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

François Langot<sup>†</sup> Selma Malmberg<sup>‡</sup> Fabien Tripier<sup>§</sup> Jean-Olivier Hairault<sup>¶</sup>

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## Abstract

The French government has implemented a tariff shield on energy products to dampen the impact of the increase in energy prices started in 2021. To assess the macroeconomic and redistributive effects of this policies, we propose a new methodology for ex-ante evaluations, based on the government forecasts embedded in the Finance Act and on a new-Keynesian business cycle model with heterogeneous agents. From a macroeconomic perspective, this policy supports economic growth and curbs inflation, but slightly rises the debt-to-GDP ratio. In terms of redistribution, this policy contains the rise in consumption inequalities. We compare the effects of this policy with alternative policies such as a re-indexation of wages on prices or a redistributive policy targeted at the most vulnerable households.

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

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

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# 1 Introduction

At the outset of 2022, the incursion of Russia into Ukraine precipitated an energy shock in Europe, unparalleled in the history of the Euro area. With gas prices surging by a factor of more than five and barrel prices more than doubling since 2021, the inflationary shock has been of huge magnitude. Inflation rates in 2022 surged to 8% in Italy, 8.3% in Germany, and a staggering 12% in the Netherlands. In contrast, France demonstrated a comparatively lower inflation rate of 6.2%, thus distinguishing itself from its European counterparts. From October 2021, the French government has implemented a “tariff shield” to mitigate the impact of the energy shock. These measures include a freeze on gas prices at their October 2021 levels, a cap on the increase in electricity prices, and the introduction of a pump discount starting in April 2022. Ex post, it appears that this policy has had a significant effect on inflation, which would have been 3.1 points higher between the second quarters of 2021 and 2022, according to French statistical institute (INSEE).<sup>1</sup> At the end of 2022, the French government had to decide whether or not to extend the tariff shield for 2023. This policy has multiple stakes. Beyond inflation, it is likely to affect economic growth and public finances, as well as economic inequality, given the higher share of energy in the expenditure of the most disadvantaged households.<sup>2</sup> The objective of this paper is to assess the impact of this tariff shield on the French economy.

The originality of our quantitative method is to propose ex-ante evaluation, i.e. a method that can be used in real time to help governments make their economic policy decision. To carry out its public spending and levy taxes, each government must obtain the approval of Parliament through a vote on the Finance Act (“Loi de finances” in France). This policy commitment contains forecasts for public finances (mainly spending, taxes, deficit and debt), as well as macroeconomic trends (e.g. growth and inflation) consistent with the government’s economic policy project attesting its credibility.<sup>3</sup> Our method integrates these forecasts into a general equilibrium model (*i*) to estimate the size of the different shocks that likely hit the French economy so that the government forecasts

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<sup>1</sup>See the publication INSEE Analysis n°75 [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"](#).

<sup>2</sup>In France, the share of income spent on energy is more than 10% for those with an income lower than the median and 8% for those in the top 10% of income.

<sup>3</sup>The “government’s forecasts” are based on a mixture of non-structural models using a very large set of information and also statistical information and informal knowledge usually used by forecasters. These forecasts may dominate those based on a structural model because they use a larger information set and fewer restrictions.

come true, and (ii) to develop counterfactual scenarios, given these sequences of shocks, providing real-time evaluations of alternative policies needed for the decision-making. Therefore, we proceed in two steps. In the first step, we use the general equilibrium model to estimate the sequence of shocks compatible with the government’s forecasts, in the spirit of the conditional forecasts methodology presented by [Del Negro and Schorfheide \(2013a\)](#).<sup>4</sup> In particular, we identify the size of the energy shock that the policy aims to dampen. In the second step, we simulate the model under alternative policies to those adopted by the government, assuming that the economy is still affected by the sequence of shocks estimated in the first step. This structural approach provides an evaluation of the energy crisis on the economic indicator (aggregates and inequalities) and enables a rigorous comparison of alternative policies, as they are all conducted in an identical context, in particular the shock realizations.

The choice of the general equilibrium model is crucial to the implementation of this method. We use a Heterogeneous-Agent New-Keynesian (HANK) model because it allows us to study at the same time both the impacts on the macroeconomic aggregate variables (such as output, inflation or public debt) and the dynamics of inequalities across households. The main advantage of a HANK model is that it predicts the observed depressive effect of positive shock on energy price, contrary to a Representative-Agent New-Keynesian (RANK), as shown in [Auclert et al. \(2023\)](#).<sup>5</sup> Moreover, since the “yellow vests” protests, the evaluation of an economic policy changing the price of energy must take care of its redistributive impacts, which is possible with a HANK model. In order to properly capture the greater sensitivity of the poorest to the shock of energy prices, our model introduces an incompressible consumption of energy products: this allows the model to generate a share of the energy products in the consumption basket decreasing with incomes as in the data, but also a price elasticity increasing with incomes, making it difficult for the poorest to avoid energy price increases. Another originality of our model is to allow the government to smooth the financing of its policies by issuing new debt.<sup>6</sup> Based on calibrated parameters for the steady state,

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<sup>4</sup>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 credible the government’s forecasts to the eyes of the model. Our quantitative method mixes non-structural (government forecasts) and structural (HANK forecasts) approaches. There is a large literature on the optimal way to mix non-structural and structural DSGE approaches for forecasting. See e.g. [Boivin and Giannoni \(2006\)](#), [Schorfheide et al. \(2010\)](#), [Del Negro and Schorfheide \(2013b\)](#) or [Gelfer \(2019\)](#). We let future research discuss this point in the context of HANK models.

<sup>5</sup>In the representative agent model, the energy shock leads demand to shift towards the consumption of domestically produced goods, which counterfactually sustains growth.

<sup>6</sup>In [Auclert et al. \(2023\)](#), there is no incompressible consumption and no public debt dynamics, whereas [Pieroni](#)

our HANK model for the French economy reproduces the government forecasts (output, inflation and public debt) conditionally to the government’s policies (expenditures and receipts) and energy prices. Solutions are obtained thanks to a first-order approximation around the steady-state (Reiter (2009), (2010)) and the sequence-space Jacobian approach (Auclert et al. (2021a)). This method allows us to determine the unique sequence of unanticipated shocks allowing one to fit a given observed time series. This estimation of the shocks reveals the size of the energy shock in France, allowing us to go beyond an IRF analysis, but also unveil the size of the budget intervention needed to cope with the magnitude of this shock. Next, to evaluate an alternative policy, we keep the paths of all exogenous variables as given by the benchmark and only change the policy tool under consideration.

We show that the “tariff shield” play a crucial role during the last energy crisis. As this is shown

Scenario	GDP growth		Inflation rate		Inequality	Debt-to-GDP ratio
	2022	2023	2022	2023	evolution	Long-term (2027)
No tariff shield	1.18%	0.92%	7.5%	3.5%	2.24 → 2.34	110.7%
Tariff shield in 2022 and 2023	2.85%	1.00%	6.5%	3.4%	2.24 → 2.26	112.5%
Wage indexation on prices	2.01%	0.40%	8.0%	4.8%	2.24 → 2.28	115.1%
Transfers	1.70%	1.28%	7.9%	5.0%	2.24 → 2.14*	119.3%

\* Lecture for “Inequality evolution”: 2.14 means that the consumption of the top 10% earners is 2.14 times larger than the consumption of the bottom 10% earners when policy is implemented whereas it was 2.24 times larger before the crisis.

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

in Table 1, this policy has supported economic growth which has reached 1.9% per year on average between 2022 and 2023, while limiting inflation (5.6% per year on average between 2022 and 2023). It has also contained the rise in consumption inequality in crisis times. The fiscal cost is substantial (about 2% of GDP per year, i.e. 58 billion euros per year) yet sustainable in terms of public finances because the debt-to-GDP ratio would rise by 2.2 points in 2027. This policy yields better results than alternative scenarios such as indexing wages to inflation<sup>7</sup> or a redistribution policy.<sup>8</sup> Table 1 shows that indexing wages to consumer prices (or implementing a redistributive policy) would had lead to an average growth rate of 1.6% (or 1.49%) with an inflation rate reaching 6.3% (or 6.44%)

(2023) introduces incompressible consumption, but not public debt dynamics. These two papers do not present policy evaluations but theoretical analyses of hypothetical policies.

<sup>7</sup>At the time of the energy shock, nominal wages were indexed to consumer price inflation in less than a year.

