $\forall z \in \mathcal{Z}$, where $\mathcal{Z}$ is the set of shocks. Therefore, the solution of the HANK model can be represented by an MA(∞) that involves the Jacobians of the model:

$$dY_t = \sum_{s=0}^{\infty} \sum_{z \in \mathcal{Z}} \left[G^{Y,z} \mathbf{m}^z \right]_s \varepsilon_{t-s}^z \equiv \sum_{s=0}^{\infty} \sum_{z \in \mathcal{Z}} m_s^{Y,z} \varepsilon_{t-s}^z \tag{3}$$

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

3.2 Conditional Forecasts

In the spirit of Del Negro and Schorfheide (2013), we assume that in period $t \in \{T+1, ..., T+H\}$ the vector of endogenous variables $\mathcal{F} = \{Y_s, \pi_s, \frac{b_s}{Y_s}, G_s, T_s, P_{Es}\}_{s=T+1}^{T+H}$ takes the forecasted values $\mathcal{F}^f$ reported in the Finance Act. To achieve this objective, we use Equation (3) to compute the vector of unanticipated shocks Ψ allowing the model solution $\mathcal{F}$ to match the target $\mathcal{F}^f$, $\forall t \in \{T+1, ..., T+H\}$. In order to satisfy the rank condition necessary for identification, the 6 time series in $\mathcal{F}^f$ and the model (equation (3)) allow us to identify the time series of the 6 shocks $\Psi = \{\varepsilon_s^{\beta}, \varepsilon_s^{\mu}, \varepsilon_s^{\vartheta}, \varepsilon_s^{P_E}, \varepsilon_s^{G}, \varepsilon_s^{T}\}_{s=T}^{T+H}$ on preference (β), markup (μ), measurement error (ϑ), energy price (P_E), government expenditures (G), and transfers (T). Among the shocks Ψ, it is necessary to distinguish between the two groups of shocks.

(i) The shocks $\{\varepsilon_s^{P_E}, \varepsilon_s^{G}, \varepsilon_s^{T}\}_{s=T+1}^{T+H}$ that affect the exogenous and observable variables $\{P_{FE}, G, T\}$. They are identified using only the forecasts for $\mathcal{F}_x^f = \{P_E, G, T\}_{s=T+1}^{T+H}$, without any filtering by the model. In order to evaluate the tariff shield, we add a supplementary shock that mimics the dynamics of the subsidies s_H provided over the $T+1, ..., T+h$ period, with $h \leq H$. For all these exogenous variables, we assume that $dz_t = \rho^z dz_{t-1} + \varepsilon_t^z$, for $z \in \{P_E, G, T, s_H\}$.

(ii) The shocks $\{\varepsilon_s^{\beta}, \varepsilon_s^{\mu}, \varepsilon_s^{\vartheta}\}_{s=T+1}^{T+H}$ that affect the unobservable variables $\{\beta, \mu, \vartheta\}$. They are identified using the model restrictions (equation (3)) and shocks $\{\varepsilon_s^{P_E}, \varepsilon_s^{G}, \varepsilon_s^{T}\}_{s=T+1}^{T+H}$ where dY_t contains $\{Y_s, \pi_s, \frac{b_s}{Y_s}\}$. We assume that $dz_t = \rho^z dz_{t-1} + \varepsilon_t^z$ for $z \in \{\beta, \mu, \vartheta\}$.

Given that the Finance Act may announce many policy changes, the decision rules for G and T may be unstable, biasing the policy evaluation (Lucas (1976)). Using the government's forecasts to identify $\{\varepsilon_s^{G}, \varepsilon_s^{T}\}_{s=T+1}^{T+H}$, we test whether these realizations are in the confidence band of the model estimated using historical data. In this case, the stability of the model parameters is not rejected. Otherwise, the unstable parameters must change and their new estimated values are based on forecasted data, implying changes in the estimation of Ψ.

We can interpret the estimated shocks Ψ as the economic context that allows for the realization of the Finance Act forecasts. To evaluate the effect of an alternative policy by considering the economy in the same context, this vector of shocks must be invariant. Therefore, economic policies are compared by controlling the economic context, as in a controlled experiment.

3.3 Methodology for Real-Time Policy Evaluations

Let us index by $\emptyset$ the economy with no policy changes, by $\mathcal{S}$ the economy where policy changes can be summarized by additional shocks (ς) and by $\mathcal{P}$ the one where the new policy involves parameter changes and additional shocks.[20] The economies $\emptyset$ and $\mathcal{S}$ share the same Jacobians ($G_{\mathcal{S}} = G_{\emptyset}$) and thus the same multipliers ($m^{Y,z}_{\mathcal{S},s} = m^{Y,z}_{\emptyset,s}$) because the exogenous processes of shocks do not change ($\mathbf{m}^{z}_{\emptyset,s} = \mathbf{m}^{z}_{\mathcal{S},s}$) if an additional shock is introduced ($m^{Y,\varsigma}_{\mathcal{S},s} \neq 0$). Therefore, for $t \in \{T+1, ..., T+H\}$, the evaluation of a policy change modeled as a shock is given by

$$\left.\begin{array}{rcl} dY_{\emptyset,t} & = & \sum_{s=0}^{\infty} \sum_{z\in\mathcal{Z}} m^{Y,z}_{\emptyset,s} \varepsilon^{z}_{t-s} \\ dY_{\mathcal{S},t} & = & \sum_{s=0}^{\infty} \left[\sum_{z\in\mathcal{Z}} m^{Y,z}_{\emptyset,s} \varepsilon^{z}_{t-s} + m^{Y,\varsigma}_{\mathcal{S},s} \varepsilon^{\varsigma}_{t-s}\right] \end{array}\right\} \Rightarrow \quad dY_{\mathcal{S},t} - dY_{\emptyset,t} = \sum_{s=0}^{\infty} m^{Y,\varsigma}_{\mathcal{S},s} \varepsilon^{\varsigma}_{t-s}$$

where only the dynamics driven by the shock ς matter, as in typical IRFs. On the contrary, the economy $\mathcal{P}$ does not have the same multipliers as $\emptyset$ and $\mathcal{S}$ ($G_{\mathcal{P}} \neq G_{\emptyset}$ thus, $m^{Y,\upsilon}_{\mathcal{P},s} \neq m^{Y,\upsilon}_{\emptyset,s}$ $\forall \upsilon = z, \varsigma$). The evaluation of policy $\mathcal{P}$ with respect to $\emptyset$ or $\mathcal{S}$ is given by:

$$\begin{array}{rcl} dY_{\mathcal{P},t} & = & \displaystyle\sum_{s=0}^{\infty} \sum_{z\in\mathcal{Z}} \left[m^{Y,z}_{\mathcal{P},s} \varepsilon^{z}_{t-s} + m^{Y,\varsigma}_{\mathcal{P},s} \varepsilon^{\varsigma}_{t-s}\right] \\ dY_{\mathcal{P},t} - dY_{\mathcal{S}|\emptyset,t} & = & \displaystyle\sum_{s=0}^{\infty} \sum_{z\in\mathcal{Z}} \left[(m^{Y,z}_{\mathcal{P},s} - m^{Y,z}_{\emptyset,s}) \varepsilon^{z}_{t-s} + (m^{Y,\varsigma}_{\mathcal{P},s} - m^{Y,\varsigma}_{\mathcal{S}|\emptyset,s}) \varepsilon^{\varsigma}_{t-s}\right] \quad \text{where } m^{Y,\varsigma}_{\emptyset,s} = 0. \end{array} \quad (4)$$

Because all multipliers $m^{Y,z}_{\mathcal{P},s}, m^{Y,\varsigma}_{\mathcal{P},s}$ change, the evaluation of the policy $\mathcal{P}$ depends on the sequences of all shocks by combining all IRFs. Therefore, if the multipliers are not invariant and contingent on the implemented policy, and if the sample size is limited, equation (4) must be used for policy evaluation, even with a linear approximation of the model dynamics.[21] The finiteness of the sample is crucial for policy evaluation because decisions hinge on *(i)* a context defined by the initial conditions resulting from a particular combination of shock history and *(ii)* policy implications over a short

[20] The analysis is conducted for changes in parameters that do not modify the steady state.

[21] Usually, two tools are available to the public policy evaluator: *(i)* IRFs provide the dynamics of equilibrium disturbed by a shock, *(ii)* stochastic simulations generate the ergodic distribution of endogenous variables when all shocks are considered. Obviously, for a model that remains stable over an infinite sample, analysis of the ergodic distribution via its second-order moments for a linearized model is the most exhaustive tool.

horizon (generally less than five years). A finite sample requires focusing on a specific realization of shock dynamics, for which the natural candidate is Ψ because it enables the model to replicate the observed series and thereby identify relevant time dependence for policy evaluation. Conditional on beginning with the current economic state, policy evaluation must compare the benchmark scenario with a counterfactual scenario. To maintain the principle of "all things being equal," shocks Ψ are retained when evaluating any alternative scenario, leaving no explanation for the differences other than the policy change. By focusing on particular business cycle episodes, this method assigns significant importance to the relative size of each shock, because it weighs the IRFs of each shock to determine the level of each endogenous variable. Therefore, the specific identification of shocks favors policies that interact with the largest shocks.

4 Take the Model to the Data

4.1 Calibration and Estimation Based on Historical Data

Income process. The log of labor income follows the $AR(1)$ process $\log(e_t) = \rho \log(e_{t-1}) + \eta_t$ where $\eta_t \sim \mathcal{N}(0, \sigma)$. Following Fonseca et al. (2023), ρ is set to 0.966.[22] σ is not set to its estimated value (0.014) because our modeling choices limit the ability of the model to reproduce income and wealth distributions. First, we restrict the labor income process to follow $AR(1)$, which cannot generate extreme income values, as in Guvenen et al. (2021). Second, our model has only one asset, while Kaplan et al. (2018) highlighted the importance of risky assets, in addition to riskless assets, in explaining the magnitudes of wealth inequalities. A larger value for σ can compensate for these limitations; with $\sigma = 0.5$ the income, wealth, and consumption distributions generated by the model are close to their empirical counterparts (see Appendix C).

Parameters of the decision rules. The parameters of preference, technology, price and wage-setting rules, monetary policy, and long-run fiscal aggregates were calibrated to reproduce stylized facts about the French economy using external information (see Table 2).

The energy production function is calibrated by targeting the adjustment of prices in the energy

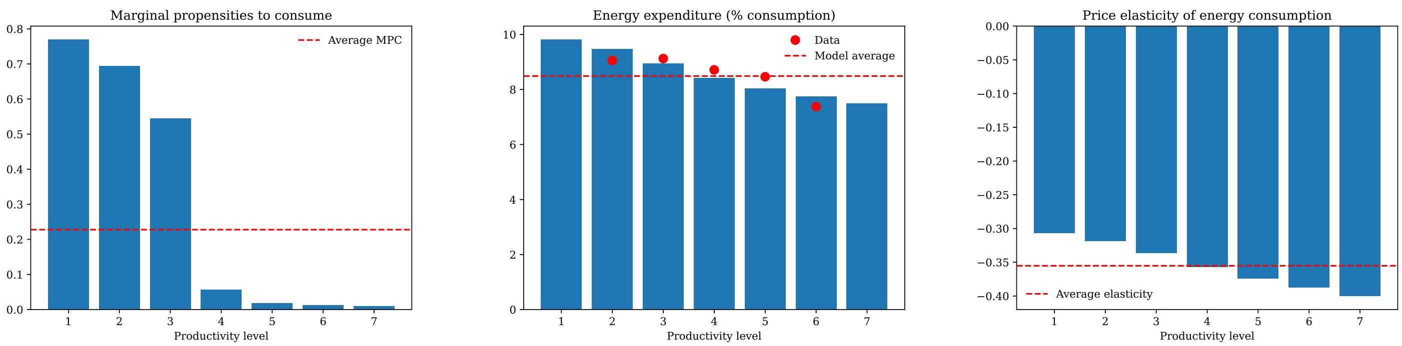
[22] This estimation is based on the European Community Household Panel (ECHP), after *(i)* controlling by age and *(ii)* extracting a purely transitional shock treated as a measurement error, uncorrelated with the innovation of the persistent component of the labor income.

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 et al. (2021a)
Incompressible energy consumption $\underline{c}$	0.0370	20% of the households' energy consumption
Elasticity of substitution between tasks ε	11	Wage markup $\mu_w = 1.1$, Auclert et al. (2021a)
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: 40% of energy to households
Production		
Returns of energy production ν	1	Meyler (2009) and Gautier et al. (2023)
Elasticity of substitution between production inputs σ_f	η_E	Simplifying assumption
Share parameter (energy, labor) α_f	0.075	Sharing rule: 60% of energy to firms
Elasticity of substitution between goods c_i	6	Firm markup $\mu = 1.2$, Burstein et al. (2020)
Aggregate targets		
Share of GDP spent on energy	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 higher 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	To match consumption inequalities

Table 2: Calibrated parameters

market. Studies such as Meyler (2009) and Gautier et al. (2023) demonstrated that changes in consumer energy prices are primarily driven by variations in oil prices in the short run; consumer prices for liquid fuels reflect a direct, complete, and rapid pass-through of crude oil prices. Additionally, IGU (2015) indicated that changes in wholesale gas prices, which are highly correlated with crude oil prices during crises, are generally passed on to consumer gas prices with a short lag of three to six months. In the EU electricity market, prices are based on the costs of the fossil fuels used in production. This mechanism, known as the "economic order of precedence" principle, sets the wholesale price of electricity in the EU at the costs of the last plant called upon to ensure balance (see Chapter II of the EU directive 2019/944). As gas is a flexible resource, the electricity market is often balanced by its use. Consequently, gas prices will strongly influence EU electricity prices by 2022. All these observations lead us to calibrate $\nu = 1$ so that changes in crude oil prices largely pass through to consumer energy prices.

This calibration results in 19.6% of households being financially constrained. The Marginal Propensities to Consume (MPC) per level of income are reported in Panel (a) of Figure 1. As expected, agents with low income consume a larger fraction of their income. Panel (b) of Figure 1 shows that these agents devote a larger share of their energy expenditure, as in the data. Finally,



(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)

panel (c) of Figure 1 shows that agents with low income have more difficulty reducing their energy consumption as prices increase. This result originated from the largest share of incompressible consumption in their energy consumption.

Parameters of the Aggregate Shocks. As in all dynamic models, the impact of each shock depends on how agents expect them to persist. The autocorrelations of these $AR(1)$ processes and standard deviations of their innovations are listed in Table 3.

	Z	**Persistence** ρ^Z		**Standard dev.** σ^Z		**Variance**
Shock		Mode	Mean	Mode	Mean	$\frac{(\sigma^Z)^2}{1-(\rho^Z)^2}$
Energy price	p_E	0.9563 (0.0155)	0.9548	0.1656 (0.0121)	0.1685	0.321335
Government spending	G	0.9669 (0.0156)	0.9643	0.0035 (0.0003)	0.0036	0.000184
Transfers	T	0.9079 (0.0302)	0.9062	0.0051 (0.0004)	0.0052	0.000151
Measurement error	ϑ	0.9374 (0.0048)	0.9373	0.6886 (0.0424)	0.7165	4.226374
Price markup	μ	0.7463 (0.0398)	0.7467	1.5172 (0.1052)	1.5136	5.178079
Preference	β	0.9380 (0.0127)	0.9356	0.0681 (0.0103)	0.0666	0.035583

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

The values for ρ^z, $\forall z \in \{\beta, \mu, \vartheta, G, T, P_E\}$, were estimated using a Bayesian method based on dataset $\{Y, \pi, \frac{b}{Y}, G, T, P_E\}$ over the 2Q1995-4Q2019 sample.[23] The autocorrelation functions of these variables are deduced from the model solution (see Equation (3)). These estimates show that the shocks to the residual part of transfers ϑ have a large variance, which is not surprising given the non-stationarity of the debt-to-GDP ratio during this period. Shocks to markups have larger variance than shocks to energy prices and preferences. These estimates of the shock sizes underline that the energy shock had a large magnitude even before the period of the last crisis.

For the tariff shield, we assume that households expect the government not to remove it all at once, as provided in the Financial Act, but to take a year to remove all subsidies. Thus, even if we implement what is provided for in the Financial Act in our evaluation–that is, subsidies between 1Q2022 and 4Q2023–households act in the belief that this subsidy will persist.

Finally, following Auclert et al. (2023b), we use the Onatski (2006) criterion for a quantitative determinacy assessment and check that the winding number is zero.

4.2 Shock Identification over the Forecasting Horizon

As explained in Section 3.3, our quantitative method requires an estimation of the relative size of all shocks identified to generate the data. After presenting the data used to estimate these shocks, we now present their estimates.

Data for Forecasted Aggregates. We estimate the sequence of shocks from 4Q2019 to 4Q2027, including both COVID-19 and energy crisis episodes, as well as the post-crisis period until 4Q2027. To do so, we use *(i)* observed data from 4Q2019 to 4Q2021 and *(ii)* forecasts from 1Q2022 to 4Q2027 published by the French government when the Prime Minister presented the Financial Act.These data[24] contains the government forecasts for the

- $\{G, T\}$, which are its commitments concerning its policy until 4Q2027.
- $\{P_E\}$, which is a crucial forecast on the exogenous shock that hit France at the end of 2021.
- $\{Y, \pi, \frac{b}{Y}\}$, which summarizes the objectives underpinning its policy.

[23] Appendix D presents the data used in the study. All data are stationarized by extracting a linear trend or sample mean. Additional details on the estimation procedure are in Appendix E.