<sup>8</sup>To model a credible scheme of redistribution, we assume that all households receive a lump sum transfer calibrated to finance their incompressible energy consumption, homogeneous among households but representing a larger share of expenditures for the poorest.

and a larger Debt-to-GDP ratio (+3.4 points and +8.6 points respectively).

**Literature.** Our paper contributes to several strands of the literature. We contribute to the literature on the role of household heterogeneity in business cycle models. Following the seminal contributions of [Aiyagari \(1994\)](#) and [Krusell and Smith \(1998\)](#), extensive literature has expanded over the past few years to develop quantitative models with heterogeneous agents, which also included market frictions, as price and wage rigidities, relevant for business cycle analysis.<sup>9</sup> [Kaplan et al. \(2018\)](#) and [Auclert et al. \(2021b\)](#) demonstrate the empirical performance of these HANK models and their relevance for macroeconomic policy evaluations. [Auclert et al. \(2023\)](#) show that HANK models generate a recession after an energy shock as in the data, contrary to RANK models. HANK models have been widely estimated to explain the business cycle and inequality dynamics of the US economy, our contribution to this literature is to extend the analysis of these models to the French economy whose specificity is to belong to a monetary union. The Taylor rule is then adapted to account for the fact that the European Central Bank (ECB) only partly responds to French inflation which is only a part of the European inflation.

We also contribute to the literature on the unequal consequences of distortions on energy prices. As shown in [Känzig \(2021\)](#)<sup>10</sup>, the carbon tax is regressive since it impacts more heavily on the most disadvantaged households whose consumption is more energy intensive and/or less elastic to prices. [Rausch et al. \(2011\)](#) and [Goulder et al. \(2019\)](#) provide general equilibrium-based analysis of the distributional effects of carbon pricing. We contribute to this literature by considering these distributional effects in a stochastic model that allows us to include the business cycle in the analysis as well as the role of short-run macroeconomic policy as the monetary policy. To do so, we extend the [Auclert et al. \(2023\)](#)'s model to account for the consumption of energy by households but also as an input for production. Additionally, households have to consume an incompressible level of energy consumption, as in [Pieroni \(2023\)](#). Depending on the scenario considered, we model the

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<sup>9</sup>Many new methods have been developed to more easily use these models. In continuous time, [Achdou et al. \(2022\)](#) have popularized an approach based on solving Kolmogorov-Fokker-Planck forward equations coupled with HJB backward equations (See e.g. [Kaplan and Violante \(2018\)](#)). In discrete time, [Reiter \(2009\)](#), [\(2010\)](#), [Winberry \(2018\)](#) and [Bayer and Luetticke \(2020\)](#) have developed methods to improve the accuracy and resolution speed of these heterogeneous agent models. The [Auclert et al. \(2021a\)](#) approach integrates the set of tools necessary for macro-economists to use these HANK models to make economic policy assessments: it is possible *(i)* to compute the dynamic responses to aggregate shocks, *(ii)* to check the stability of the dynamics, *(iii)* to estimate parameters and shock realizations and *(iv)* to use a very friendly Python toolbox. We use this approach.

<sup>10</sup>[Känzig \(2021\)](#) studies the impacts of the European carbon market reforms on the euro area economy.

relevant fiscal tools used by the government (subsidy on energy prices or transfers to households for instance). Our analysis of the energy taxation in the context of the French economy supplements other applications to HANK models with an explicit energy sector, as e.g. [Benmir and Roman \(2022\)](#) who study the implications of the net-zero emissions target in the U.S..

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

The remainder of the article is organized as follows. Section 2 presents the model. Section 3 describes the quantitative methodology. Section 4 analyzes the quantitative results of the calibrated model and finally section 5 concludes.

## 2 Model

The model presented in this section is close to [Auclert et al. \(2018\)](#) ([2021b](#)), and ([2023](#)). Additional features are included to account for energy as a consumption and an input. Moreover, fiscal tools are introduced to explain how the French government fights the inflation rise during the energy crisis. Finally, the Taylor rule is adapted to account for the low weight of the French economy in the Euro area.

### 2.1 Households

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

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

expenditures for consumption  $c$  are paid at price  $P$ . Therefore, the value of total consumption is

$$Pc \equiv P_{HC}H + (1 - s_H)P_{FE}c_{FE}$$

where  $s_H$  denotes the subsidy of energy purchases induced by the tariff shield.

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

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

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

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

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

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

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



we assume that

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

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

## 2.2 Supply

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

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

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

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

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

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

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

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

### 2.2.1 Intermediate Goods

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

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

The optimal demands of production factors are:

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

with a marginal cost defined as follows

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

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

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

### 2.2.2 Final Goods

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

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

The optimal decisions satisfy

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

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

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

### 2.2.3 Retailers

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

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

This leads to the following NKPC:

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

with  $mc_t = \frac{P_{Ft}}{P_t}$ ,  $\kappa_P = \frac{\varepsilon_d}{\psi_P}$  and  $\mu = \frac{\varepsilon_d}{\varepsilon_d - 1}$ .<sup>11</sup> The firm profit (its dividends) is defined by

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

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

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

<sup>11</sup>Remark that for  $\pi$  "small", we have  $(\pi_t + 1) \pi_t \approx \pi_t \equiv \frac{P_t}{P_{t-1}} - 1$ .

### 2.3 Unions

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

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

where the equilibrium distribution of households satisfies  $\int_e \int_{a_-} d\Gamma(a_-, e) = 1$ . The purchasing power (income after wage and consumption taxes) of the household  $i$  is

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

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

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

and the union's objective is

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

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

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

## 2.4 Government

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

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

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

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

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

## 2.5 Monetary Policy

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

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

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

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

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

## 2.6 Energy Market

We assume that the energy price  $P_{FEt}$  is exogenous and therefore the supply  $\bar{E}$  adjusts to satisfy the demand for this price:

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

## 2.7 Equilibrium

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

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

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

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

## 3 Quantitative Method

In the first subsection, we briefly describe how we solve the dynamics of the model. This method is described in detail in [Auclert et al. \(2021a\)](#).

In the second subsection, we present our original method for an ex-ante policy evaluation using HANK models. We develop a method allowing us to evaluate in “real time” different policies aiming to dampen the energy shock. This method can be useful because the parliament votes before the end of 2022 on the government’s budget for the year 2023. This Finance Act commits the government to its expenditures and receipts based on forecasts for 2023 to 2027 given its policy choices. We propose a method that evaluates before the policy-maker’s decision the different alternatives that she can take.

### 3.1 Dynamics

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

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

with  $\mathbf{Y}$  gathering the time series of unknown aggregate variables and  $\mathbf{Z}$  of exogenous aggregate shocks. For solving the dynamic paths of this economy, we use the approximation method developed by Auclert et al. (2021a). Given a vector  $\mathbf{X}_t$  summarizing the exogenous variables for the households<sup>12</sup>, the dynamic of individuals' choices and their distribution is given by

$$\begin{aligned} V_t(e, a_-) &= \max_a u(e, a_-, a, \mathbf{X}_t) + \beta \mathbb{E}V_{t+1}(e', a) & (\text{DP}) \\ D_{t+1}(e', \mathcal{A}) &= \sum_e D_t(e, a_t^{*-1}(e, \mathbf{X}_t)) P(e, e', \mathbf{X}_t) & (\text{LoM}) \\ \mathbf{W}_t &= \sum_e \int_a w(e, a_-; V_{t+1}, \mathbf{X}_t) D_t(e, da_-) & (\text{Aggr.}) \end{aligned}$$

where  $a_t^{*-1}(e, \mathbf{X}_t)$  denotes the unique value for  $a_-$  consistent with the optimal decision  $a_t^*(e, \mathbf{X}_t)$  and  $\mathbf{W}_t$  the vector of the aggregates for  $w$  (consumption, wealth, hours worked,...) summarizing individual choices. This system can be rewritten as follow:

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

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<sup>12</sup>For the households, the exogenous variables are not necessarily the vector  $\mathbf{Z}$ , but also prices or wages contained in  $S_t$ . For this reason, the vector for exogenous variables for the agent denoted  $\mathbf{X}$ , is different from  $\mathbf{Z}$ .