[24] Data are presented in Appendix D (raw data). The sample spans from $4Q2019$ to $4Q2027$.

The cost of the "tariff shield" is evaluated at €85 billion by the government from October 2021 to December 2023 (27 months), that is, €37 billion per year (see Sénat (2023) and Appendix B). However, only part of the total cost can be considered in our model. This leads us to calibrate $s_H = 0.2$ (see Appendix B.1 for further details). Due to its unanticipated nature, its unknown duration as well as the unannounced modalities of its interruption (see Appendix B.2), we consider it as a shock: each quarter it is a "fiscal" surprise with a persistence modeled as an $AR(1)$ process.

In order to estimate $\{\varepsilon_s^\beta, \varepsilon_s^\mu, \varepsilon_s^\vartheta, \varepsilon_s^G, \varepsilon_s^T, \varepsilon_s^{P_E}, \varepsilon_s^{s_H}\}_{s=4Q2019}^{4Q2027}$, we use stationarized data described in Appendix D. We cannot reject the stability of the model parameters (see Appendix F), suggesting that our evaluation is not biased (Lucas (1976)).

Estimations results. Figure 2 shows that the dynamics of GDP (Y) and inflation (π) are mainly driven by preference shocks (demand shocks, β) and markup shocks (supply shocks, μ).[25] Shocks to the two public spending indicators (G and T) have smaller effects.[26] However, starting at the end of 2021, a shock to the price of energy (p_E) significantly disrupts the decomposition of the sources of macroeconomic fluctuations. Throughout 2022 and 2023, this shock accounted for as much as 60% of GDP and inflation dynamics. During these two years, only markup shocks support the GDP (with a decrease in markups), whereas public spending and the price of energy reduced it. The tariff shield also supports GDP by mitigating the recessive effects of energy shocks. The magnitude of the impact of the tariff shield is comparable to that of public spending, highlighting the significance of this policy during this particular episode of the French economic cycle.

Over the two years, the markup and energy price shocks explain the majority of the inflation dynamics. Only energy price shocks increase inflation during this period, whereas markup shocks reduce it. The net impact of the tariff shield on inflation seems negligible and the direct effect of moderating inflation is countered by the indirect effect of stimulating demand, which contributes to inflation.

It appears that energy shocks initially reduced the debt-to-GDP ratio until 2023. Indeed, their recessive effects on the GDP are not yet sufficiently strong, although inflation has increased since 2021. However, after 2023, the recessive effects of energy shocks became stronger while inflation

[25]Our estimation identifies only one supply shock, the markup shock. Hence, it can also capture the TFP shocks.

[26]Even during the COVID-19 crisis (see Figure 16 in Appendix H), the shocks $\{\beta, \mu\}$, which can be interpreted as the temporary obstacles on demand and supply induced by lockdowns, are the main sources of fluctuations. See Appendix H for additional details on variance decomposition.

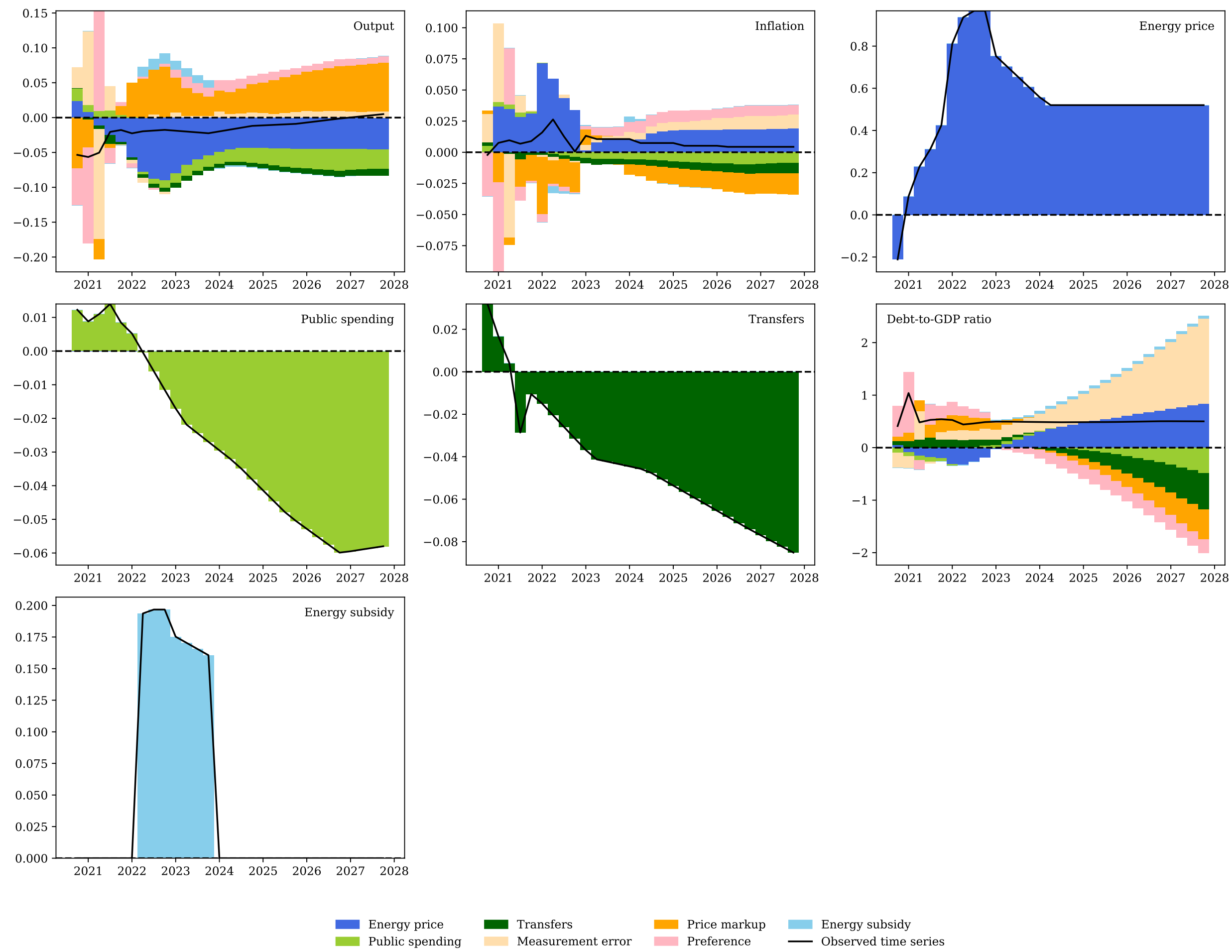


Figure 2: Shock decomposition: focus after 4Q2020

declined, which explains why the debt-to-GDP ratio increased with energy shocks. In the medium-term, the decline in markups partly counteracts the persistence of high energy prices, whereas the reduction in government expenditures and transfers to households contributes to public indebtedness after 2025. The impact of the tariff shield on the debt-to-GDP ratio is relatively moderate because its fiscal cost is partly offset by its positive impact on GDP.[27] Finally, the measurement error ϑ explains more than 50% of the debt-to-GDP ratio in the long run, providing a measure of uncertainty in the estimation and data.

Our evaluation reveals that firms are willing to reduce their markups. This has been validated by the OECD (Employment Outlook 2023), which emphasizes that France is the only country in which growth in profits was lower than growth in labor costs during this period.

[27] Appendix I provides a measure of the implied uncertainty around these forecasts.

5 Policy Analysis

This section evaluates the effectiveness of the tariff shield–a supply side policy–for correcting market prices. Using IRFs, we show that their initial impact partially offsets the increase in energy prices, thereby mechanically reducing inflation by mitigating their energy components. Reducing the magnitude of the shock prevents its diffusion and, consequently, its recessive impact on the economy. This policy also sustains households purchasing power by lowering their energy expenditure. This enables them to avoid excessively reducing demand for domestic producers, thereby supporting economic growth. However, as shown in Section 3.3, an analysis based solely on IRFs is insufficient to fully account for this crisis, in which the model multipliers can change.

Alvarez et al. (2022) suggested that wages are no longer indexed to prices, implying that inflation driven by the energy shock could result in a significant reduction in purchasing power. This suggests that it could be efficient to index wages to prices more quickly to reinforce the tariff shield in the fight against the reduction of purchasing power. Therefore, we analyze the effectiveness of the tariff shield when complemented by a faster wage indexation.

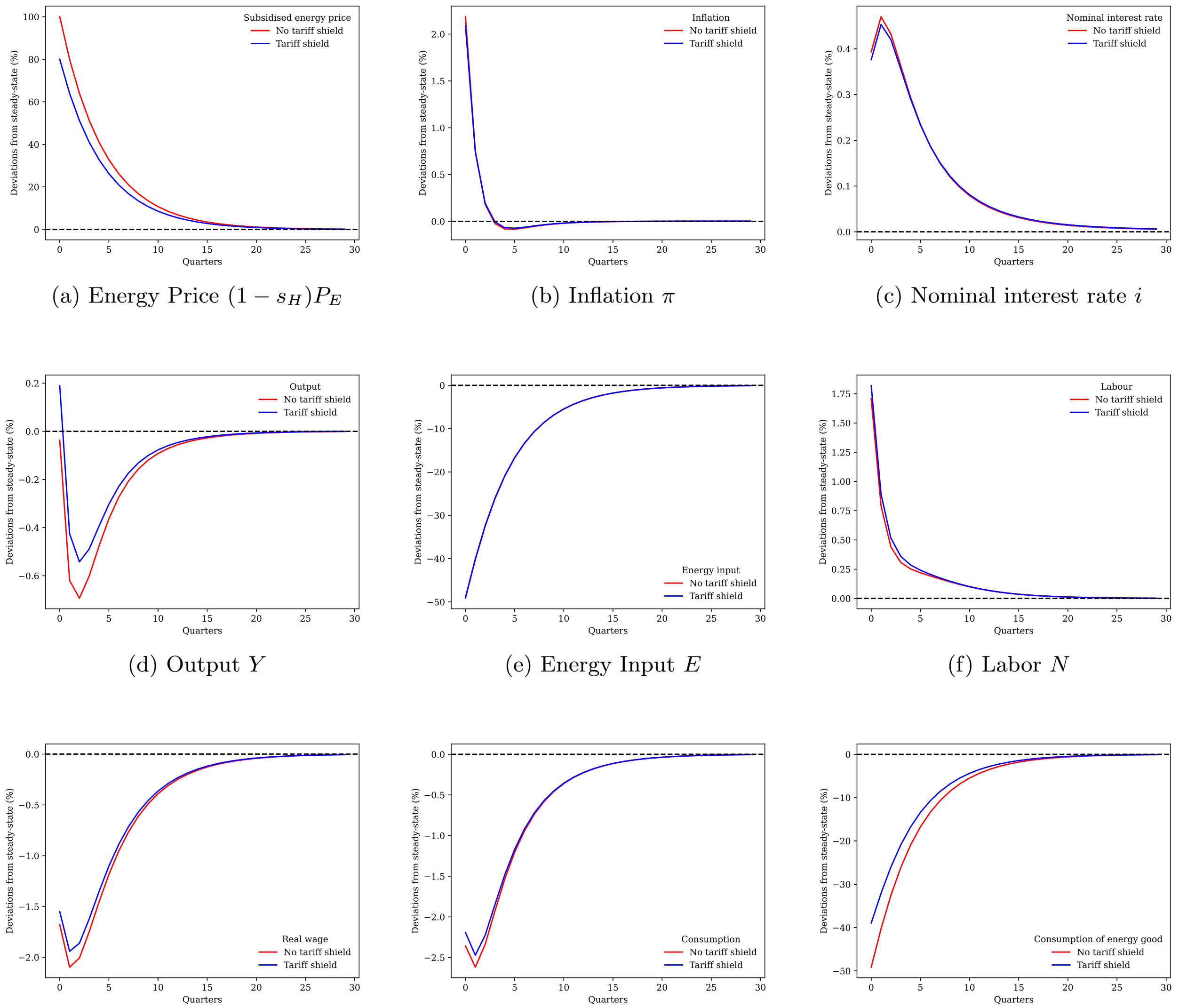
An alternative policy comprises favoring redistribution tools. This demand-oriented policy aims to fight the recession induced by an energy shock by stimulating consumption demand. Consequently, recession can also be mitigated, as the tariff shield can, but is unlikely to address inflation, contrary to what the tariff shield does.

Hereafter, we assess the macroeconomic and distributive effects of the tariff shield and compare them with two alternative scenarios.

5.1 Impulse Response Functions (IRF)

Since Boppart et al. (2018), the MIT shock analysis has provided insights into the economic mechanisms at work in the HANK models. It also evaluates a policy if perceived as a shock.[28] This is the case for the tariff shield; this shock's IRFs for each variable depict the policy impact. Figure 3 shows the IRFs for an energy shock (panel (a)) with and without a tariff shield. Therefore, the difference between the two lines in each panel indicates the impact of the tariff shield. Energy shocks lead to an increase in inflation (panel (b)), subsequently increasing the nominal interest rate (panel (c)). The

[28]See Section 4.2 for the details on the calibration of the tariff shield shock.



(a) Energy Price $(1 - s_H)P_E$

(b) Inflation π

(c) Nominal interest rate i

(d) Output Y

(e) Energy Input E

(f) Labor N

(g) Real Wages w

(h) Consumption C

(i) Household Energy Consumption Y_E

Figure 3: Impulse Responses Functions: Energy Shock with or without Tariff Shield

tariff shield mitigates the inflation increase by 0.1 percentage point (pp) and the nominal interest rate by 0.017 pp upon impact. Both scenarios generate similar adjustment dynamics for the two variables. A reduction in inflation affects real wages (as nominal wages are more rigid than prices), prompting firms to increase their labor demand (panel (g)).[29] Concurrently, workers agreed to work more to offset the negative wealth effect of an increase in energy prices. A reduction in real wages partially offsets this increase in labor supply. By moderating inflation, the tariff shield alleviates the decline in real wages, thereby reducing the crowding-out effect on labor supply caused by real

[29] Firms that do not benefit from the tariff shield are encouraged to replace energy with workers (panels (e) & (f)).

wage dynamics and explaining better performance in terms of employment and output (panels (d) & (f)). Without a tariff shield, the energy shock reduces GDP by 0.65% four quarters after the impact, whereas it is only 0.5% with a tariff shield. As the tariff shield dampens the increase in energy prices, households decrease their consumption of goods and energy to a lesser extent (panels (h) & (i)).[30]

5.2 On the Effectiveness of the Tariff Shield

		GDP		Inflation			$\frac{\text{Debt}}{\text{GDP}}$
No tariff shield	2022	1.68%	1.31%	7.3%	5.4%	2027	111.3%
	2023	0.94%		3.5%			
Tariff shield 2022 2023	2022	2.85%	1.92%	6.5%	4.9%	2027	112.6%
	2023	1.00%		3.4%			
Tariff shield 2022 only	2022	2.85%	1.76%	6.5%	5.1%	2027	112.8%
	2023	0.70%		3.7%			

Table 4: Tariff Shield Impact

With a tariff shield in 2022 and 2023, incurring an annual cost of €37 billion and resulting in a 1.3pp increase in the debt-to-GDP ratio by 2027, Table 4 shows the support provided by the French government for growth during these two years.[31] The annual growth rate for 2022-2023 would have been 1.31% without the tariff shield, compared to the forecasted 1.92% by the government. Inflation is contained as the price-wage spiral is not initiated; the annual inflation rate for 2022-2023 would have been 5.4% without the tariff shield, instead of 4.9%. Indeed, without a tariff shield, a significant increase in consumer prices triggers a strong reaction in nominal wages, fueling inflation and increasing labor costs, which explains the significantly weaker growth. If the tariff shield is not renewed by 2023, there will no longer be any growth smoothing, leading to an abrupt halt in growth by 2023. However, inflation remained because of the tariff shield operating in 2022. This partial measure does not result in budgetary savings, because it diminishes GDP growth. Thus, the tariff shield helps contain inflation while achieving higher GDP growth. Therefore, the negative shock from the rise in energy prices was cushioned, allowing for the recovery of a significant portion of the growth associated with the post-Covid crisis catch-up.

[30]The non-linear IRFs show that the linear approximation does not bias the results. See Appendix G.
[31]In Appendix J, the complete description of the quarterly path of the aggregates is presented.

Who loses the most without the 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 2.21 times more than those in the Bottom 10% (B10) income (see Appendix C).