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

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

where  $dz_t$  is the gap between the current value of  $z$  ( $z_t$ ),  $\forall z = v, D, X, W$  and its steady state value ( $\bar{z}$ ), i.e.  $dz_t = z_t - \bar{z}$ . Knowing  $d\mathbf{v}_T = 0$ , the terminal condition, and  $d\mathbf{D}_0 = 0$  an initial condition, the solution of this system describes the dynamics of individual responses ( $d\mathbf{v}$ ) to a change in an exogenous variable ( $d\mathbf{X}$ ) as well as the changes in the distribution ( $d\mathbf{D}$ ) and thus changes in aggregates ( $d\mathbf{W}$ ). Hence, this system implicitly defines the solution for  $\mathcal{A}_t$  and  $\mathcal{N}_t$ ,  $\forall t$ ,

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

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

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

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

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

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



## 3.2 Methodology for Ex-Ante Policy Evaluations

Our objective is to develop a method which provide an ex ante evaluation of alternative policies implemented in the future. This method can be used before the observations of the macroeconomic series, i.e. at the moment when the policymaker must make her choice.<sup>13</sup> In the case of the “tariff shield” evaluation, we do not observe data from 1Q2022. Instead of these observed data, we use the “government’s forecasts” as observable variables to reveal the time-specific realizations of the structural shocks of our model that make its endogenous variables consistent with these forecasts.<sup>14</sup> Consequently, the time-specific realizations of these shocks can be interpreted as the evolution of the economic environment necessary to make the government forecasts credible under the null hypothesis that the model is true. In all other experiments in the evaluation, these shocks will then be kept in order to have a controlled experiment.

Our benchmark scenario will constrain our HANK model to reproduce these government forecasts concerning output, inflation and public debt, conditionally to the paths for government’s expenditures and receipts also contained in this project of Finance Act. We also use the forecasts on the energy price in order to reveal the size of the energy crisis, which is crucial for the evaluation of the policy. Therefore, we impose strong restrictions based on theory to offer causal interpretations. The cost of our approach is to describe relationships among a small set of variables, therefore limiting the information set used for forecasting and thus its accuracy relative to larger scale, non-structural models.

The limits of this quantitative method based on conditional forecast are first described in [Leeper and Zha \(2003\)](#). *“Suppose that the interest rate path is not announced to the public but its implementation requires a sequence of strongly positively correlated unanticipated monetary policy shocks. Over time, the agents in the DSGE model might be able to detect the persistence in the deviation from the systematic part of the monetary policy rule and suspect that the policy rule itself might have changed permanently, which, in turn, creates an incentive to update decision rules.”* ([Del Negro and](#)

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<sup>13</sup>When the parliament approves the government’s budget, the government commits itself to its expenditures and receipts by presenting the implications of these commitments on the output, inflation and public debt.

<sup>14</sup>The time series of the government forecasts are based on a mixture of non-structural models, the experience of the forecasters and the knowledge of domain experts. They are based on less restrictive relations than those implied by a HANK model, but mostly on significantly larger information sets (that include the knowledge of domain experts for improving the credibility of these forecasts).

Schorfheide (2013b)).<sup>15</sup> This type of adjustment is not taken into account in our analysis, which means that we assume the changes in the government’s policy are “too small” (in the sense of Leeper and Zha (2003)) to trigger a costly learning mechanism leading the agents to believe that the policy regime has shifted.

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

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

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

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

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

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

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

<sup>15</sup>See also Gali (2011) for a critical analysis of conditional forecasts.

where  $d\tilde{Y}_t$  contains real GDP, inflation rate and public debt over GDP ratio and  $z = P_{FE}, G, T, \beta, \mu, \vartheta$ .

As previously, we assume that

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

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

## 4 Quantitative Results

### 4.1 Calibration and Estimation

**Income process.** The French earnings data are those of the European Community Household Panel (ECHP). Following [Fonseca et al. \(2023\)](#), we control by age and we extract the purely transitional shock treated as a measurement error, uncorrelated with the innovation of the persistent component of the earnings. This persistent component of the log of net income follows an AR(1) process:

$$\log(e_t) = \rho \log(e_{t-1}) + \eta_t \quad \text{where } \eta_t \sim \mathcal{N}(0, \sigma) \quad (3)$$

The estimated values for  $\rho$  and  $\sigma$  are respectively 0.966 and 0.014.<sup>16</sup>

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

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<sup>16</sup>In this paper, we do not set  $\sigma$  to this estimated value. Indeed, as all HANK models with only one riskless asset, our simple model is unable to match the wealth distribution, and more importantly the distribution of consumption expenditures, the main argument of welfare inequalities. In order to compensate for this gap, we choose to calibrate  $\sigma$  in order for the model to match consumption inequalities observed in the data. This leads us to set  $\sigma = 0.5$ .

Parameter	Value	Target
<b>Preferences</b>		
Discount factor $\beta$	0.9922	Real interest rate $r = 0.5\%$ per quarter
Disutility of labor $\theta$	0.6343	Aggregate labor $L = 1$
Frisch elasticity of labor supply $\varphi$	0.5	<a href="#">Auclert et al. (2021a)</a>
Elasticity of intertemporal substitution $\sigma$	1	Log-utility
Incompressible energy consumption $\underline{c}$	0.0370	20% of the households' energy consumption
Wage markup $\mu_w$	1.1	<a href="#">Auclert et al. (2021a)</a>
Elasticity of substitution between production inputs $\eta_E$	0.5	Negative impact on GDP of energy price shock
Share parameter (energy, intermediate good) $\alpha_E$	0.025	Sharing rule: a half of energy to households
<b>Production</b>		
Elasticity of substitution between production inputs $\sigma_f$	$\eta_E$	Simplifying assumption
Share parameter (energy, labor) $\alpha_f$	0.075	Sharing rule: a half of energy to firms
Firm markup $\mu$	1.2	<a href="#">Auclert et al. (2021a)</a>
<b>Aggregate targets</b>		
Share of GDP spent on energy $se$	3.18%	Share of energy in GDP
Public debt $B$	4.749	Debt-to-GDP ratio 100% with annual GDP
Public spending $G$	0.2374	Public spending-to-GDP ratio 20%
Transfers	0.2968	Transfers-to-GDP ratio 25%
VAT rate $\tau_c$	20%	French VAT
Income tax rate $\tau_l$	20%	French employee tax rate
<b>Nominal rigidity</b>		
Price rigidity $\kappa$	0.95	Arbitrary higher than <a href="#">Auclert et al. (2018)</a>
Wage rigidity $\kappa_w$	0.1	<a href="#">Auclert et al. (2018)</a>
<b>Monetary policy</b>		
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 $\rho_r$	0.85	<a href="#">Carvalho et al. (2021)</a>
<b>Heterogeneity</b>		
Persistence of productivity shocks $\rho$	0.966	<a href="#">Fonseca et al. (2023)</a> data for France
Volatility of productivity shocks $\sigma$	0.5	To match consumption inequalities

Table 2: Calibrated parameters

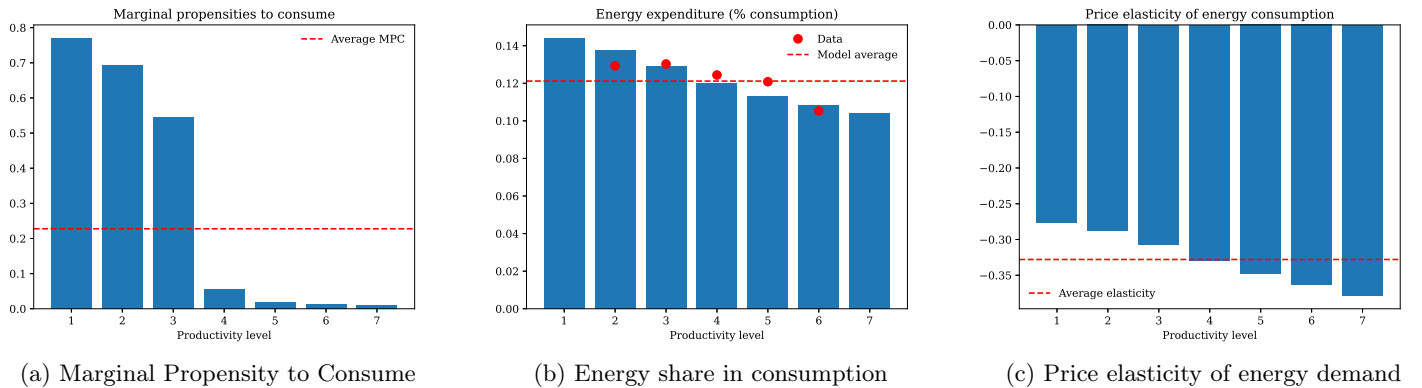


Figure 1: Heterogeneity in household's behaviors (per income level)

consumption when the price increases. This result comes from the largest share of incompressible consumption in their energy consumption.