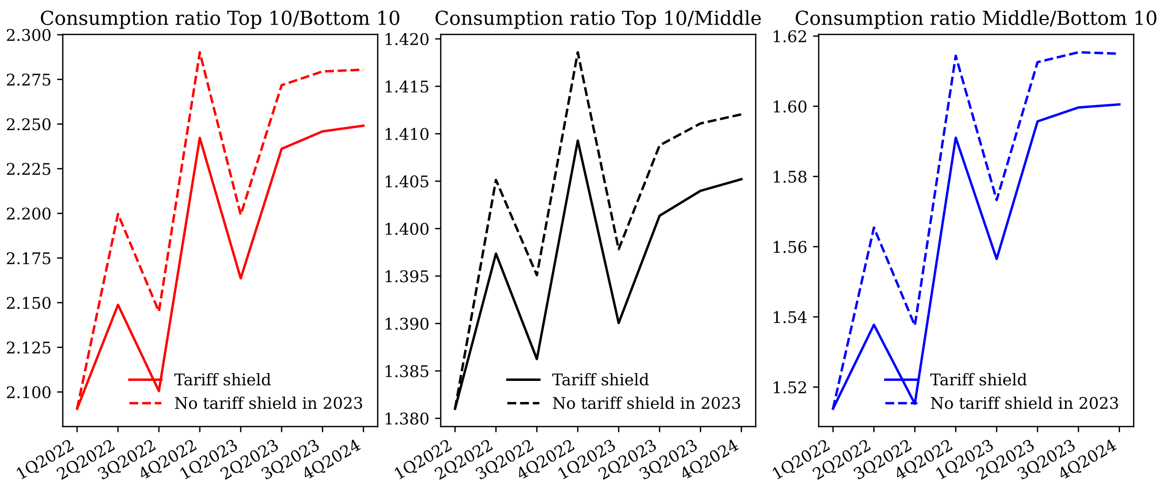


Figure 4: Dynamics of Inequalities with Tariff Shield

Without the tariff shield, Figure 4 shows that the consumption of T10, which was 2.095 times higher than that of B10 in 1Q2022, increased to 2.275 times higher than that of B10 in 4Q2022 (an 8.6% increase). Consequently, the energy crisis has exacerbated consumption inequalities. However, with the tariff shield, the consumption of the T10 would only be 2.25 times higher than that of the B10 in 4Q2022 (a 7% increase). These findings also indicate that mitigating rising inequalities primarily benefits the lower end of the distribution by sustaining the consumption of low-income households, for whom substitutions are less feasible.

General equilibrium effects on public debt dynamics. In stochastic debt sustainability analysis (see, e.g., Bohn (1998) and Blanchard (2019)), the dynamics of public debt result from changes in government surplus, given the distributions of GDP growth, interest rates, and inflation. However, changes in government surplus also modify the distribution of GDP growth, interest rates, and inflation owing to general equilibrium (GE) effects. What is the magnitude of GE feedback on the dynamics of public debt? Figure 5 shows the breakdown of the evolution of the debt-to-GDP ratio. The first scenario solely reflects the tariff shield's additional costs, with GDP, inflation, interest

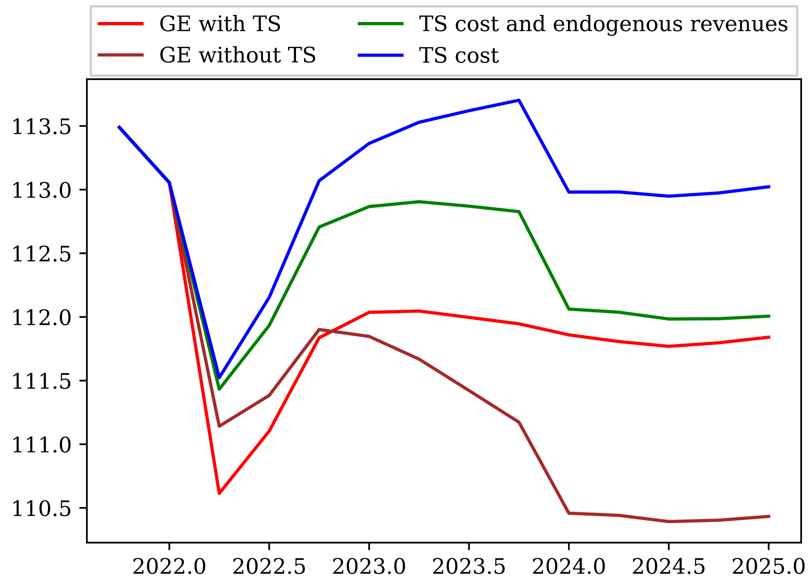


Figure 5: Decomposing Public Debt-to-GDP Dynamic. GE: General Equilibrium; TS: Tariff Shield

rates, and government revenues, following their equilibrium trajectory in an economy without a tariff shield (blue line). The second scenario (green line) depicts the trajectory of the debt-to-GDP ratio by concurrently integrating the extra costs induced by the tariff shield and the changes in the government's revenue if it implements this policy (GDP, inflation, and interest rates following their equilibrium trajectory in an economy without a tariff shield). Finally, the third scenario (red line) represents GE, in which everything is endogenous (government expenditure and revenue, as well as GDP, inflation, and interest rates). Without the tariff shield, the debt-to-GDP ratio would have been lower, except during the year 2022 when the crisis begins because the tariff shield absorbs the recession (see Figure 5). However, the GE effects significantly mitigate the impact of the tariff shield on this ratio. Indeed, relative to the simulation without the policy, the tariff shield increases the debt-to-GDP ratio by 1.2pp. Without considering the GE effects, the cost of the tariff shield would have raised the debt-to-GDP ratio by 2.5pp: thus, the GE effect reduced the cost of the tariff shield by half through the sustenance of GDP growth.

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

The tariff shield mitigates the decrease in household purchasing power caused by energy price hikes but does not alleviate those affecting goods manufactured using energy. To address these declines, faster indexation of wages to consumer prices can be considered. To assess this strategy, we calibrate the nominal wage adjustment cost parameter such that wages adjust throughout the year in response to changes in inflation.[32]

		GDP		Inflation			$\frac{\text{Debt}}{\text{GDP}}$
No tariff shield	2022 2023	1.68% 0.94%	1.31%	7.3% 3.5%	5.4%	2027	111.3%
Tariff shield 2022 2023	2022 2023	2.85% 1.00%	1.92%	6.5% 3.4%	4.9%	2027	112.6%
Faster wage indexation & tariff shield	2022 2023	2.38% 0.77%	1.57%	7.4% 4.1%	5.7%	2027	114.1%
Faster wage indexation & No tariff shield	2022 2023	1.35% 0.70%	1.02%	7.9% 4.1%	6.0%	2027	112.8%

Table 5: Strong Wage Indexation Accompanying Tariff Shield

Table 5 indicates that inflation rises significantly when faster indexation of nominal wages to prices accompanies a tariff shield.[33] This high inflation, reaching 7.4% in 2022, benefits real hourly wages, but leads to a notable reduction in employment. Despite the positive impact on real hourly wages, the negative effect on employment outweighs the impact, resulting in a decrease in household purchasing power. Consequently, this measure is less effective for growth, which declines by $(1.92 - 1.57) \times 2 = 0.7$ pp over two years compared to the reference scenario with a tariff shield in 2022 and 2023. This growth slowdown also affects government revenues, causing the debt-to-GDP ratio to increase by 1.5 points compared to the scenario with a tariff shield in 2022 and 2023.

If faster indexation of wages to prices were implemented, the pressure on labor costs would exacerbate the decline in economic activity, especially in a more inflationary context. This finding demonstrates that stronger indexation amplifies both the recessive effect of the energy shock and its inflationary impact. Moreover, Figure 6 shows that the redistributive effects of faster wage indexing are minimal, resulting in inequality remaining at the same level as the benchmark.

[32]The parameter $\kappa_w = 0.1$ is linked to a Calvo model by $\psi_W = \frac{\theta(\varepsilon-1)}{(1-\theta)(1-\beta\theta)}$ and $\kappa_w = \frac{\varepsilon}{\psi_W}$, where θ is the probability of not switching wages. Our calibrations for $\{\mu_w, \beta, \kappa_w\}$ lead to $\psi_P = 110$ and $\theta \approx 0.74375$ implying that 30% of wages do not change over a year. When the wage indexation is modified, we set $\kappa_w = 0.5$, which leads to $\psi_P = 22$ and $\theta \approx 0.5175$ implying that only 7% of wages do not change over the year.

[33]In the Appendix K, the complete description of the quarterly path of the aggregates is presented.

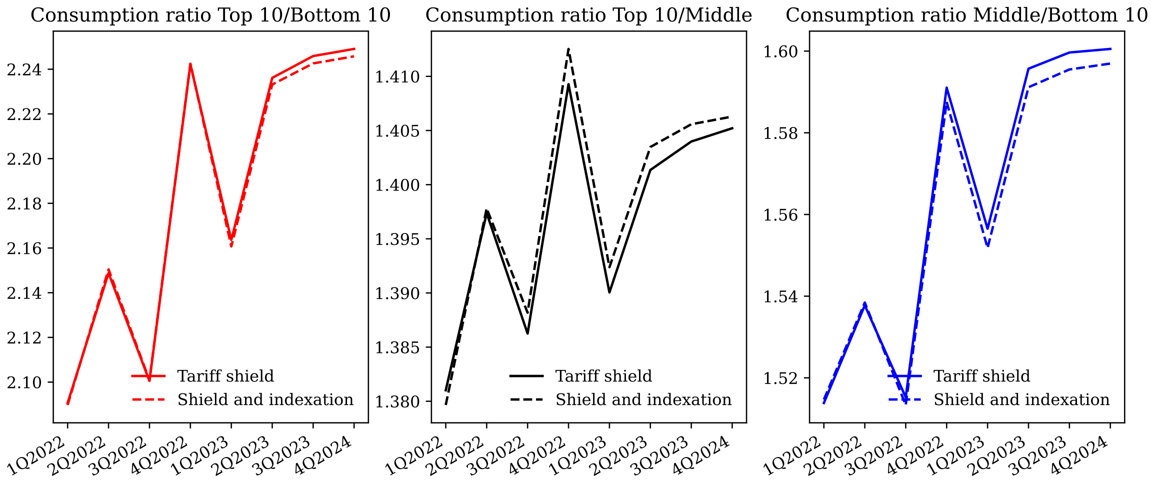


Figure 6: Dynamics of Inequalities When a Strong Wage Indexation Accompanied Tariff Shield

5.4 On the effectiveness of a redistributive demand policy

An alternative policy involves boosting the demand by redistributing transfers to households. In this approach, we suggest replacing the tariff shield with a universal transfer for all households, which represents a larger share of the budget for the most disadvantaged households. This transfer specifically targeted households to cover their essential energy-consumption expenses. Consequently, we must calibrate the portion of consumption that the government considers incompressible. To implement this, we assume that the government evaluates incompressible consumption for all households as 20% of the total energy consumption of the average household. The budgetary cost of this measure is equivalent to 25% of that induced by the tariff shield. This policy is inherently redistributive because the share of incompressible energy consumption in the total energy consumption varies across income deciles, ranging from 31% for individuals in the first decile to 14% for those in the tenth decile.[34] Low-income households exhibit the lowest price elasticity with respect to energy, indicating that they have less flexibility in offsetting the impact of energy price shocks on consumption (see Figure 1). As shown in Table 6, this policy is less effective in supporting growth: $(1.92 - 1.55) \times 2 = 0.74$ percentage points of growth are lost over two years.[35] Additionally, it is

[34]The share of incompressible 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. These proportions have been computed from the INSEE's "Household Budget" survey data.

[35]In Appendix L, the complete description of the quarterly path of the aggregates is presented.

		GDP		Inflation			$\frac{\text{Debt}}{\text{GDP}}$	
No tariff shield	2022	1.68%	1.31%	7.3%	5.4%	2027	111.3%
	2023	0.94%		3.5%			
Tariff shield 2022 2023	2022	2.85%	1.92%	6.5%	4.9%	2027	112.6%
	2023	1.00%		3.4%			
Subsidies to incompressible consumption	2022	1.97%	1.55%	7.5%	5.9%	2027	116.1%
	2023	1.13%		4.4%			
Targeted subsidies to lowest income households	2022	2.31%	1.90%	7.6%	6.0%	2027	114.3%
	2023	1.45%		4.5%			

Table 6: Redistributive Demand Policy

significantly more inflationary because it directly stimulates demand, thereby activating the price-wage spiral more strongly. This high inflation prompts the ECB to sharply increase its interest rate. Consequently, despite having a lower fiscal cost in absolute terms, the combination of weak growth and higher interest rates results in an increased debt burden, leading to a surge in the debt-to-GDP ratio compared with the tariff shield scenario.

However, this redistributive demand policy has led to a greater reduction in inequality. With this transfer targeted at incompressible energy consumption, the consumption of T10, which was 2.05 times higher than that of B10 in 1Q2022, now stands at only 2.12 in 4Q2023 (a small increase of 3.4% compared to 7% with the tariff shield). The increase in the consumption ratio of the T10 group compared to that of the middle-income group is almost identical to that with a tariff shield. The ratio of middle-income group consumption compared to that of B10 drops from 1.60 in 4Q2023 to 1.52 (5.25% reduction). This larger reduction in inequality can be explained by the significantly higher MPC of low-income households, larger share of energy in their consumption baskets, and lower price elasticity (see Figure 1).

However, this demand policy redistributes the same transfers to all households, whereas the highest-income households have lower MPC (see Figure 1).[36] Therefore, it may be preferable to target all transfers to modest households. We consider an alternative that targets transfers to households with income in the lowest 30% of the distribution. These transfers are calibrated to be two times larger than the previous ones; therefore, for an ex-ante budgetary cost, they are 40% lower. As shown in Table 6, these "targeted subsidies" to lowest-income households generate the same GDP growth as the tariff shield. However, this policy induces larger inflation and higher public debt than

[36] Appendix M shows that IRFs of consumption by income levels are different.

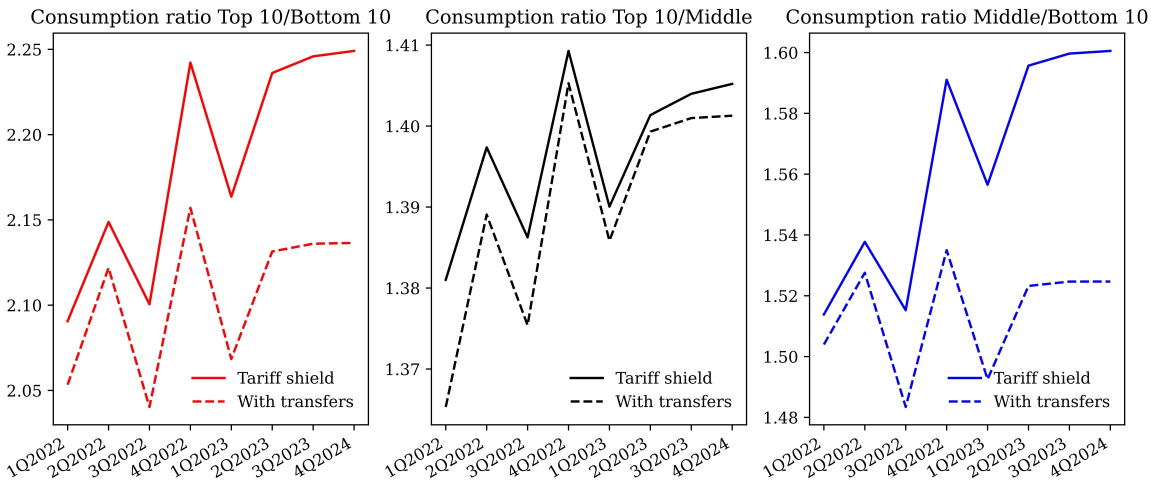


Figure 7: Dynamics of Inequalities: A Redistributive Demand Policy

tariff shields. By strongly stimulating demand, this policy adds to the inflationary tensions induced by energy shocks. This leads to a significant increase in interest rates, resulting in a higher financial cost of public debt. Hence, although the ex-ante cost is lower than the tariff shield (only 30% of households perceive a transfer of an amount twice as large as their incompressible consumption), the effective cost of this targeted demand policy is higher because its strong inflationary effects induce a steep rise in interest rates. Therefore, although specific transfers may lead to the same GDP growth as the tariff shield, they incur significantly higher costs in terms of inflation and public debt. Therefore, tariff shields seem to be better designed to fight the recessionary effects of rising energy prices.

6 Robustness

In Section 5, we demonstrated that the tariff shield supports economic activity while mitigating inflation and reducing inequality at a cost equivalent to a 1.3 pp increase in the debt-to-GDP ratio. Are the findings robust? This section presents robustness analyses of the monetary and fiscal policies that may change during the energy crisis.[37]

[37]These adjustments in monetary and fiscal policy are unanticipated and take effect concurrently with the tariff shield. Therefore, these scenarios do not necessitate model re-estimation, but they do entail changes to the model multipliers.

6.1 Monetary Policy

In our benchmark, the ECB responds to the European inflation by considering only French inflation, as the rest of the European inflation correlates with it. Consequently, the ECB supported the implementation of the French tariff shield by reducing interest rates. However, this could result in an overestimation of the effectiveness of the tariff shield because France is the sole country implementing a tariff shield. As other Euro area countries have not adopted such anti-inflationary policies, their inflation rates are likely to increase because of energy price inflation. Consequently, the ECB might raise its interest rate, contrary to what occurs in our benchmark. This argument also applies to evaluating transfers to low-income households. However, in this case, an adjustment of the ECB interest rate would lead to an underestimation of its effectiveness because this policy is inflationary.

To isolate the dynamics of the ECB interest rate (i_t) from policy decisions in France, we assume that i_t follows the equilibrium values determined in the model without a tariff shield. This trajectory of i_t reflects the equilibrium in which no country implements a tariff shield. For the equilibrium with policy to align with the predetermined path of i_t, we estimate the occurrence of monetary policy shocks (ε_t) to ensure consistency. Consequently, we assess the impact of the policy implemented in France by specifying that it does not affect the ECB interest rates.