As in all dynamic models, the impact of each shock depends on how the agents expect them to persist. The autocorrelations of these  $AR(1)$  processes and the standard deviations of their innovations are reported in Table 3. The values for  $\rho^Z$ ,  $\forall Z \in \{\beta, \mu, \vartheta, G, T, P_{FE}\}$ , are estimated

Shock	$Z$	Persistence $\rho^Z$		Standard dev. $\sigma^Z$		Variance $\frac{(\sigma^Z)^2}{1-(\rho^Z)^2}$
		Mode	Mean	Mode	Mean	
Energy price	$p_{FE}$	0.816	0.798 (0.036)	0.012	0.013 (0.0023)	0.000465
Government spending	$G$	0.920	0.916 (0.014)	0.0035	0.0036 (0.0003)	0.000081
Transfers	$T$	0.872	0.862 (0.024)	0.0049	0.0051 (0.0004)	0.000101
Taxes	$\vartheta$	0.778	0.777 (0.024)	0.151	0.148 (0.011)	0.055275
Price markup	$\mu$	0.793	0.792 (0.024)	0.057	0.059 (0.005)	0.009339
Preference	$\beta$	0.887	0.888 (0.0158)	0.0046	0.0047 (0.0006)	0.000104

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

using a Bayesian method based on the data set  $\{Y, \pi, \frac{b}{Y}, G, T, P_{FE}\}$  over the sample 2Q1995 to 4Q2019.<sup>17,18</sup> The autocorrelation functions of these variables are deduced from the model solution (see equation 2). These estimates show that the shocks on the residual part of transfers  $\vartheta$  have the largest variance, which is not surprising given the non-stationarity of the debt-to-GDP ratio during this period that the model must fit. The shock on markups has a larger variance than the shock on energy prices (20 times larger) but is 10 times larger than the other shocks (preferences, government expenditures and transfers). 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 energy consumption subsidy (the tariff shield), we assume that households expect the government not to remove it all at once, as provided for in the Financial Act, but to take a year to remove all these subsidies. Thus, even if we implement in our evaluation what is provided for in the Financial Act, i.e. subsidies between 1Q2022 and 4Q2023, households act in the belief that there is a persistence of this subsidy.

<sup>17</sup>The appendix A presents the data used in the paper. All data are stationarized by extracting a linear trend, except the debt-to-GDP ratio where only its average over the sample is extracted.

<sup>18</sup>Additional details on the estimation procedure can be found in appendix B.

## 4.2 Data for Aggregates

The originality of our work is to propose an ex-ante evaluation of alternative policy scenarios. Therefore, we choose to estimate the sequence of shocks from 4Q2019 to 4Q2027, hence including both Covid and the energy crises episodes as well as the post-crises period going until 4Q-2027. For doing that we use (i) observed data from 4Q-2019 to 4Q2021 and (ii) forecasts from 1Q2022 to 4Q2027 that are published by the French government when the Prime Minister presents the Financial Act. These data contain the government’s forecasts for

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

and the size of  $s_H$  is chosen in order to generate an ex-ante cost of the tariff shield of 50 billion euros per year, as announced by the government at the time of its implementation. The data  $\{G, T, P_{FE}, Y, \pi, \frac{b}{Y}\}$  are presented in figures of the Appendix A (raw data). The sample goes from 4Q2019 to 4Q2027. In order to estimate the sequences of shocks  $\{\varepsilon^\beta, \varepsilon^\mu, \varepsilon^\vartheta, \varepsilon^G, \varepsilon^T, \varepsilon^{P_{FE}}, \varepsilon^{s_H}\}_{s=4Q2019}^{4Q2027}$ , we use stationarized data reported in the figures of Appendix A.

## 4.3 Shock Decomposition

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

$$\begin{array}{ll}
 \textbf{Endogenous variables:} & \text{Output } (Y), \text{ Inflation } (\pi), \text{ Debt-to-GDP ratio } (\frac{b}{Y}) \\
 \textbf{Exogenous variables:} & \left\{ \begin{array}{l} \text{Government spending } (G), \text{ Transfers } (T), \\ \text{Energy prices } (P_{FE}), \text{ Subsidies to households } (s_H) \end{array} \right.
 \end{array}$$

For the exogenous variables, the time series  $\{G, T, P_{FE}, s_H\}$  directly identify the shocks that are their only drivers.

Figure 2 shows that the shocks on unobservable variables  $\{\beta, \mu, \vartheta\}$  explain a large part of the endogenous variables dynamics, namely Output  $Y$ , Inflation  $\pi$ , Debt-to-GDP ratio  $\frac{b}{Y}$ .<sup>19</sup> The Table

<sup>19</sup>This shock decomposition is made over a longer sample in Figure 8 of Appendix C.

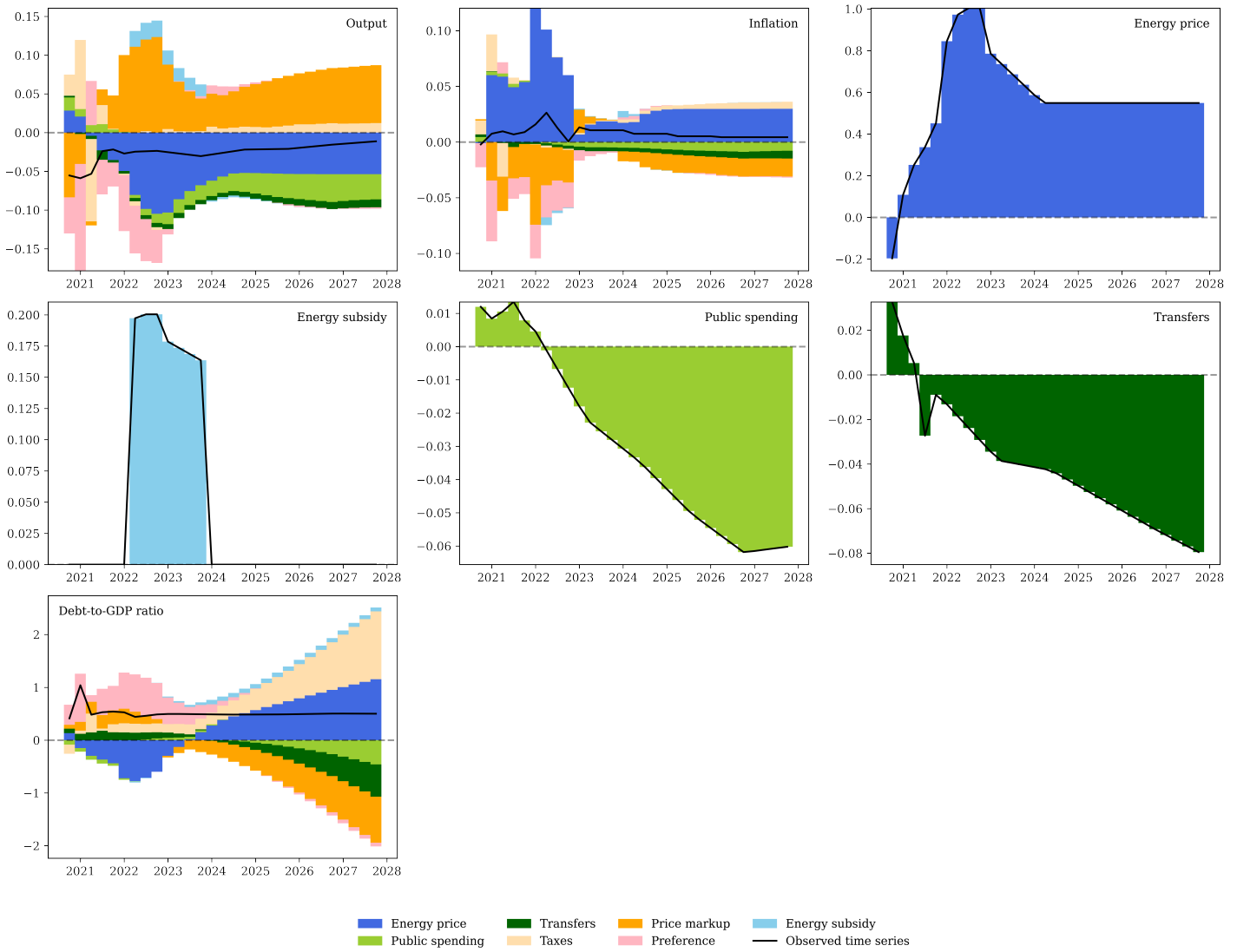


Figure 2: Shock decomposition: focus after 4Q2020

4 shows that the contributions of the others shocks, namely  $\{G, T, P_{FE}\}$ , are lower than a half, except the contribution of  $P_{FE}$  on inflation ( $\pi$ ). In 2022 and 2023, years during which the tariff shield is implemented, the three shocks which explain the large majority of the GDP dynamic are, in descending order, that on the markups (supply shock)<sup>20</sup>, that on the price of energy and that on preferences (demand shock). Only the first supports GDP during this period (fall in markups), while the other two reduce it. Obviously, the tariff shield also supports GDP, which mitigates the recessive effect of the energy shock. Over the same two years, these are the same three shocks which explain