		GDP		Inflation			$\frac{\text{Debt}}{\text{GDP}}$
No tariff shield	2022	1.68%	1.31%	7.3%	5.4%	2027	111.3%
	2023	0.94%		3.5%			
Monetary policy: benchmark Taylor rule							
Tariff shield 2022 2023	2022	2.85%	1.92%	6.5%	4.9%	2027	112.6%
	2023	1.00%		3.4%			
Targeted subsidies to lowest income households	2022	2.31%	1.90%	7.6%	6.0%	2027	114.3%
	2023	1.45%		4.5%			
Neutral monetary policy: Taylor rule independent of French policies							
Tariff shield 2022 2023	2022	2.47%	1.78%	6.2%	4.5%	2027	112.9%
	2023	1.10%		2.9%			
Targeted subsidies to lowest income households	2022	2.50%	2.25%	7.7%	6.6%	2027	108.3%
	2023	2.00%		5.5%			

Table 7: Robustness to Alternative Monetary Policies

The results are presented in Table 7. By fixing the nominal rate on a trajectory aimed at fighting high European inflation—without considering the disinflation achieved in France due to the tariff shield—shows an average loss of 0.14 pp in growth over the period 2022-2023, with the inflation rate being higher by 0.4 pp. This loss of growth primarily occurred in 2022, as the interest rates in this scenario were higher than those in our benchmark, prompting intertemporal substitution of consumption. These macroeconomic outcomes do not favor a reduction in public debt, which increases by 0.3 pp compared to our benchmark evaluation of the tariff shield.

This hypothetical interest rate path, independent of French policy, is favorable for inflationary policies that could be implemented in France. This is the case for demand policies, such as transfers targeted at low-income individuals. As their inflationary effects are not offset by an increase in ECB rates, the gains in growth are higher by 0.35 pp on average per year, and inflation is higher by 0.6 pp relative to our benchmark evaluation. These changes in the aggregates make it easier to achieve a low debt-to-GDP ratio, which is even lower than that without a tariff shield.

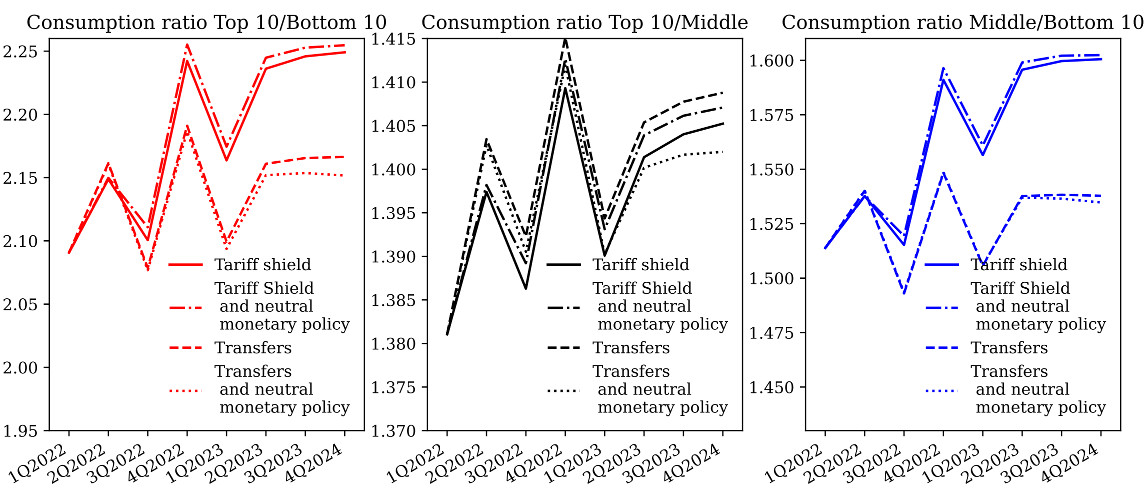


Figure 8: Dynamics of Inequalities With Lower Inflation Correlation and Tariff Shield

Figure 8 shows that a Taylor rule unaffected by the policies implemented in France provides even greater advantages for transfers in fighting inequalities. In this scenario, transfers are more expansionary (supporting low-income individuals) and lead to a more substantial reduction in the real interest rate (lowering the financial income of the wealthiest individuals).

In summary, during the tariff shield period, when the ECB followed European inflation and diverged from French inflation, the effectiveness of the tariff shield policy was likely weaker for output growth, but stronger for inflation. Conversely, the effectiveness of a transfer policy would have been affected oppositely, being stronger in terms of production, but weaker in terms of inflation. Two lessons can be drawn from these results, which extend beyond the scope of the present model but are worth highlighting. First, a coordinated policy based on tariff shields at the European level is likely to be more effective than a coordinated policy for transfers. Second, a unilateral tariff shield was less noncooperative than a transfer policy that induced inflation without internalizing the overall inflationary costs for the Euro area.

6.2 Fiscal Policy

In our benchmark scenario, the tariff shield is not financed by any contemporaneous tax and leads to an increase in public debt, which is consistent with French policy. To assess the robustness of the tariff shield, this section examines the case in which it is financed contemporaneously by payroll ($\Delta\tau_l$) or consumption ($\Delta\tau_c$) taxes, which are distortionary. We introduce the following budgetary adjustments: $\Delta\tau_l wN = \Xi s_H p_E(Y_E + (1+\tau_c)\underline{c}E)$ or $\Delta\tau_c C = \Xi s_H p_E(YE + (1+\tau_c)\underline{c}_E)$, where Ξ represents the tariff shield share financed by an increase in one of the tax rates. Similar to the tariff shields, these tax increases were transitory and unanticipated. We set $\Xi = 1$ to introduce the largest distortion, which implies no debt financing.

		GDP		Inflation			$\frac{\text{Debt}}{\text{GDP}}$
No tariff shield	2022	1.68%	1.31%	7.3%	5.4%	2027	111.3%
	2023	0.94%		3.5%			
Tariff shield 2022 2023	2022	2.85%	1.92%	6.5%	4.9%	2027	112.6%
	2023	1.00%		3.4%			
Tariff shield in 2022 & 2023 financed by distorsive taxation							
Payroll tax ($\Delta\tau_l$)	2022	2.46%	1.64%	6.7%	5.2%	2027	111.1%
	2023	0.82%		3.7%			
Consumption tax ($\Delta\tau_c$)	2022	1.85%	1.48%	6.0%	4.4%	2027	111.0%
	2023	1.11%		2.8%			

Table 8: Robustness to Alternative Fiscal Policies

Table 8 shows that the introduction of this budgetary adjustment, which increased tax distortions, diminished the effectiveness of tariff shields in terms of GDP growth. However, even if the tariff shield is entirely financed by a distorting tax (either payroll or consumption tax), it remains effective. The dampening effect of tariff shields on inflation continues to have positive spillover effects across the economy.

Taxation on labor is less detrimental to growth because it has a broader base, which means that it can be increased to a lesser extent to achieve the same budgetary benefit.[38] The increase in

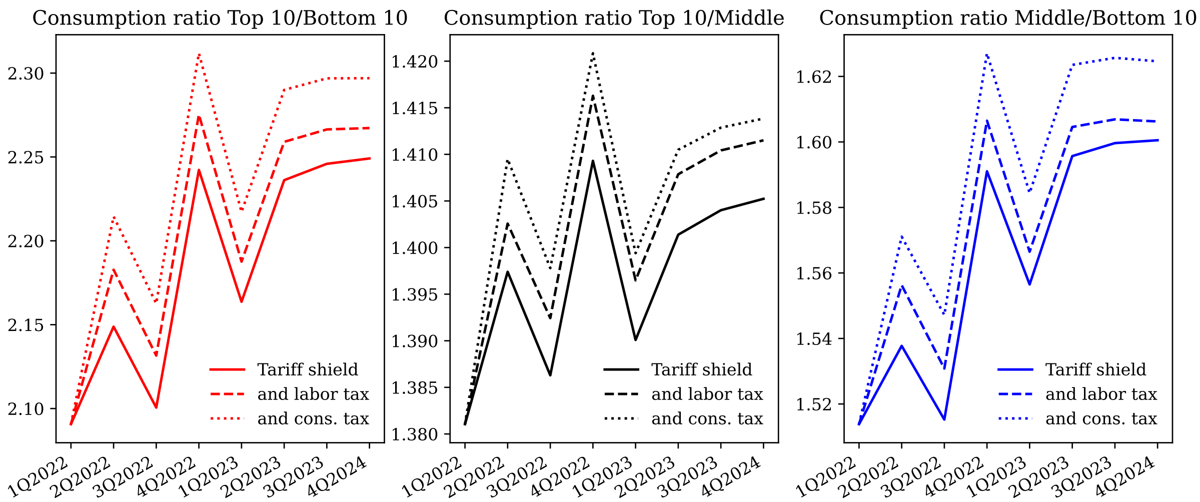


Figure 9: Dynamics of Inequalities With Alternative Tax Adjustments

payroll tax rates is inflationary because it constitutes a negative supply shock, leading to a reduction in labor supply, whereas consumption tax reduces inflation because it works as a demand shock. Table 8 illustrates that higher GDP growth with payroll tax adjustments than with consumption tax adjustments also results in higher inflation in the former scenario. However, the debt-to-GDP ratio is slightly lower than without the tariff shield, indicating that the subsequent stronger GDP growth provides additional dividends to a tax-financed tariff shield.

Figure 9 illustrates that an increase in tax rates exacerbates inequalities because they distort labor supply, which is the primary source of income for the poorest households. Consequently, even if tax adjustments diminish the efficiency of the tariff shield, they remain powerful tools for increasing the GDP growth.

[38]Indeed, in our simplified model, output is primarily generated through labor, and it is divided into private consumption and public consumption. Importantly, public consumption is not included in the consumption tax base.

7 Conclusion

This article presents a method for conducting "real-time" policy evaluations. This approach enables the comparison of alternative policies that alter the structure of the economy during a specific period. A benchmark policy is used for identifying the shocks that shape the relevant environment for evaluating the policies under study.

Using this method, we show that the tariff shield implemented in France from 2022 to 2023 represents a favorable compromise to mitigate inflation, support growth, and dampen the increase in inequality. Its fiscal cost would amount to a 1.3 pp increase in the debt-to-GDP ratio by 2027. This policy appears to explain why France experienced lower inflation than its European counterparts. Additionally, we show that supporting this policy through wage indexation is not advisable. Finally, the tariff shield proves to be more effective than direct transfers to households (demand policy) because it provides greater support for employment by containing the rise in labor costs.

It's worth noting that our study does not address the "free rider" problem highlighted by Auclert et al. (2023a) and Bayer et al. (2023): if all countries had implemented a tariff shield, the price of energy could have risen even further, potentially cancelling out the effect of the policy. However, in this crisis, which appears to have been a one-shot game, France was the first and quickest to react. This opportunistic response may provide the French economy with a temporary competitive advantage, even if the ECB follows Euro area inflation that diverges from French inflation during the crisis.

An important limitation of the tariff shield is its environmental cost. By subsidizing energy, it fails to encourage energy-saving behaviors. The rise in energy prices and its repercussions on the purchasing power of households, especially the poorest, raise questions about the acceptability of environmental policies. Our framework can be used to assess policies aimed at mitigating the adverse effects of a carbon tax on efficiency and inequalities, as shown in Langot et al. (2023).

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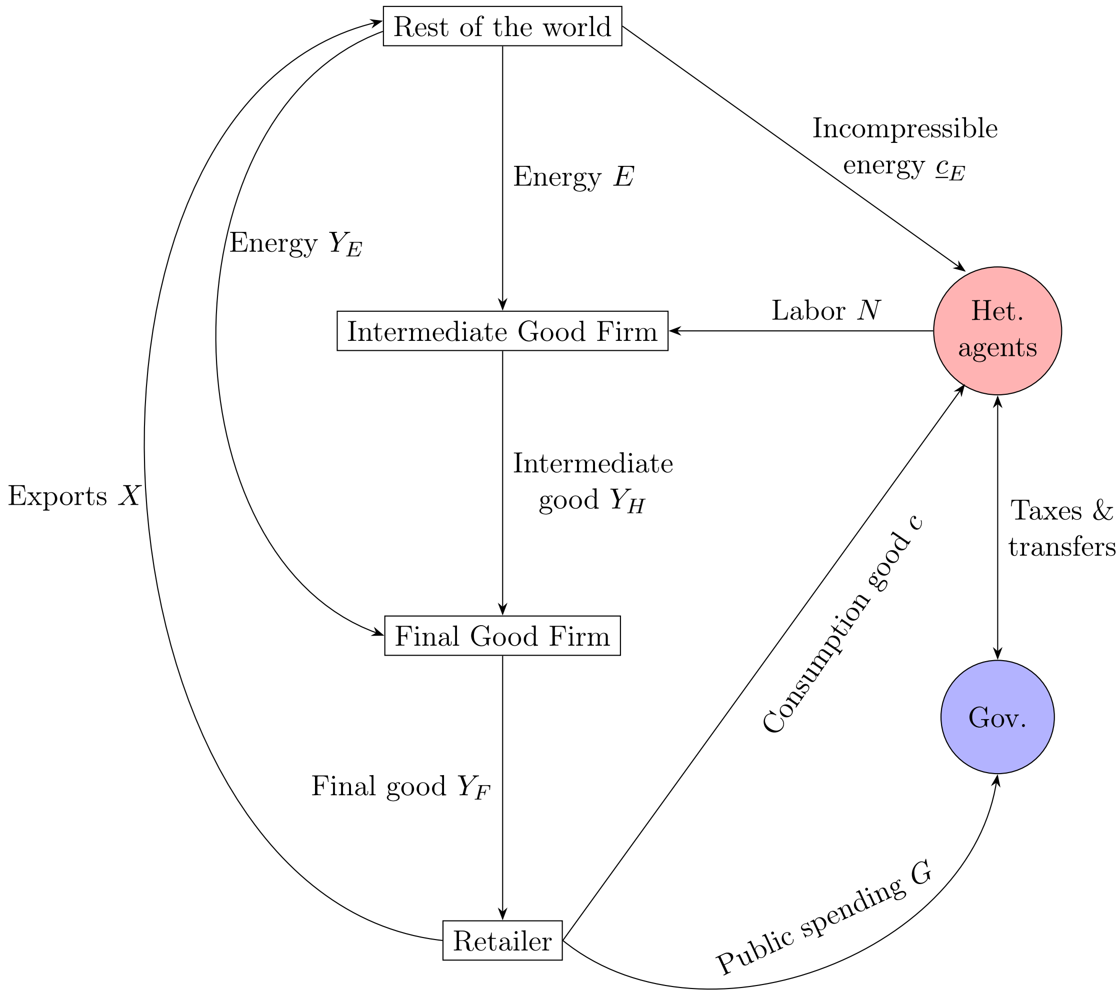
A Model's structure



B The tariff shield

B.1 Model's calibration

We calibrate the total expenditures in energy as $\frac{p_E \mathcal{E}(p_E)}{Y} = 3.18\%$ where the GDP= Y =€2,639.1 billion in 2022 and $\mathcal{E}(p_E)$ is the quantity of consumed energy that depends on price with $\mathcal{E}'(p_E) < 0$. Hence, we have $p_E \mathcal{E}(p_E)$ =€83.9234≈€84 billion. The cost of the "tariff shield" is evaluated at €85 billion by the government from October 2021 to December 2023 (27 months), i.e. €37 billion per year (see Sénat (2023)). The set of interventions included in the tariff shield is given in Table 9.

(1) Tariffs of electricity	(2) Tax on elect.	(3) Nuclear elect.	(4) Tariffs of gas	(5) Energy vouchers	(6) Damper on elect.	(7) Task "Economy"	(8) Tariffs of fuel	(9) Univ.	(10) Total
24.7	18	8	10	2.9	3.6	7.2	10.4	0.3	85.1

Table 9: Tariff shield (billions of €) — October 2021 to December 2023. Source: Sénat (2023).

The subsidies perceived by the households (columns (1)-(5) & (8) of the Table 9) represent 87% of the total, i.e. €32 billion per year.

After the energy crisis, the energy price changes because p_E increases by dp_E, but also because the tariff shield s_H can be implemented. At the new price $\widehat{p}_E$, the energy expenditures $\widehat{p}_E \mathcal{E}(\widehat{p}_E)$ can be approximated around $p_E \mathcal{E}(p_E)$ by $\widehat{p}_E \mathcal{E}(\widehat{p}_E) \approx p_E \mathcal{E}(p_E) \left[1 + (1+\varepsilon)\frac{\widehat{p}_E - p_E}{p_E}\right]$ where we denote $\varepsilon = \mathcal{E}'(p_E)\frac{P_E}{\mathcal{E}(p_E)}$. After the crisis, the energy price is $\widehat{p}_E \equiv p_E + dp_E$ without a tariff shield, implying $\frac{\widehat{p}_E - p_E}{p_E} = \frac{dp_E}{p_E}$, or $\widehat{p}_E \equiv (1-s_H)(p_E + dp_E)$ with a tariff shield, implying $\frac{\widehat{p}_E - p_E}{p_E} = -s_H + (1-s_H)\frac{dp_E}{p_E}$. Therefore, the difference between the two "after crisis" scenarios (with and without policy) identifies the impact of the tariff shield. This gap $\frac{\Delta}{Y}$ (relative to GDP) is defined by

$$\frac{\Delta}{Y} \approx -s_H \frac{p_E \mathcal{E}}{Y}(1-\varepsilon)\left(1 + \frac{dp_E}{p_E}\right) \quad \Rightarrow \quad s_H \approx -\frac{\frac{\Delta}{Y}}{\frac{p_E \mathcal{E}}{Y}(1-\varepsilon)\left(1+\frac{dp_E}{p_E}\right)}$$

With $\frac{p_E \mathcal{E}}{Y} = 0.0318 \times 40\%$, where 40% is the share of energy used by the households, $\frac{\Delta}{Y} = \frac{-37}{2{,}639.1} \times 87\%$, where 87% is the share of the tariff shield targeted to households (sum of the columns (1)-(5) & (8) of Table 9 over the total cost) and $\frac{dp_E}{p_E} = \frac{180-50}{50} = 2.6$ (an increase from \$50 to \$180 per barrel from the middle of 2020 to middle of 2022), we obtain $s_H \approx 20\%$ with $\varepsilon = 0.05$.

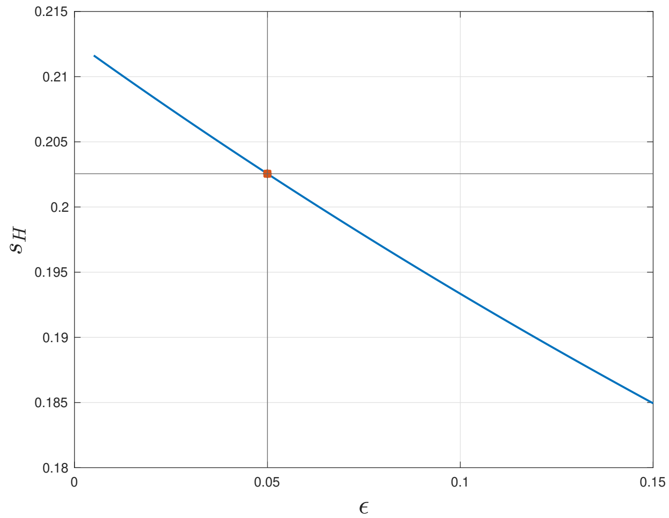


Figure 10: Calibration of the "tariff shield"

Figure 10 gives the sensitivity of s_H to the calibration for the price elasticity of energy demand. Even with the "conservative" value of 0.1 preferred by Bachmann et al. (2022), Baquee et al. (2022) and Langot et al. (2022), the value of s_H is still below 0.21.[39]

B.2 Implementation

We present the main features of the "tariff shield" components reported in Table 9. The key point is that these components were introduced on a discretionary basis, without prior planning and with numerous unanticipated changes in amounts, scope and duration.[40] This leads us to model it as a shock following a $AR(1)$ process. A forecast of its annual cost is provided for in the Finance Act, but for individuals, each quarter it represents a "fiscal" surprise. In what follows, we detail the set of measures contained in the "tariff shield" and highlight their unanticipated nature.

Tariffs of electricity. To mitigate the surge in electricity prices, the French government implemented a freeze on the escalation of regulated electricity sale prices. This freeze was enacted

[39] Labandeira et al. (2017) distinguish between short-run (within one year) and "long-run" (otherwise) elasticity estimates. For natural gas, they find an average short-run elasticity of -0.18 and a long-run elasticity of -0.684. For heating oil, the average short- and long-run estimates are -0.017 and -0.185, respectively. For energy in general, the estimates are similar with a short-run elasticity of -0.221 and a long-run elasticity of -0.584. In our analysis, which accounts for variations in the short run, we retain the value of -0.05, closer to the "short-run" elasticity estimates of Labandeira et al. (2017).

[40] In its report Sénat (2023), the "commission des finances" of the French Senate states that *"An initial assessment of the implementation of these measures reveals that they were conceived in a hurry and in an iterative way, even though they could have been better anticipated. The players involved are unanimous in regretting the hasty conditions that governed the design and implementation of the measures."*

through decrees, prohibiting any increase in the regulated electricity prices that the French Energy Regulatory Commission proposes each January, following the calculation methods outlined in the Energy Code. The gap between the non-frozen regulated price levels and the decreed frozen price levels is reimbursed to suppliers by the State as part of the energy public service charges. These measures were disclosed in the Finance Act, which is annually enacted in the fall. Consequently, economic agents were only made aware of the tariff shield for 2022 towards the end of 2021, with the Finance Act not committing to extend the scheme into future years. The tariff shield for 2023 was likewise only disclosed to economic agents at the end of 2022, upon the passing of the Finance Act. Therefore, the introduction of the electricity tariff shield resulted from two successive economic policy shocks, unanticipated by economic agents.

Tax on electricity. For both 2022 and 2023, the freeze on electricity tariffs was partially funded through a cut in the electricity excise duty. These decisions were enacted by decree and disclosed in the Finance Act exclusively for the current year, without a multi-year framework. Consequently, each of these decisions for 2022 and 2023 caught economic agents off guard.

Nuclear electricity. Since 2011, electricity suppliers have been granted regulated access to the energy produced by existing nuclear power plants. In 2022, the nuclear energy producer expanded the volume of regulated access to historical nuclear electricity by 20 terawatt-hours (TWh). This adjustment, applied across all electricity supply contracts, advantaged all consumers, encompassing both private individuals and businesses, extending well beyond those eligible for the shield. This decision was made spontaneously, without prior planning.

Tariffs on gas. The gas tariff shield is predicated on the freezing of regulated natural gas sales prices. The gap between these regulated prices and the unfrozen regulated price, reflective of the suppliers' average costs, is covered by the government and directly compensated to gas suppliers. This arrangement enables customers to benefit from a reduced supply price, which directly includes the government's assistance under the tariff shield, even for contracts under market offers (which account for 75% of consumers). The gas tariff shield was initially announced by the Prime Minister on October 21, 2021, and subsequently enacted into law on December 30, 2021. At its announcement, the gas tariff shield was intended to last until June 30, 2022. However, diverging from the initial timeline, the "gas" tariff shield was extended for the first time on June 25, 2022, until December 31, 2022. This extension represented a deviation in the scheme's duration that economic agents could not have foreseen, which is modeled as an unanticipated shock. Another unexpected turn occurred on December 30, 2022, with a further extension from January 1, 2023, to June 30, 2023, this time capping the rise in regulated tariffs to 15% incl. tax relative to the October 2021 price. Consequently, the application period and the scope of the gas tariff shield have been altered several times at discretion. Initially limited to customers on a regulated tariff offer, it was broadened to include all customers on a market offer contract, as well as sole building owners for primary residential use and co-ownership syndicates of such buildings, on August 17, 2022. This expansion of the tariff shield's scope, equally unforeseen, is also incorporated as a surprise in the model.

Energy vouchers. The energy voucher serves as a government subsidy for the lowest-income 20% of households, aiding them in paying their energy bills (electricity, natural gas, fuels such as wood or fuel oil) or funding energy renovation projects. It is allocated based on income and the composition of the household (individuals living under the same roof) as declared to the tax authorities. Introduced in 2018 to supplant social energy tariffs, the energy voucher has undergone several discretionary modifications amid the energy crisis, which are subsequently modeled as unanticipated shocks. These alterations encompass both the voucher's amount – with an initial additional sum of €100 declared in 2021 and a further increase of €200 announced in 2022 – and the criteria for income eligibility. In 2022, eligibility unexpectedly expanded to include the 3rd and 4th income deciles of households, granting them €100, and addressed expenditure specifically for households using domestic fuel or wood for heating. The "fuel oil voucher" targets the first five income deciles, providing a €200 grant for energy voucher recipients and 100 euros for others. Meanwhile, the "wood voucher" is designed for the first seven income deciles, offering an aid amounting to between €50 and €200, based on income, household size, and the type of wood fuel utilized.

Damper on electricity. The damper mechanism is intended for small and medium-sized businesses and public or semi-public sector entities that are not eligible for the electricity tariff shield scheme. Eligible entities benefit from a reduction in the price of their electricity supply equal to an amount in €/MWh corresponding to the difference between the contract electricity price and a reference price, up to a ceiling also expressed in €/MWh. Application of the electricity damper therefore reduces the bill of eligible customers, for half the volumes consumed, by the difference between the electricity price of their contract and the strike price of €180/MWh, capped at €320/MWh. The maximum annual subsidy under this scheme is €160/MWh. This scheme, due to come into effect on December 31, 2022, has also been subject to discretionary changes in response to demands from very small businesses, with bakers at the forefront. On February 3, 2023, an "over-amortizer" was introduced to guarantee an electricity price of €230/MWh for these very small businesses.

"Economy" Task. In the French government's budget, the task "Economy" brings together several budgetary instruments designed to promote employment, growth, business competitiveness, export development, competition and consumer protection. The funds allocated to this mission were used to set up an assistance mechanism designed to support the largest energy-consuming companies that are not eligible for the dampers. A first allocation of €1.5 billion was decided in April 2023, a second allocation of €1.5 billion in August 2022 and a third of €4 billion in November 2023. These allocations were not part of a multi-year program, but were made on a discretionary basis for each year and therefore could not be anticipated. Depending on the company's situation, the aid will be equal to a capped amount of between 30% and 70% of the company's sales over the period concerned. However, due to overly restrictive criteria and an overly complex procedure, these amounts of aid have not been fully distributed.

Tariffs on fuel. To respond to the price hike observed in the spring of 2022, a fuel price rebate of €0.15 (excluding tax) was implemented in March 2022. This fuel subsidy then underwent several modifications, each of which was decided independently, creating surprises for consumers who were unaware of the various changes in advance. This aid was initially scheduled to run from April to July 2022. It was then extended and even increased to €0.25 from September to November 2022, before being reduced to €0.0833 until the end of the year. All individuals were concerned by this general aid. The aid was paid directly to the operators responsible for supplying or releasing the fuels for consumption, and was then passed on by them to the end consumer in the form of prices. This non-targeted fuel rebate was replaced on January 1, 2023 by a €100 allowance targeted at low-income workers who use their private vehicles to commute to work. Once again, consumers were unaware of this decision until it was implemented.

University (Univ.). The university category corresponds to the specific aid scheme set up in 2022 to assist universities in covering their energy costs.

C Income, wealth and consumption distributions

Income inequalities. As in Bayer et al. (2023) and following the approach proposed by Castaneda et al. (1998), we calibrate the parameters governing individual labor income risk in our model to reproduce moments of the observed total income distribution. More precisely, we choose σ to minimize the difference between what the model predicts for Q75/Q50 ($\approx \frac{\text{D6-D7}}{\text{D4-D5}}$) and the observed values (see Table 10).

	Model		Data	
	Deciles	Deciles/Med	Deciles	Deciles/Med
Lower than D2	0.7066	0.7408	11025	0.5008
D2-D3	0.8570	0.8984	17195	0.7811
D4-D5	0.9538	1.0000	22015	1.0000
D6-D7	1.2341	1.2939	27785	1.2621
D8-D9	1.6788	1.7601	32540	1.4781
Greater than D9	2.3507	2.4645	49300	2.2394

Table 10: Income inequalities (see INSEE data)

We then obtain $\sigma \approx 0.5$, given the value of the persistence of the productivity shock estimated by Fonseca et al. (2023) on French panel data ($\rho = 0.966$).

	D1/D5	D2/D5	D3/D5	D4/D5	D6/D5	D7/D5	D8/D5	D9/D5	D10/D5	D10/D1
Data	0.6778	0.7703	0.8438	0.9517	1.1385	1.2216	1.3724	1.5078	2.0327	2.9990
Model	0.6741	0.7471	0.9140	0.9292	1.0892	1.1404	1.2310	1.3472	1.9949	2.9595

Table 11: Consumption inequalities (see INSEE data)

This calibration of σ also allows the consumption distribution generated by our model to be close to the one observed in the data (see Table 11). We are particularly attentive to consumption inequalities, because they are the closest measure of household welfare.

We consider that a higher calibration of σ than the one estimated with an $AR(1)$ process on individual panel data is not unrealistic because recent work on labor income has shown that the process generating their dynamics would be more complex than an $AR(1)$. Guvenen et al. (2021) underline that earnings growth rates are negatively skewed and exhibit excess kurtosis. Relative to a normal distribution, their results suggest that there are more individuals with small and large earnings changes, but fewer with medium-sized earnings changes. Moreover, the large earnings changes are often negative. Ferriere et al. (2023) show that a productivity process modeled as a Gaussian Mixture Autoregressive ($GMAR$) process can account for these facts. This process generates more extreme income values than what is possible to obtain with an $AR(1)$ process estimated on individual panel data. However, with a larger value for σ, some of the large dispersion contained in a complex model of labor income, such as a $GMAR$, can be approximated by the simple $AR(1)$ process used in our model.

Wealth inequalities. Another challenge for heterogeneous-agents models is to replicate the observed wealth inequalities (see, e.g., De Nardi and Fella (2017)). Since the work of Kaplan et al. (2018), it has been known that two-asset models are better suited to generate the large wealth inequalities observed in the U.S. Table 12 shows that our simple one-asset model can generate a wealth distribution not far from the one observed in France, which is, of course, less unequal than in the U.S.. The main issue is not the typical inability of the model to generate the large wealth share

	Model		Data	
	Deciles	Deciles/Med	Deciles	Deciles/Med
Lower than D2	0.0015	0.0008	2000	0.1921
D2-D3	0.2845	0.1430	5300	0.5091
D4-D5	1.9892	1.0000	10411	1.0000
D6-D7	6.1588	3.0961	15908	1.5280
D8-D9	7.7627	3.9024	28196	2.7083
Greater than D9	10.6023	5.3299	61751	5.9313

Table 12: Wealth inequalities (see INSEE data)

held by the richest individuals, but rather its incapacity to generate sufficient savings at the bottom of the distribution. This lack of saving incentive for the poorest can stem from the substantial French transfers targeted at workers beyond the median labor income, which are not conditioned to any eligibility criteria in our model, unlike the French tax-benefit system. The detailed modeling of the French tax and transfer system is highly complex, and we defer it to future research.

Consumption inequalities. To simplify the numerical resolution of the model, we compute the average consumption by labor productivity deciles. This approach is essential for generating the cyclical evolution of consumption inequalities, as it requires computing Impulse Response Functions (IRFs) for different levels of consumption. To ensure comparability of inequality measures across various policy counterfactuals, we define each consumption level relative to an exogenous state of the economy shared among all economies. A natural candidate for this is the labor productivity e at the time of the shock, which serves as a common state variable. In the model, the income process involves a distribution as shown in Table 13.

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 13: Definition of the earning groups

With this distribution, it possible to calculate the consumption of individuals whose labor income is among the lowest 1.5%, or among the lowest 10% and so on.

	D1/Med	Q1/Med	Q2/Med	Q3/Med	D10/D5	D10/D1
Conditionally to consumption	0.7340	0.9044	1.0956	1.3498	2.1723	2.9595
Conditionally to income	0.7347	0.9034	1.0966	1.2953	1.6245	2.2112

Table 14: Consumption inequalities when deciles are based on the distribution of consumption or income

The comparison between the two rows of Table 14 indicates that the differences between these two computation methods are small. It is noteworthy that the computation is contingent upon labor income being less unequal, especially at the top of the distribution, when wealth matters.

D French Data

D.1 Observed data

Data	Web access	Providers
Population	DBnomics code	Eurostat
GDP	DBnomics code	Eurostat
CPI	DBnomics code	INSEE
Enrergy price	DBnomics code	OECD
Government consumption	DBnomics code	Eurostat
Government transfers	DBnomics code	Eurostat
Public debt	DBnomics code	Eurostat

Table 15: Data sources

All the raw series of Table 15 are quarterly and range from 2Q1995 to 4Q2021. For the population, which is an annual series, we build a quarterly series by interpolation. All these series (with the exception of prices) are divided by the population to obtain per capita variables: $\{Y, \frac{b}{Y}, G, T\}$. The Consumer Price Index (CPI) series is monthly. It is quarterlyized using a moving average, from which we derive π. Finally, the energy price (P_E) is the crude oil price.

D.2 From government forecasts to quarterly data

	2021	2022	2023	2024	2025	2026	2027
Population (15-64)	41462267	41427249	41402466	41381174	41360167	41338765	41311515
GDP growth	6,8%	2.5%	1.4%	1.6%	1.7%	1.7%	1.8%
GDP share of G	25%	23.6%	23.1%	22.7%	22.3%	22%	22.4%
GDP share of T	21.2%	19.9%	19.4%	19.2%	19.1%	19.1%	18.5%
Debt-to-GDP	112.5%	111.9%	111.7%	112.8%	113.3%	113.2%	112.5%
Energy price	$71	$110	$98	$85	$85	$85	$85
CPI (inflation rate)	1.6%	4.5%	3.2%	1.9%	1.75%	1.75%	1.75%

Table 16: Government forecasts. Source: Financial Act

The government consumption (G) is the sum of "intermediate consumption" + "compensation of employees" + "social benefits in kind". The transfers (T) are "Social benefits in cash".

For GDP, CPI and energy price of the year τ, we compute the quarterly growth rates g^z_τ using the annual growth rates $g^z_{a,\tau}$ (forecasts of the GDP, CPI and energy price growth rates reported in

Table 16)[41], solving

$$(1+g^z_{a,\tau}) \times \sum_{q=1Q}^{4Q} Z_{q,\tau} = Z_{1Q,\tau+1} \times \left[1 + (1+g^z_\tau) + (1+g^z_\tau)^2 + (1+g^z_\tau)^3\right]$$

where Z = GDP, IPC, energy price. We constructed quarterly data for GDP, IPC, and energy prices over the periods 1Q2022 to 4Q2027 (see panels (a), (b), and (c) of Figure 11). To obtain quarterly series, we interpolated the GDP shares of G (government expenditure) and T (government transfers). Subsequently, using the quarterly GDP data, we derived quarterly data for G and T over the same periods (see panels (d) and (e) of Figure 11). Regarding the debt-to-GDP ratio, we simply performed quarterly interpolation to construct quarterly data for $\frac{b}{y}$ over the periods 1Q2022 to 4Q2027 (see panel (f) of Figure 11).