	2022				2023				2024	2025	2026	2027	
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	2Q	2Q	2Q	2Q	
$y$	$\beta$	16.41	10.90	6.31	0.25	0.01	0.03	0.12	1.78	2.30	0.01	0.01	0.03
	$\mu$	53.37	51.29	53.10	37.93	33.63	29.54	25.25	29.02	32.32	50.34	53.08	56.57
	$\vartheta$	0.13	0.01	0.04	0.11	0.02	0.02	0.05	0.94	0.51	0.80	1.43	1.49
	$G$	0.06	0.23	0.47	1.24	2.56	3.63	5.05	6.31	7.78	11.75	13.22	11.22
	$T$	0.07	0.09	0.11	0.21	0.35	0.39	0.44	0.47	0.51	0.72	0.85	1.02
	$P_{FE}$	28.12	35.71	38.35	58.38	61.04	63.51	65.79	61.39	56.43	36.35	31.39	29.63
	$s_H$	1.79	1.74	1.58	1.83	2.36	2.83	3.27	0.05	0.13	0.00	0.00	0.00
	$\pi$	$\beta$	6.80	9.81	10.34	14.73	5.98	1.78	0.49	0.81	2.04	0.02	0.04
$\mu$		9.40	12.08	17.03	72.74	11.65	0.75	0.06	17.16	17.79	19.79	20.05	20.04
$\vartheta$		0.02	0.00	0.02	0.40	0.23	0.18	0.23	1.92	1.38	1.14	2.36	2.90
$G$		0.00	0.06	0.20	2.77	6.52	5.84	6.19	5.55	6.05	4.51	5.65	4.86
$T$		0.03	0.07	0.15	1.71	3.60	2.98	2.92	2.43	2.48	1.80	2.56	3.44
$P_{FE}$		83.32	77.87	72.23	7.52	71.93	88.42	90.07	65.08	69.64	72.70	69.32	68.66
$s_H$		0.39	0.07	0.00	0.09	0.06	0.02	0.00	7.02	0.59	0.00	0.00	0.00
$\frac{b}{y}$		$\beta$	41.38	47.19	53.52	66.76	69.71	59.60	35.92	11.31	2.59	0.04	0.14
	$\mu$	4.34	2.33	0.75	0.27	5.54	17.05	27.46	30.20	27.35	21.64	19.62	17.82
	$\vartheta$	2.47	2.35	3.17	6.65	13.72	19.95	21.84	21.52	21.66	26.25	31.81	37.07
	$G$	0.00	0.02	0.12	0.53	1.07	1.03	0.60	0.19	0.01	0.88	2.48	4.46
	$T$	1.64	1.56	1.54	2.54	2.45	1.25	0.17	0.06	0.57	4.33	6.64	8.24
	$P_{FE}$	50.09	46.52	40.87	23.14	7.11	0.18	12.51	33.68	45.74	46.16	38.98	32.10
	$s_H$	0.04	0.00	0.00	0.08	0.36	0.91	1.46	3.01	2.04	0.67	0.30	0.15

Table 4: 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  $\{\beta, \mu, \vartheta, G, T, P_{FE}, s_H\}$

the large majority of the inflation dynamic (markups, price of energy and preferences). Only the energy price shock increase inflation during this period, while the other two reduce it. Obviously, the tariff shield damps inflation, which mitigates the inflationary effect of the energy shock. Regarding the evolution of the debt-to-GDP ratio in 2022 and 2023, the decline in GDP induced by the

<sup>20</sup>Our estimation procedure allows us to identify only one supply shock, the markup shock. Hence, it can also capture a part of the TFP shocks.



contraction in demand, combining preference and energy price shocks, mainly explains the increase in short-term debt. In the medium term, the decline in markups partly counters the persistence of high energy prices whereas the reduction in government expenditures and transfers to households contribute to the public indebtedness after 2025. The impact of the tariff shield on the debt-to-GDP ratio is quite small.<sup>21</sup>

The interesting result of this ex-ante estimation is to reveal that French firms would have accepted to reduce their markups during this crisis. Ex-post, this scenario is validated by the OECD, which underlines that France is one only country where growth in profits has been lower than growth in labor costs during this period (see [OECD Employment Outlook 2023](#)).

#### 4.4 Policy Analysis

The tariff shield is a supply-side policy in the sense that it aims at “correcting” a market price. Its first impact is to partially kill the increase in energy price and therefore, mechanically reduce inflation by cutting down its energy component. By directly reducing the shock size, it thus prevents its diffusion and thus its recessive impact on the economy. This policy also sustains the purchasing power of households by reducing the cost of their energy expenditures. This allows them to not reduce excessively their demand addressed to home producers and thus economic growth. We first assess the macroeconomic and distributive effects of the tariff shield, and then compare them with two alternative policy scenarios.

[Alvarez et al. \(2022\)](#) have suggested that wages are no longer indexed on prices and thus that the inflation driven by the energy shock could lead to a significant reduction in purchasing power. This suggests that it could be effective to index wages to prices more quickly in order to amplify the positive impact of the tariff shield on growth. We then analyze the efficiency of the tariff shield when complemented by a quicker wage indexation, implemented at the same time as the tariff shield.

An alternative view consists of favoring a redistributive policy. This demand-oriented policy fights the recession induced by the negative supply shock (namely the energy shock in this context), by stimulating the consumption demand. Hence, the recession can also be damped, as with a tariff shield, but certainly not inflation, contrary to what a tariff shield does.

In the subsections that follow, we examine these different scenarios.

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<sup>21</sup>The appendix [D](#) provides a measure of the implied uncertainty around these forecasts.

#### 4.4.1 On the Effectiveness of the Tariff Shield

	GDP		Inflation			$\frac{\text{Debt}}{\text{GDP}}$	
No tariff shield	2022	1.18%	} 1.04%	7.5%	} 5.5%	2027	110.7%
	2023	0.92%		3.5%			
Tariff shield	2022	2.85%	} 1.92%	6.5%	} 4.9%	2027	112.5%
2022 2023	2023	1.00%		3.4%			
Tariff shield	2022	2.85%	} 1.70%	6.5%	} 5.1%	2027	112.8%
2022 only	2023	0.57%		3.8%			

Table 5: Tariff Shield Impact

With a tariff shield in 2022 and 2023, which represents an annual budgetary cost of 2% of GDP, i.e. 58 billion euros, Table 5 shows that the French government is supporting growth over the two years, 2022 and 2023.<sup>22</sup> The growth rate for 2022-2023 would have been 1.04% without the tax shield against 1.92% as forecasted by the government. Inflation is contained because the price-wage spiral is not initiated: the inflation rate for 2022-2023 would have been 5.5% without the tariff shield instead of 4.9%. Indeed, without a tariff shield, the sharp rise in consumer prices causes nominal wages to react strongly, which fuels inflation and increases the cost of labor, which explains why growth is also significantly weaker. If the tariff shield was not renewed in 2023, then there is no longer any smoothing of growth, which then stops abruptly in 2023. Inflation remains contained thanks to the tax shield which operates in the year 2022. This half-measure does not induce budgetary savings because it implies a loss of growth. Thus, the tariff shield makes it possible to contain inflation while achieving a growth rate almost twice as high. The negative shock of the rise in energy prices is therefore cushioned and makes it possible to recover a significant part of the growth linked to the catch-up of the Covid crisis.

**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 3 times more than those in the Bottom 10% (B10) income, while they only consume 1.97 times more than those within the middle of the earning distribution. Finally, those in the middle of earning distribution consume 1.52 times more than those in the B10 of income. In the model, the income process involves a distribution given in Table 6.