(a) GDP (b) GDP Price Index (c) Energy Price Index

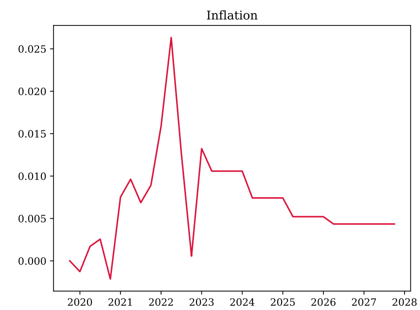
(d) Government expenditures (e) Government transfers (f) Debt over GDP

Figure 11: Raw Data: 4Q2019 = 100

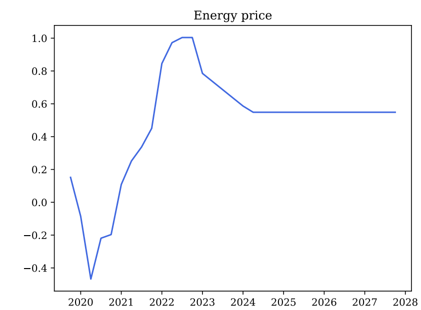
Data are stationarized by extracting a linear trend, with the exception of the debt-to-GDP ratio, for which only the average over the sample is retrieved (see Figure 12).

[41]For the energy price, we deduce the annual growth rate from forecasts of the data in level.

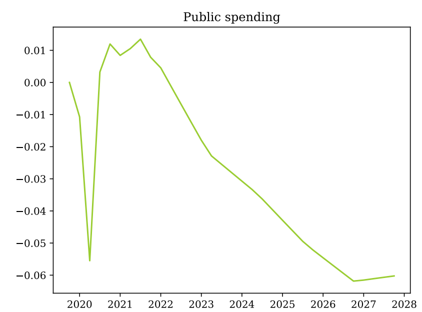
(a) $\frac{GDP_t}{1.0032^t}\frac{1}{100} - 1$



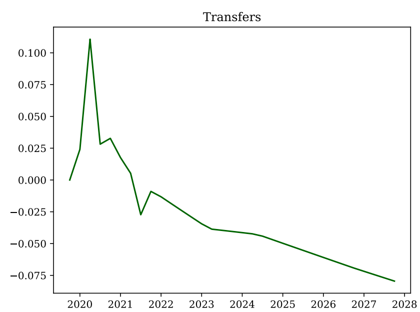
(b) $\frac{P_t - P_{t-1}}{P_{t-1}}$



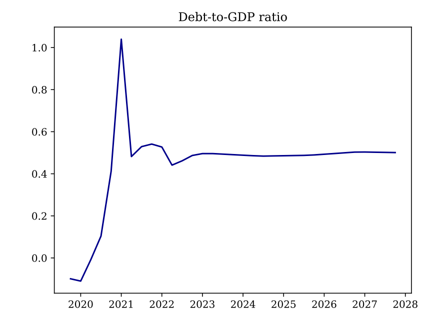
(c) $\frac{\text{Energy Price Index}_t - 86.819}{86.819}$



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



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



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

Figure 12: Stationnarized French Data: 2019 Q4 = 0

E Estimation of the exogenous shocks processes

The persistence ρ and the standard deviation σ of the shock processes are estimated using a Bayesian procedure: based on a Metropolis-Hastings algorithm, we draw one million draws. The first half of accepted draws were burned in to correct for possible mischoice of the starting point.

The prior distributions considered are reported in Table 17. For energy prices (p_E), government spending (G) and transfers (T), our HANK model simply replicates the exogenous input series. Consequently, guesses for the values of these parameters can be obtained by estimating an $AR(1)$ on the time series $\{p_E, G, T\}$. These estimates are used as information to define the priors of these shocks. The remaining priors for $\{\vartheta, \mu, \beta\}$ are assumed to follow beta distributions for the persistence and inverse-gamma distributions for the standard deviation, as usual in the literature.

Shock			**Prior**	**Mode**	**Std**	**95% CI**
Energy price	p_E	ρ	$\mathcal{N}(0.89, 0.05)$	0.956306	0.015542	[0.928103, 0.979286]
		σ	$\mathcal{N}(0.13, 0.07)$	0.168543	0.012100	[0.149946, 0.189320]
Government spending	G	ρ	$\mathcal{N}(0.73, 0.09)$	0.966911	0.015604	[0.934831, 0.986524]
		σ	$\mathcal{N}(0.004, 0.003)$	0.003563	0.000315	[0.003200, 0.004221]
Transfers	T	ρ	$\mathcal{N}(0.81, 0.07)$	0.907994	0.030241	[0.850255, 0.953381]
		σ	$\mathcal{N}(0.005, 0.006)$	0.005199	0.000422	[0.004576, 0.005950]
Measurement error	ϑ	ρ	$\beta(0.8, 0.05)$	0.937477	0.004867	[0.928861, 0.944730]
		σ	$inv\Gamma(3.0, 1.0)$	0.688678	0.042471	[0.666099, 0.795908]
Price markup	μ	ρ	$\beta(0.8, 0.05)$	0.746349	0.039882	[0.680943, 0.812585]
		σ	$inv\Gamma(0.05, 1.0)$	1.517267	0.105297	[1.346353, 1.690274]
Preference	β	ρ	$\beta(0.8, 0.05)$	0.938043	0.012706	[0.916814, 0.959411]
		σ	$inv\Gamma(0.05, 1.0)$	0.068144	0.010359	[0.048737, 0.083068]

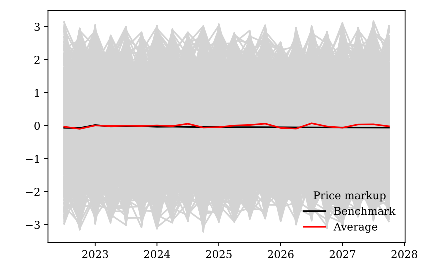
Table 17: Bayesian estimation results of the parameters of the $AR(1)$ processes

Because our model is not formulated in a linear state-space framework, the Kalman filter cannot be used to evaluate the log-likelihood. Instead, following the approach of Auclert et al. (2021), the log-likelihood of our model is computed using the covariance matrix linking the model's variables. This covariance matrix is based on the Jacobian of the model, which can be obtained using the sequence space method. It's worth noting that since we do not estimate structural parameters that affect the Jacobian of the system, the same Jacobian can be reused throughout the entire estimation process, resulting in computational time savings.

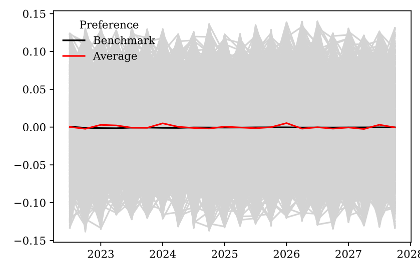
Therefore, our estimation relies on the linearized model around its steady state. Estimating based on the nonlinear model could yield different results, especially if strong nonlinearities exist in the considered regions of parameter space. However, comparing the linear and nonlinear Impulse Response Functions (IRFs) of our model (see Appendix G), it appears that these nonlinearities are not particularly strong. This suggests that a linear approximation is reasonable and computationally efficient for estimation. Indeed, estimations based on the nonlinear version of a HANK model are still in their early stages. To the best of our knowledge, Kase et al. (2023) are currently the only ones doing this. Their approach relies on a neural network particle filter, treating the model's parameters as inputs to the neural networks. This method involves: *(i)* training the neural network that maps input parameters to policy functions (as well as an additional neural network that ensures an equilibrium exists for a given parameters set), *(ii)* training the particle filter neural network that maps the parameters to the likelihood, and *(iii)* running the Bayesian estimation. Once the three neural networks are trained, the Bayesian estimation incurs almost no cost (1ms per draw in Kase et al. (2023)'s example) since each draw does not require solving the model again (particularly its fully nonlinear version). However, training neural networks is computationally expensive. Therefore, we leave this for future research where the nonlinear features of the model may be more significant.

F Testing the stability of the processes driving exogenous variables

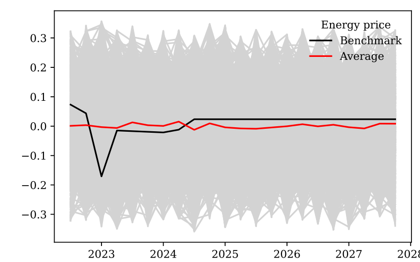
In Figure 13, we present the estimated values of each innovation used to align the time series of government forecasts (black line). Subsequently, we examine whether these estimated realizations fall within the confidence interval of the innovations for the processes driving these exogenous variables. The red line depicts the mean of the distribution of these innovations, and the gray cloud represents the 95% confidence band.



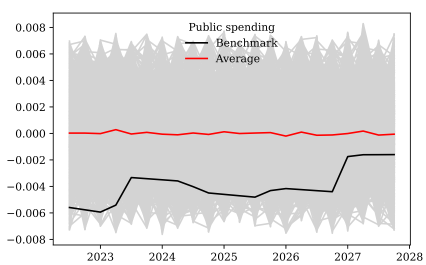
(a) Markup μ



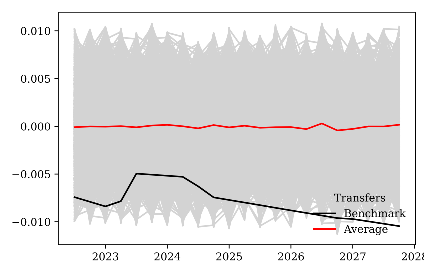
(b) Preference β



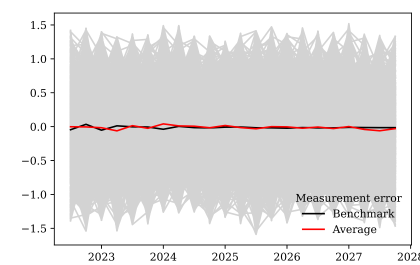
(c) Energy price P_E



(d) Government spending G



(e) Government transfers T



(f) Measurement error ϑ

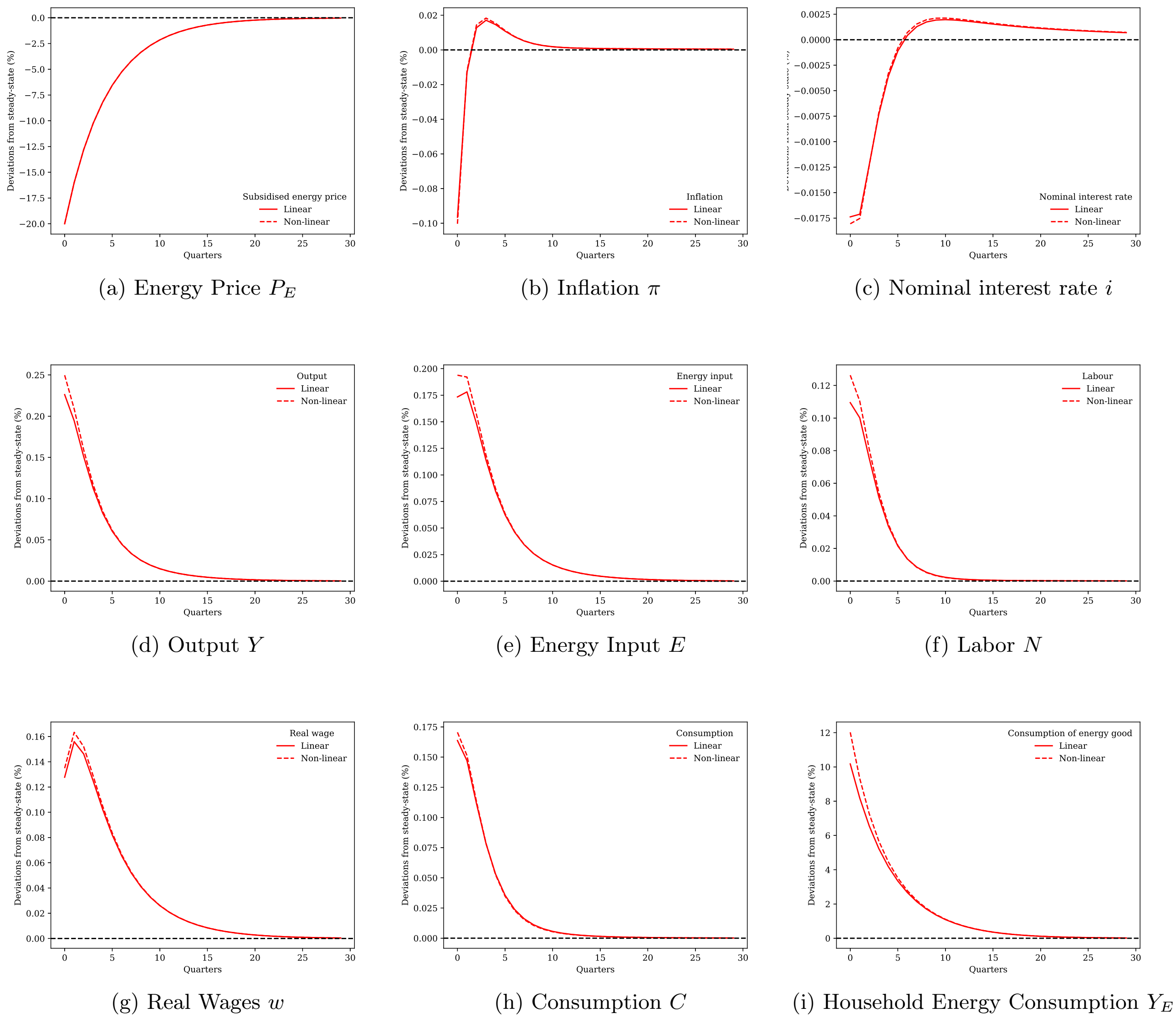
Figure 13: Impulse Responses Functions: Only tariff shield

All the estimated innovations used to align the government forecasts fall within their respective confidence bands. This suggests that the policy rules of the government, summarized by $\rho^G, \rho^T, \sigma^G, \sigma^T$, are stable. In other words, the new information on government policy contained in the Finance Act supports the view that the government's policy rule will not change. Thus, our estimation is not biased by the Lucas (1976) critique.

Finally, these results indirectly indicate that the stationarity of the time series used for model estimation cannot be rejected. Indeed, they suggest that stationary processes for the model's shocks enable the generation of the observed series, given that they were made stationary.

G Non-linear IRFs

As the size of the tariff shield shock is not so large, the gaps between a linear and a non-linear approximation of the model dynamic remain small (see Figure 14).



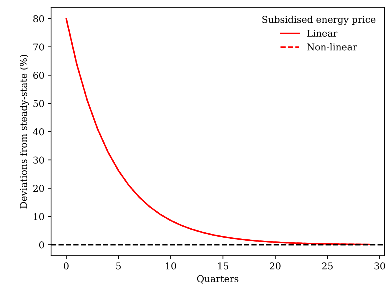
(a) Energy Price P_E (b) Inflation π (c) Nominal interest rate i

(d) Output Y (e) Energy Input E (f) Labor N

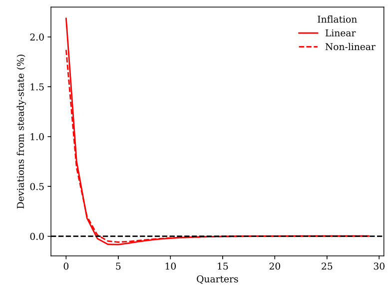
(g) Real Wages w (h) Consumption C (i) Household Energy Consumption Y_E

Figure 14: Impulse Responses Functions: Only tariff shield

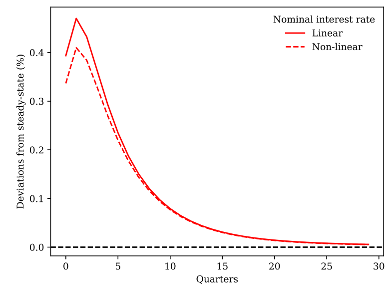
Even with a larger shock, namely the energy shock accompanied by the tariff shield, the gaps between the linear and the non-linear approximations of the model dynamic are still small, except for the energy used by firms or consumed by households (see Figure 15). Nevertheless, as the share of energy in the GDP is relatively small, these gaps in energy dynamics seem to be not of first order.



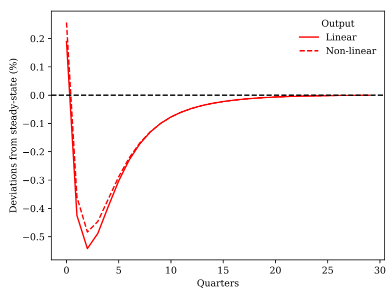
(a) Energy Price P_E



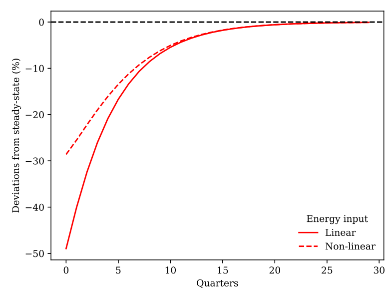
(b) Inflation π



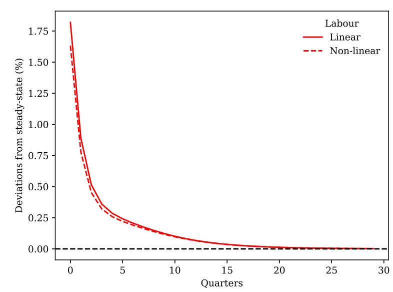
(c) Nominal interest rate i



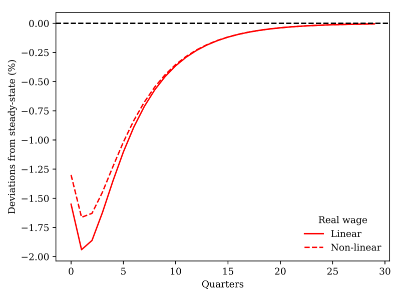
(d) Output Y



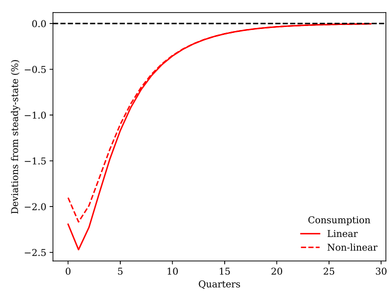
(e) Energy Input E



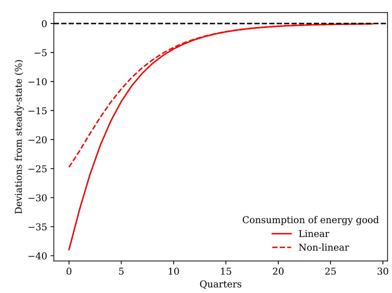
(f) Labor N



(g) Real Wages w



(h) Consumption C



(i) Household Energy Consumption Y_E

Figure 15: Impulse Responses Functions: Energy price shock and tariff shield

H Shock decomposition

		2022				2023				2024	2025	2026	2027
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	2Q	2Q	2Q	2Q
y	β	0.83	0.11	0.04	0.12	1.24	3.87	4.08	4.19	7.36	2.75	1.24	1.09
	μ	42.09	32.85	34.17	38.80	26.51	22.62	19.92	17.25	27.00	45.77	52.91	59.30
	ϑ	0.41	0.45	0.16	0.08	0.61	0.12	0.11	0.17	0.74	0.58	1.24	0.94
	G	0.01	0.15	0.46	0.84	2.01	3.69	4.84	6.38	8.92	11.74	12.72	10.81
	T	0.27	0.23	0.23	0.25	0.44	0.65	0.66	0.70	0.72	0.92	1.01	1.09
	p_E	56.39	64.11	63.05	58.31	67.44	67.00	68.01	68.67	55.16	38.22	30.88	26.77
	s_H	0.00	2.11	1.90	1.61	1.75	2.06	2.37	2.65	0.10	0.00	0.00	0.00
π	β	0.54	0.11	0.57	0.03	3.87	24.78	23.49	23.51	25.90	10.96	7.48	7.22
	μ	29.29	9.10	20.20	32.82	69.36	4.95	0.05	0.03	21.94	28.35	27.71	28.24
	ϑ	0.02	0.18	0.25	0.04	8.71	4.66	3.43	3.72	7.06	5.35	10.55	11.91
	G	0.00	0.04	0.26	0.75	9.46	16.80	13.93	13.76	9.58	8.25	9.93	8.54
	T	0.07	0.18	0.39	0.73	7.37	11.59	8.91	8.17	4.96	4.10	5.42	6.81
	p_E	70.08	89.66	78.17	65.61	1.12	37.17	50.18	50.81	30.13	42.99	38.92	37.28
	s_H	0.00	0.73	0.14	0.02	0.10	0.05	0.01	0.00	0.44	0.00	0.00	0.00
$\frac{b}{y}$	β	21.06	11.69	13.70	8.01	1.76	2.20	6.75	9.52	13.89	9.52	4.54	2.24
	μ	28.78	28.25	28.34	27.86	24.45	8.11	1.46	0.02	0.52	2.78	5.31	6.76
	ϑ	9.48	13.10	14.29	29.20	54.64	71.63	64.67	54.34	43.25	48.70	54.03	58.20
	G	0.35	0.01	0.14	0.85	3.38	3.80	2.10	0.90	0.02	0.62	2.34	4.32
	T	7.84	8.27	9.09	10.04	14.54	7.31	1.77	0.07	1.08	5.34	8.70	10.35
	p_E	32.48	38.56	34.41	24.05	1.07	6.52	22.66	34.44	40.35	32.67	24.92	18.05
	s_H	0.00	0.11	0.03	0.00	0.16	0.41	0.60	0.70	0.87	0.37	0.17	0.08

Table 18: Variance decomposition. For each variable $\{y, \pi, \frac{b}{y}\}$ and each period, the table provides the share deviation from the steady state explained by each shock $\{\beta, \mu, \vartheta, G, T, P_E s_H\}$

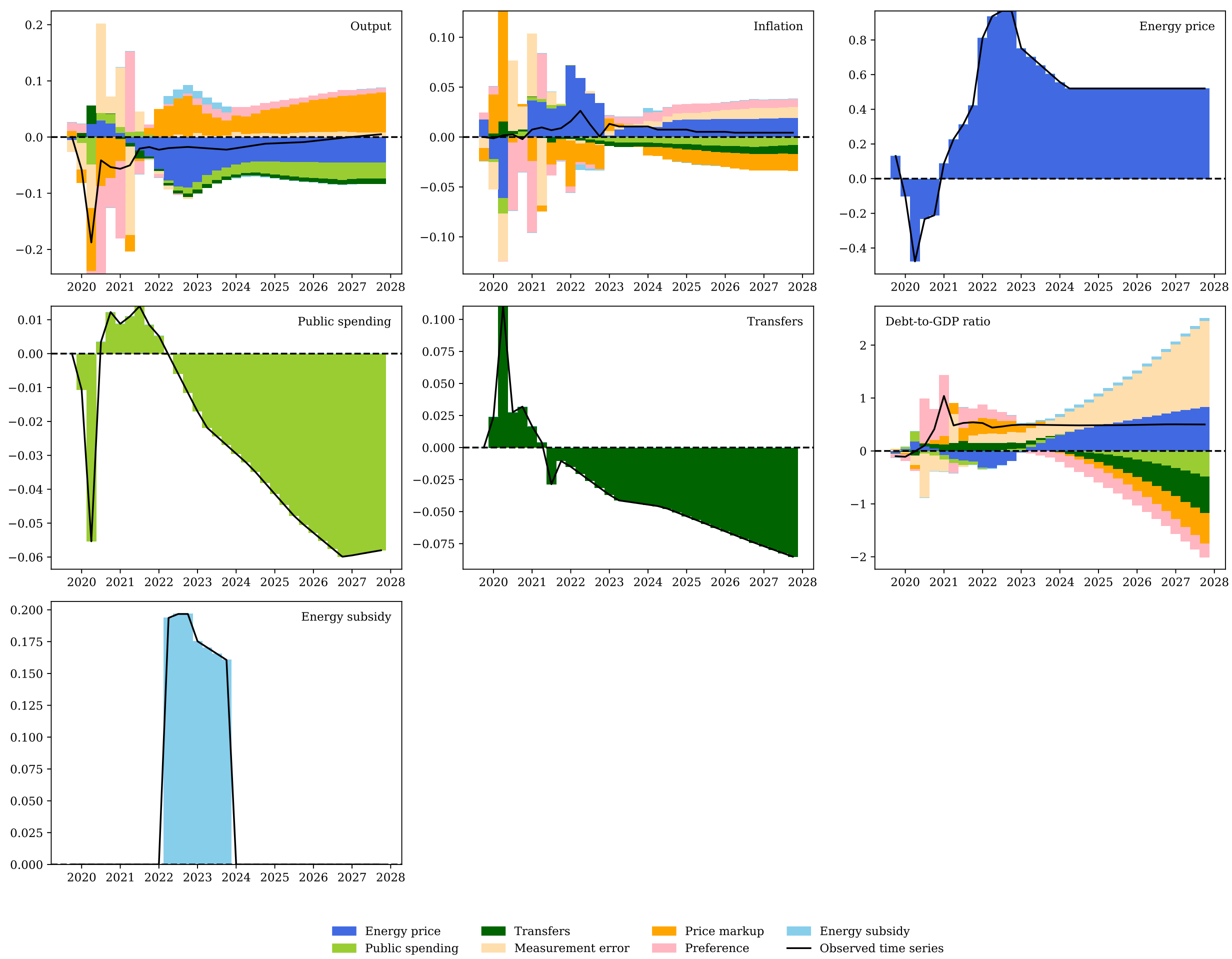
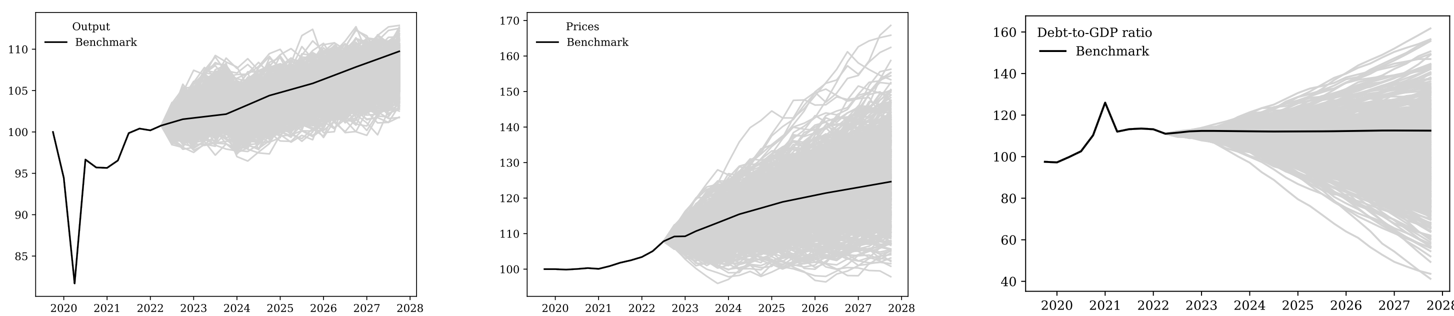


Figure 16: Shock decomposition since 4Q2019

I Forecasting

The shocks obtained in the variance decomposition are used as inputs to the model to construct the economy's response for all macroeconomic variables. Since all shocks are assumed to have normally distributed innovations ($\varepsilon^Z \rightsquigarrow N(0, \sigma_Z^2)$ for $Z = \beta, \mu, \vartheta, G, T, P_E$), we use the standard deviation of these estimated shocks over the sample period 1Q2022-4Q2027 to compute the confidence intervals of the model's forecasts, under the assumption that the subsidy on energy consumption has no uncertainty.

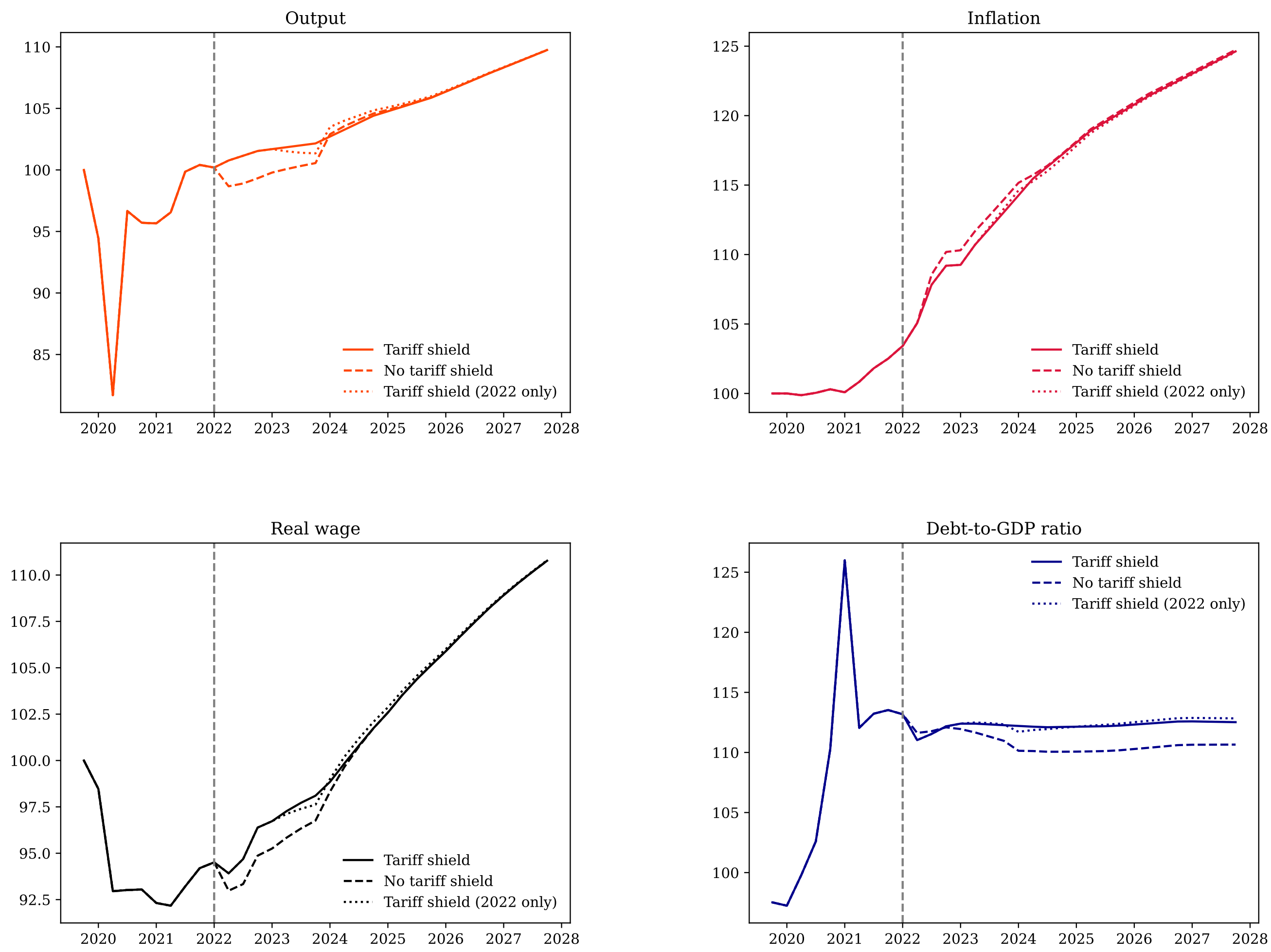
Firstly, given that the standard deviation of government and transfer innovations (ε^G and ε^T) are small, the large areas of the confidence bands reported in Figure 17 underscore that the innovations of the shocks on $\beta, \mu, \vartheta, P_E$ have a large variance, leading to uncertainty in forecasts.



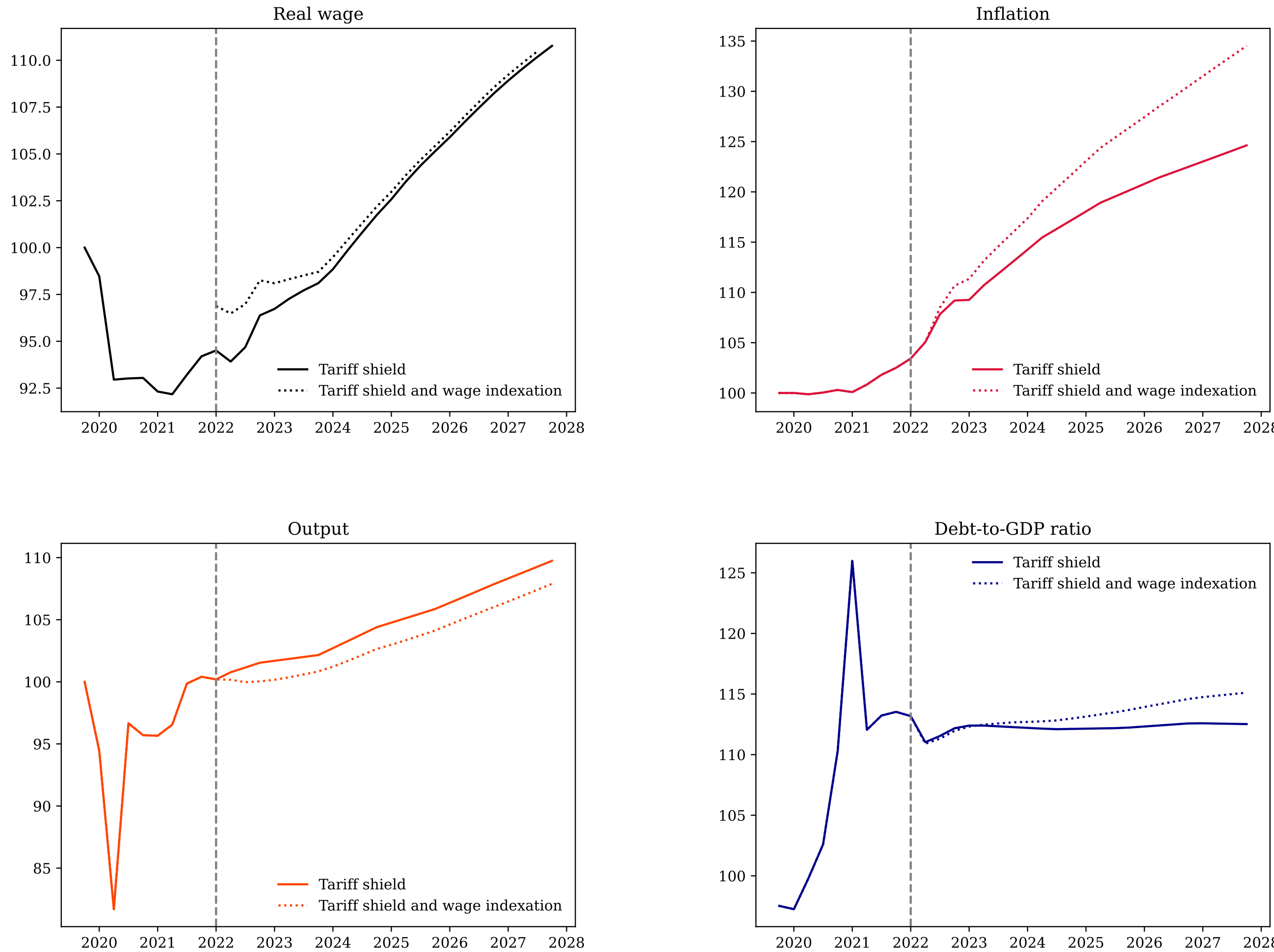
(a) GDP (b) Consumer price index (c) Debt-to-GDP ratio