<sup>22</sup>In Appendix E, the complete description of the quarterly path of the aggregates is presented.

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 6: Definition of the earning groups

Without the tariff shield, Figure 3 shows that the consumption of the T10, which was 2.25 higher than that of the B10 in 1Q2022, is 2.48 higher than that of the B10 in 4Q2022, i.e. an increase of 10.2% of this measure of inequality. The energy crisis is therefore increasing consumption inequalities. With the tariff shield, the consumption of the T10 would only be 2.38 higher than that of the B10 in 4Q2022, i.e. a very moderate increase of 6% in this measure of inequality. These figures also show that the amortization of the rise in inequalities occurs above all the bottom of the distribution (i.e. also for the Middle vs T10).

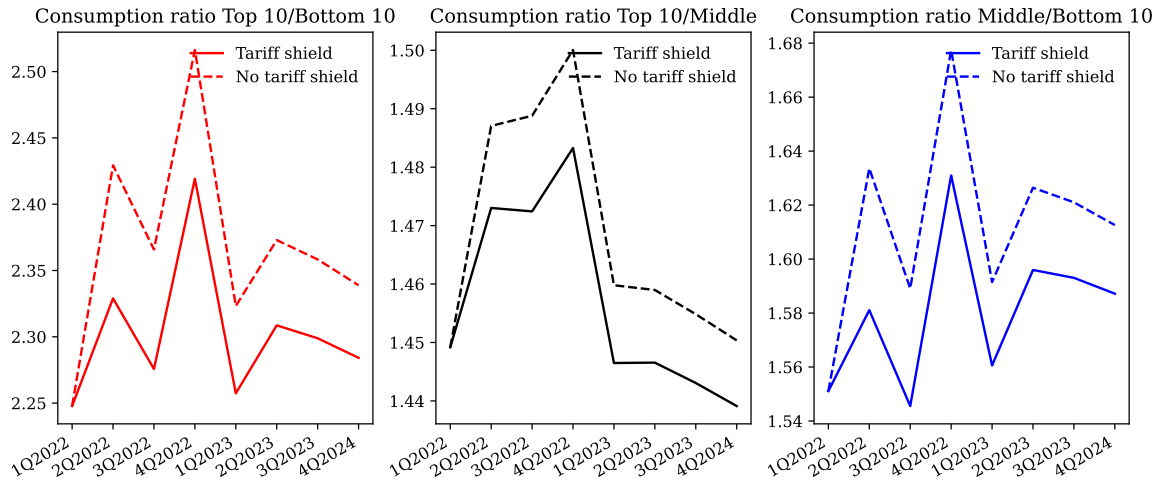


Figure 3: Dynamics of Inequalities with Tariff Shield

#### 4.4.2 Would wage indexation increase the effectiveness of the tariff shield?

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

year to variations in inflation.

	GDP		Inflation		Debt GDP		
No tariff shield	2022	1.18%	1.04%	7.5%	5.5%	2027	110.7%
	2023	0.92%		3.5%			
Tariff shield 2022 2023	2022	2.85%	1.92%	6.5%	4.9%	2027	112.5%
	2023	1.00%		3.4%			
Faster wage indexation & tariff shield	2022	2.01%	1.20%	8.0%	6.4%	2027	115.1%
	2023	0.40%		4.8%			
Faster wage indexation & No tariff shield	2022	0.54%	0.41%	8.6%	6.6%	2027	113.2%
	2023	0.29%		4.6%			

Table 7: Strong Wage Indexation Accompanying Tariff Shield

Table 7 shows that inflation is much higher when a faster indexation of nominal wages to prices accompanies the tariff shield.<sup>23</sup> This very high inflation, at 8.0% for 2022, which is favorable to real hourly wages, is nevertheless sharply reducing employment. As the effect on employment overcompensates that on the real hourly wage, households experience losses in purchasing power. This measure is, therefore, less effective on growth, which loses  $(1.92 - 1.2) \times 2 = 1.44$  points over two years compared to the reference scenario with tariff shield over the two years 2022 and 2023. This slowdown in growth reduces the government revenues, which sees its debt ratio on GDP increase by 2.6 points compared to the scenario with tariff shield over the two years 2022 and 2023. If only

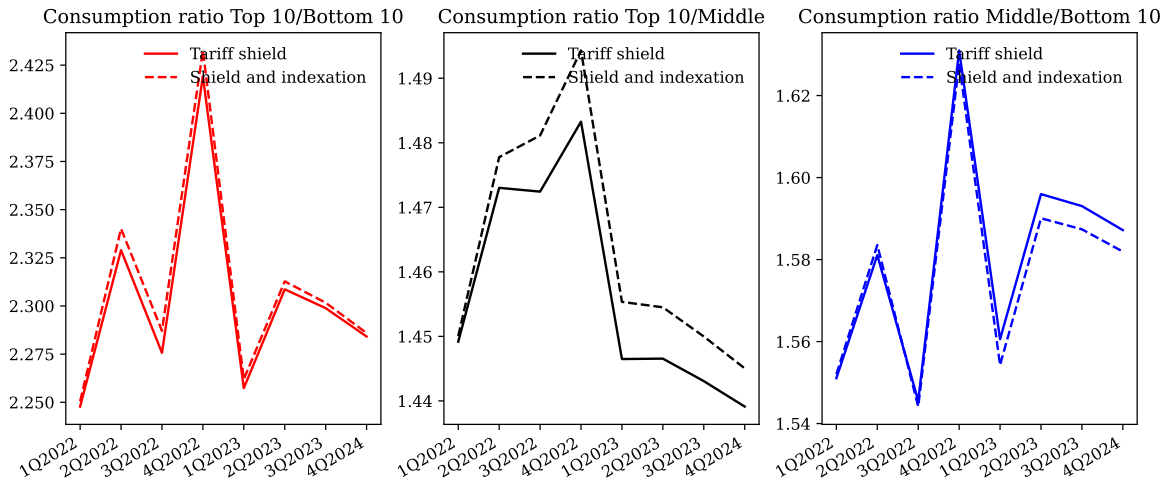


Figure 4: Dynamics of Inequalities When a Strong Wage Indexation Accompanied Tariff Shield

<sup>23</sup>In the Appendix F, the complete description of the quarterly path of the aggregates is presented.

a faster indexation of wages to prices were put in place, then the pressure of labor costs would cause activity to fall in an even more inflationary context. This experiment, therefore, shows that a stronger indexation increases the amplitude of the recessive effect of the energy shock, as well as its inflationary effect.

Finally, Figure 4 shows that the redistributive effects of faster wage indexation are very small, leaving inequality at the same level as in the reference scenario.

#### 4.4.3 On the effectiveness of a redistributive demand policy

An alternative policy consists in increasing demand by redistributing transfers to households. We, therefore, propose to replace the tariff shield with a transfer for all households (demand-oriented policy). This transfer represents a higher share of the budget for the most disadvantaged as this transfer is targeted to allow households to finance their incompressible energy consumption. We then have to calibrate the part of consumption that the government considers to be incompressible. To do this, it is assumed that the incompressible consumption for all households is evaluated by the government at 20% of the total energy consumption of the average household. The budgetary cost of such a measure is equivalent to 25% of that induced by the tariff shield. This measure is redistributive because the share of incompressible energy consumption in energy consumption for each decile goes from 31% for individuals whose income is in the first decile to 14% for those in the tenth decile.<sup>24</sup> Finally, it should be noted that low-income households also have the lowest price elasticity with respect to energy, which shows that it is less easy for them to cushion the impact of the energy shock on their consumption (see Figure 1).

As it is shown in Table 8, this policy is less effective in supporting growth:  $(1.9 - 1.5) \times 2 = 0.8$  point of growth is lost over two years.<sup>25</sup> It is also much more inflationary because it stimulates directly the demand and thus activates the price-wage spiral more strongly. This context of high inflation then leads the ECB to sharply increase its key interest rate. Therefore, even with a lower fiscal cost in absolute terms, weak growth and higher interest rate resulting in an increased debt burden, lead to a surge in the debt-to-GDP ratio compared to the tariff shield scenario.

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<sup>24</sup>The share of incompressible energy consumption in energy consumption for each decile is 31% for D1, 26% for D2, 24% for D3, 21% for D4, 20% for D5, 19% for D6, 17% for D7, 18% for D8, 16% for D9 and 14% for D10. These values have been computed from the INSEE's "Household Budget" survey data.

<sup>25</sup>In Appendix G, the complete description of the quarterly path of the aggregates is presented.

	GDP		Inflation		Debt GDP	
No tariff shield	2022	1.11%	1.0%	7.5%	7.2%	2027 110.7%
	2023	0.92%		6.4%		
Tariff shield 2022 2023	2022	2.85%	1.9%	6.5%	4.9%	2027 112.5%
	2023	1.00%		3.4%		
Subsidies to incompressible consumption	2022	1.70%	1.5%	7.9%	6.4%	2027 119.3%
	2023	1.28%		5.0%		
Targeted subsidies to lowest income households	2022	2.35%	2.1%	8.1%	6.7%	2027 116.1%
	2023	1.88%		5.3%		

Table 8: Redistributive Demand Policy

But this redistributive demand policy leads to a greater reduction in inequalities. With this transfer targeted on the incompressible energy consumption, the consumption of the T10 which was 2.25 higher than that of the B10 in 1Q2022 now only stands at 2.15 in 4Q2023, i.e. a decrease of 4.5% of this measure of inequality. The increase in the consumption ratio of the T10 compared to that of the Middle is almost identical to that with a tariff shield (benchmark scenario). The ratio of Middle consumption compared to that of B10 drops from 1.60 in 4Q2023 to 1.50, i.e. a 6% drop in this measure of inequality. This larger reduction in inequalities is explained by the significantly larger MPC of low-earning households, their larger share of energy in their consumption baskets and their lower price elasticity (see Figure 1).

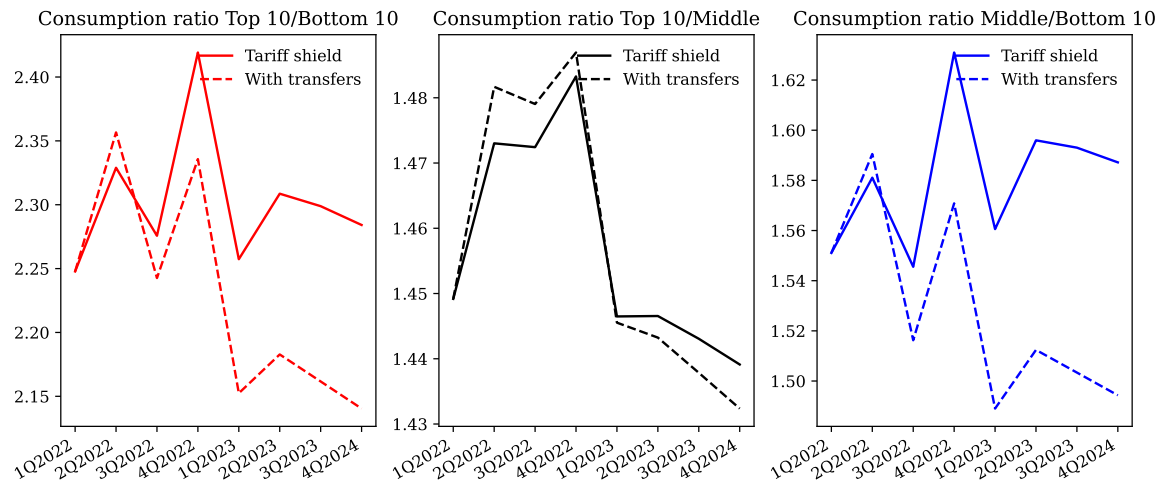


Figure 5: Dynamics of Inequalities: a Redistributive Demand Policy

But, this demand policy redistributes the same transfer to all households, while the highest

incomes households have a lower propensity to consume (see Appendix H). It may therefore be preferable to target all transfers to the most modest households. We target transfers to households with incomes 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 40% lower. As it is shown in Table 8, these “targeted subsidies” to lowest income households, generate more growth than the tariff shield by allowing to gain  $(2.1 - 1.9) \times 2 = 0.4$  points of growth over two years. But, this policy induces larger inflation and larger public debt than the tariff shield. Indeed, by strongly stimulating demand, this policy adds to the inflationary tensions already induced by the energy shock. This leads to a strong increase in the interest rate, and thus to a larger financial cost of the public debt. Hence, even if the ex-ante cost is smaller than the tariff shield (only 30% of the household perceived a transfer, of an amount twice larger than their incompressible consumption), the effective cost of this targeted demand policy is larger because its strong inflationary effects induce a steep rising interest rate. Hence, even if it seems possible to shape the transfers in a way that this policy leads to more growth than the tariff shield, it also induces costs in terms of inflation and public debt, which are then significantly higher. For these reasons, the tariff shield seems to be better designed to fight the recessive effects of the rise in energy prices.

## 5 Conclusion

This article develops a method for evaluating different policies aimed at combating the recessionary effects of rising energy prices. At the time when this shock hit European countries (at the beginning of 2022), policy-maker must compare different policies so that the best one could be put in place. We propose to extend the method of conditional forecasts to HANK models, in order to compare the impacts of different policies on macroeconomic aggregates as well as on inequalities, using only the information set available at the time when policy-makers make their choices (“real-time” policy evaluation).

We show that the “tariff shield” implemented in France from 2022 to 2023 appears as a good compromise to dampen inflation, support growth, and limit the rise of inequality. We estimate the fiscal cost of this measure at 58 billion euros in 2022, and 52 billion in 2023, i.e. approximately 2 points of GDP, which will lead to an increase of 2.5 points in the debt-to-GDP ratio in 2027.

This policy seems to explain why France experienced lower inflation than its European partners. We show that supporting this policy through wage indexation is not desirable. Finally, the tariff shield is more effective than a redistributive demand policy (direct transfers to households) from a macroeconomic point of view because it provides greater support for employment by containing the rise in labor cost.

Note that our study omits the “free rider” problem highlighted by [Auclert et al. \(2023\)](#): if all countries had implemented a tariff shield, the price of energy would have risen even more, thus cancelling out the effect of the policy. But in this crisis, which seems to have been a one-shot game, France was the first and quickest to react. This opportunistic reaction has given the French economy a temporary competitive advantage.

The most important limitation of the tariff shield is its environmental cost. Indeed, by subsidizing energy consumption, it fails at inducing energy-saving behaviors. The recent rise in energy prices and its consequences on the purchasing power of households, particularly the poorest, also calls into question the acceptability of environmental policies (such as the introduction of a carbon tax) that lead to an increase in relative energy prices. Our model can be extended to account for a carbon tax and used to evaluate additional policies that may help alleviate its negative impacts on the French economy as done in [Langot et al. \(2023\)](#).



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## A French Data

### A.1 Observed data

Data	Web access	Providers
Population	<a href="#">DBnomics code</a>	Eurostat
GDP	<a href="#">DBnomics code</a>	Eurostat
CPI	<a href="#">DBnomics code</a>	INSEE
Energy price	<a href="#">DBnomics code</a>	OECD
Government consumption	<a href="#">DBnomics code</a>	Eurostat
Government transfers	<a href="#">DBnomics code</a>	Eurostat
Public debt	<a href="#">DBnomics code</a>	Eurostat

Table 9: Data sources

All the raw series of Table 9 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 series is monthly. It is quarterlyized using a moving average, from which we derive  $\pi$ . Finally the energy price ( $P_{FE}$ ) is the crude oil price.

### A.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
IPC (inflation rate)	1.6%	4.5%	3.2%	1.9%	1.75%	1.75%	1.75%

Table 10: 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, IPC and energy price of the year  $\tau$ , we compute the quarterly growth rates  $g_{\tau}^z$  using the annual growth rates  $g_{a,\tau}^z$  (forecasts of the GDP, IPC and energy price growth rates reported in

the Table 10)<sup>26</sup>, solving

$$(1 + g_{a,\tau}^z) \times \sum_{q=1Q}^{4Q} Z_{q,\tau} = Z_{1Q,\tau+1} \times [1 + (1 + g_{\tau}^z) + (1 + g_{\tau}^z)^2 + (1 + g_{\tau}^z)^3]$$

where  $Z = \text{GDP, IPC, energy price}$ . We built the quarterly data for GDP, IPC and energy price over the periods 1Q2022 to 4Q2027 (see panels (a), (b) & (c) of Figure 6). We get quarterly series by interpolating the GDP share of  $G$  (government expenditure) and the GDP share of  $T$  (government transfers). Then, using the quarterly data of GDP, we built quarterly data for  $G$  and  $T$  over the periods 1Q2022 to 4Q2027 (see panels (d) & (e) of the Figure 6). Concerning the debt-to-GDP ratio, we simply perform quarterly interpolation to construct quarterly data for  $\frac{b}{y}$  over the periods 1Q2022 to 4Q2027 (see panel (f) of the Figure 6).