Figure 17: Uncertainty on Model's Forecasts

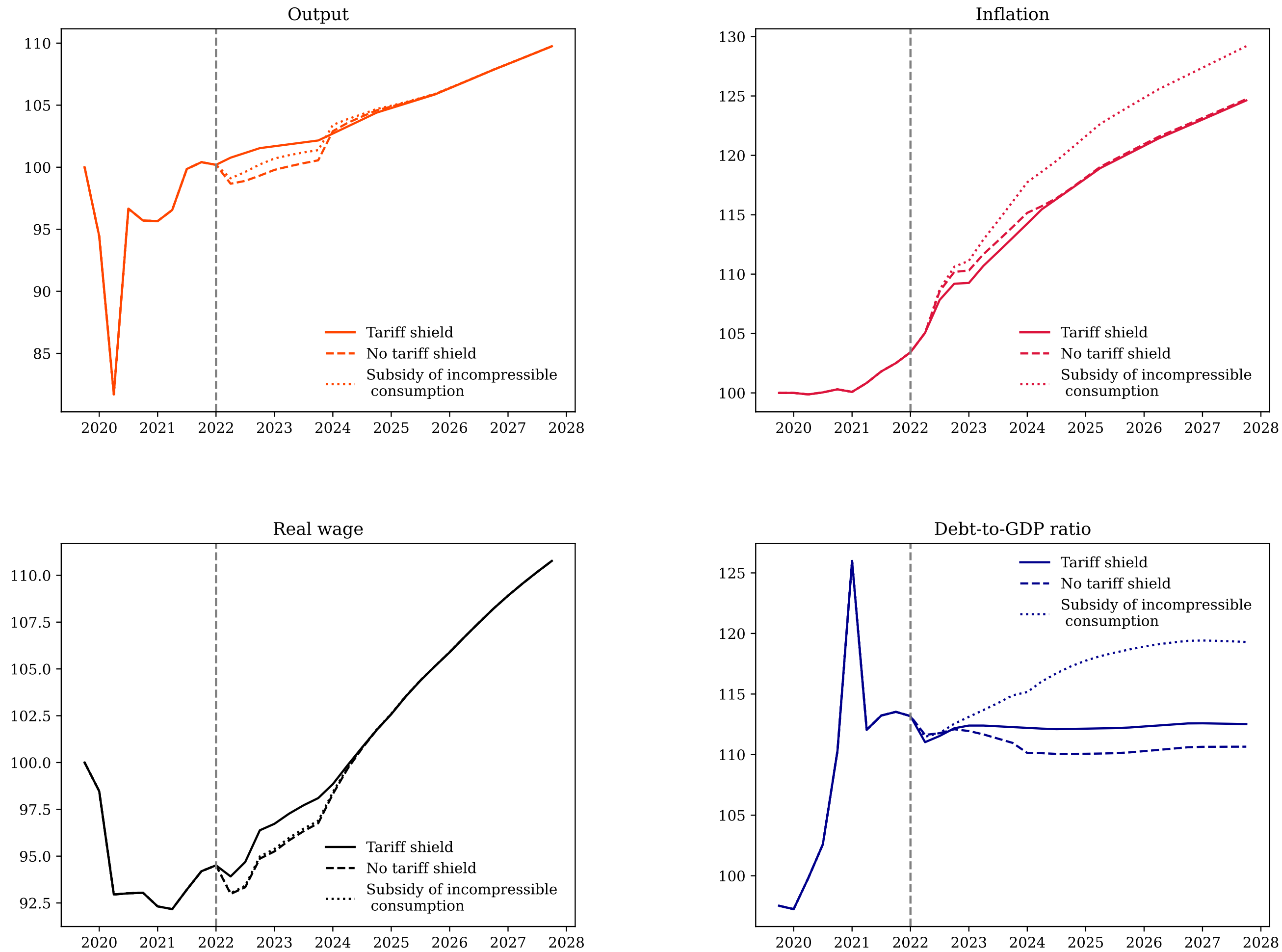
J Tariff shield: Aggregates since 4Q2019



K Re-activating the price-wage spiral: Aggregates since 4Q2019



L Subsidizing incompressible energy consumption: Aggregates since 4Q2019



M IRFs by productivity levels

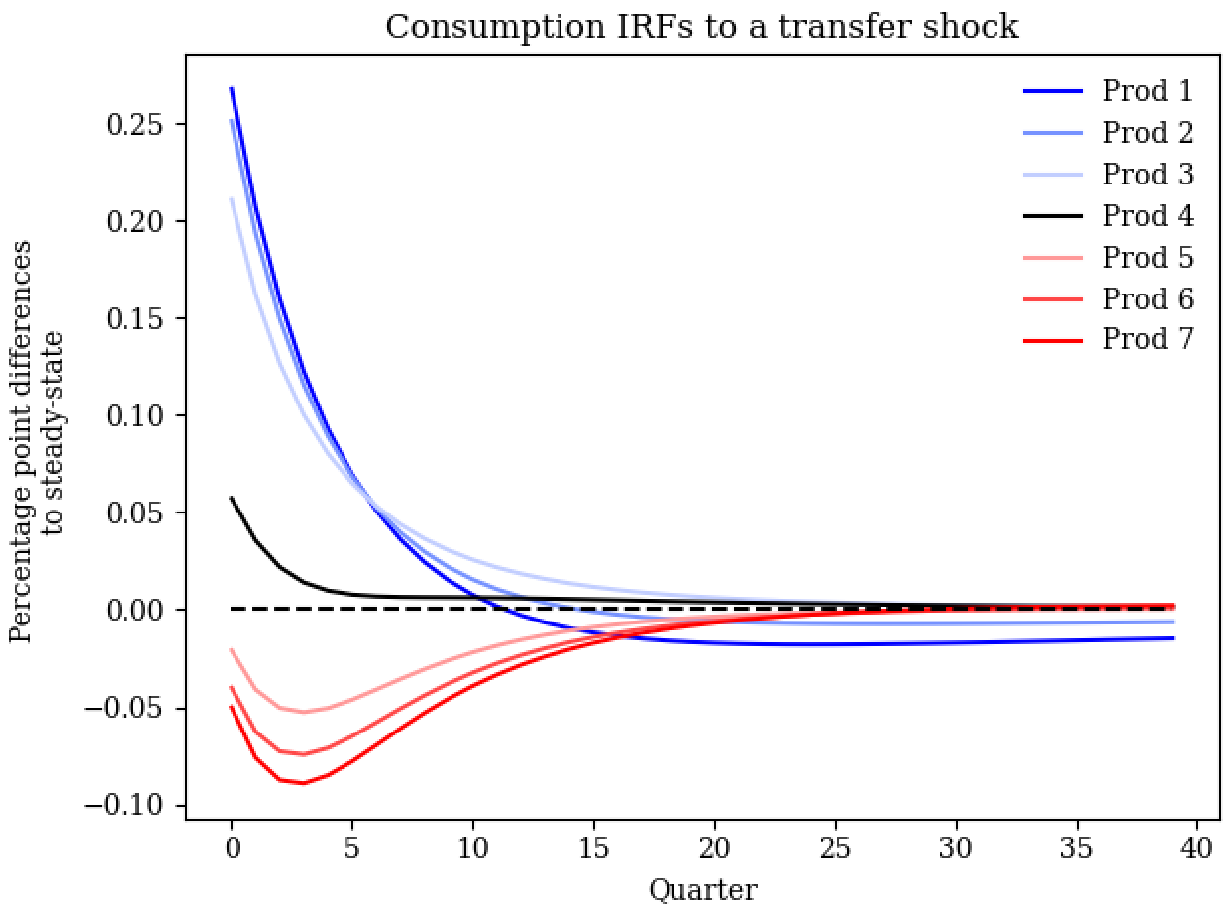
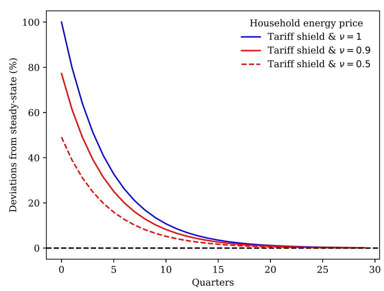


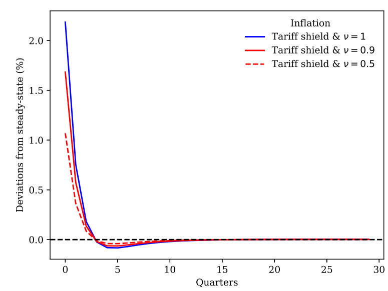
Figure 18: Consumption impulse response function of each type of household.

N Sensitivity to the Energy Production Function

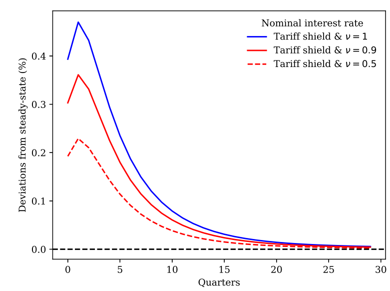
This appendix presents the IRFs of our model for different values of the parameter ν of the energy production function. In the main text, this parameter is calibrated at 1. However, we demonstrate that for values that remain admissible given the estimates of the quick pass-through of raw energy prices on energy prices ($\nu = 0.9$), the IRFs remain very close to those of our benchmark model. They only begin to diverge significantly for "unrealistic" values such as $\nu = 0.5$.



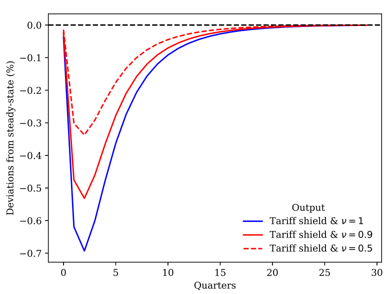
(a) Energy Price P_E



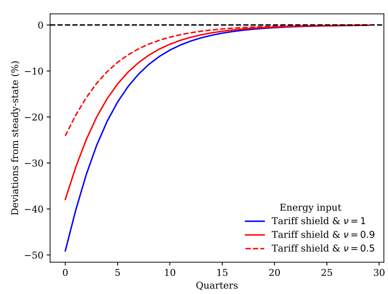
(b) Inflation π



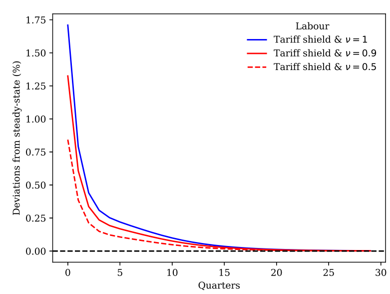
(c) Nominal interest rate i



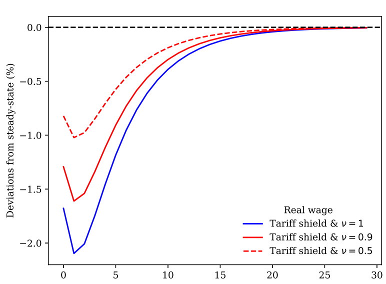
(d) Output Y



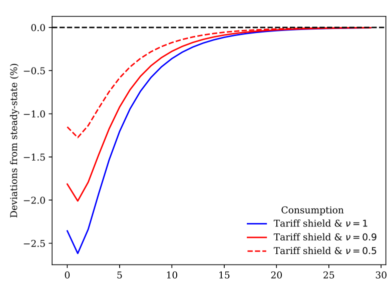
(e) Energy Input E



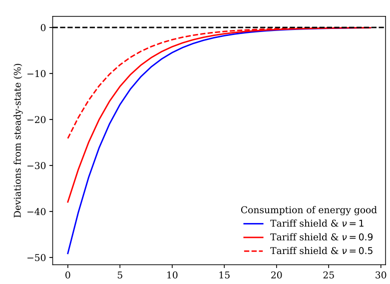
(f) Labor N



(g) Real Wages w

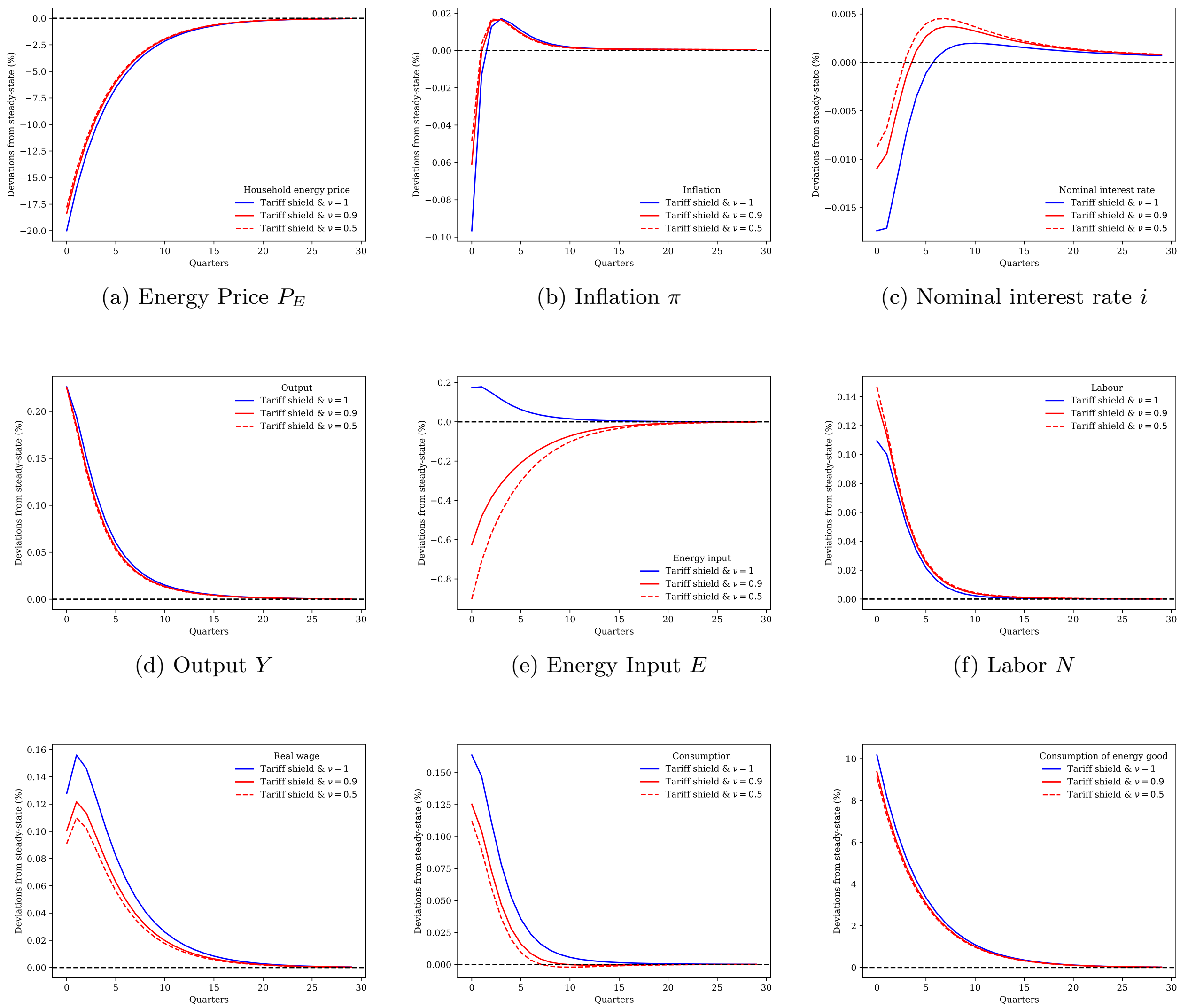


(h) Consumption C



(i) Household Energy Consumption Y_E

Figure 19: IRFs to Energy Shock. Solid blue lines for $\nu = 1$, solid red lines for $\nu = 0.9$, and dotted red lines for $\nu = 0.5$.



(a) Energy Price P_E (b) Inflation π (c) Nominal interest rate i

(d) Output Y (e) Energy Input E (f) Labor N

(g) Real Wages w (h) Consumption C (i) Household Energy Consumption Y_E

Figure 20: IRFs to Tariff Shield. Solid blue lines for $\nu = 1$, solid red lines for $\nu = 0.9$, and dotted red lines for $\nu = 0.5$.

Following an energy price shock, Figure 19 demonstrates that these alternative calibrations of the energy market generate Impulse Response Functions (IRFs) that are not significantly different from those of our benchmark model. In particular, the introduction of an endogenous energy price ('elastic supply'), which distributes the impact of the shock between a price effect and a quantity effect, does not have a strong repercussion on the other aggregates. This emphasizes that it is the value of energy (price $\times$ quantity) that ultimately matters in decision-making processes.

However, what is crucial for our analysis is the comparison of these different models as part of the evaluation of the tariff shield. Figure 20 demonstrates that these alternative calibrations of the energy production function generate similar Impulse Response Functions (IRFs) to those of our benchmark model. An endogenous energy price only alters the price-quantity adjustments in the energy market, with all other variables showing the same IRFs as in our baseline model. Therefore, our basic model appears to be more parsimonious without biasing the results of the tariff shield evaluation.