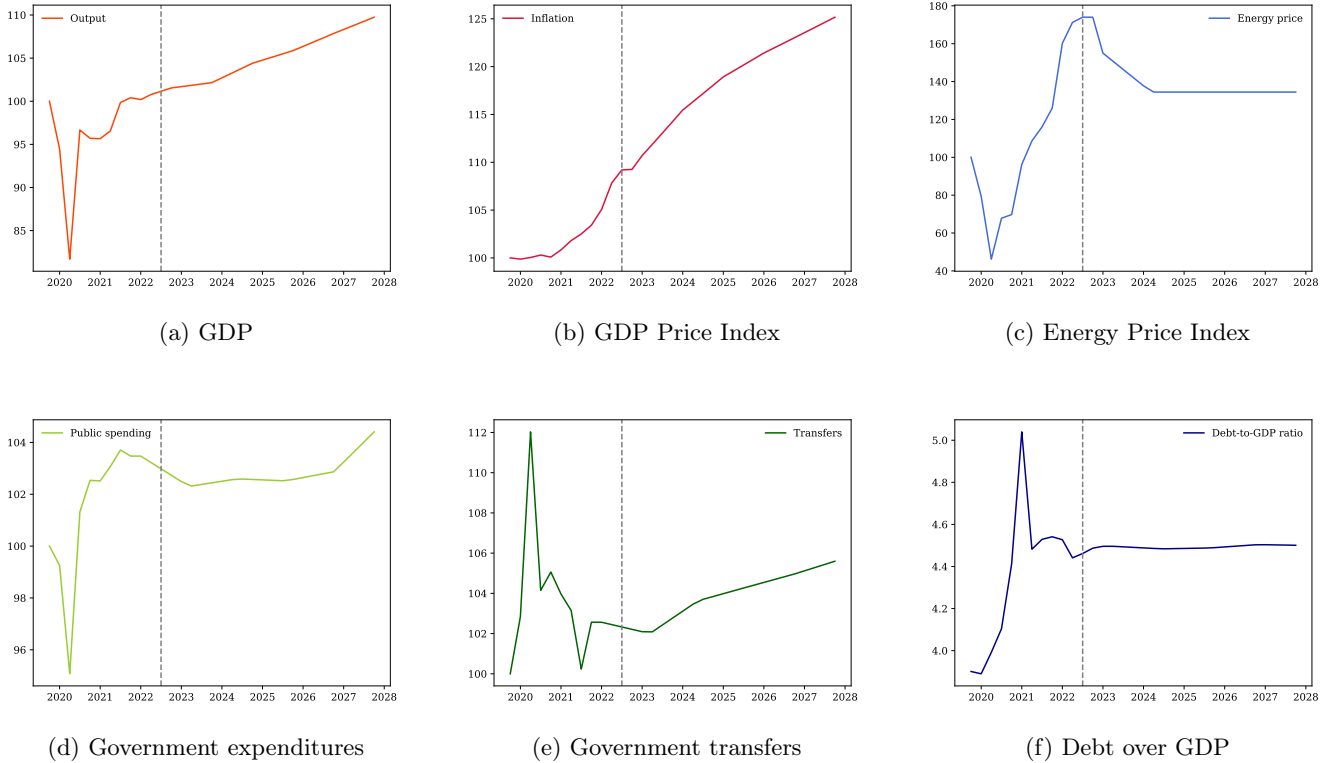
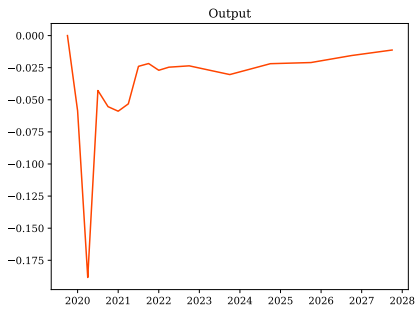


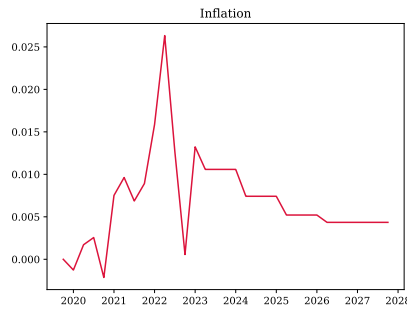
Figure 6: Raw Data: 4Q2019 = 100

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 extracted (see Figure 7).

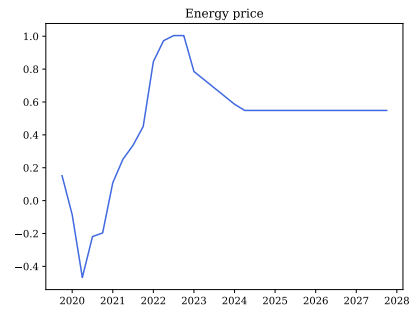
<sup>26</sup>For the energy price, we deduce the annual growth rate from forecasts of the data in level.



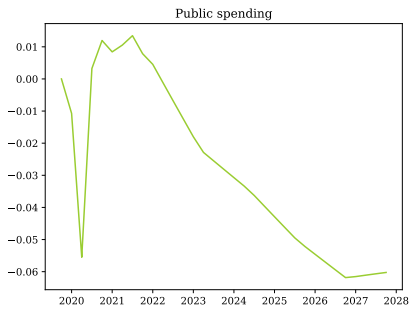
(a)  $\frac{GDP_t}{1.0032^t} \frac{1}{100} - 1$



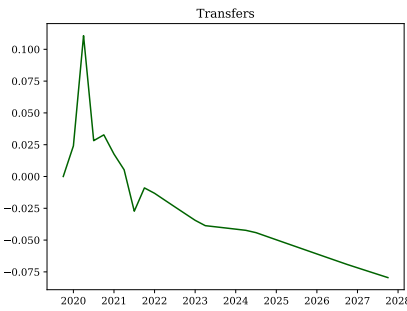
(b)  $\frac{P_t - P_{t-1}}{P_{t-1}}$



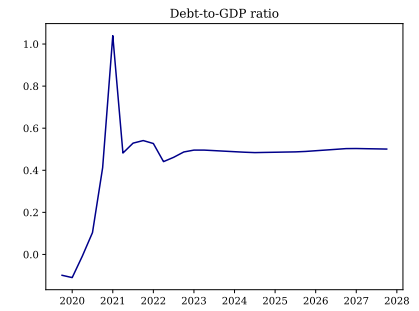
(c)  $\frac{\text{Energy Price Index}_t - 86.819}{86.819}$



(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 7: Stationarized French Data: 2019 Q4 = 0

## B Estimation of the exogenous shocks processes

The persistence  $\rho$  and the standard deviation  $\sigma$  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 11. For energy prices ( $p_{FE}$ ), 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  $\{p_{FE}, G, T\}$ . 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	$p_{FE}$	$\rho$	$\mathcal{N}(0.94, 0.036)$	0.816	0.0364	[0.734, 0.854]
		$\sigma$	$\mathcal{N}(0.15, 0.085)$	0.0122	0.00238	[0.00955, 0.0172]
Government spending	$G$	$\rho$	$\mathcal{N}(0.95, 0.030)$	0.921	0.0143	[0.892, 0.938]
		$\sigma$	$\mathcal{N}(0.0036, 0.0033)$	0.00356	0.000270	[0.00324, 0.00413]
Transfers	$T$	$\rho$	$\mathcal{N}(0.91, 0.044)$	0.873	0.0242	[0.821, 0.900]
		$\sigma$	$\mathcal{N}(0.0052, 0.0091)$	0.00500	0.000386	[0.00457, 0.00584]
Taxes	$\vartheta$	$\rho$	$\beta(0.8, 0.05)$	0.778	0.0242	[0.737, 0.817]
		$\sigma$	$inv\Gamma(0.05, 1.0)$	0.152	0.0115	[0.131, 0.169]
Price markup	$\mu$	$\rho$	$\beta(0.8, 0.05)$	0.793	0.0243	[0.750, 0.830]
		$\sigma$	$inv\Gamma(0.05, 1.0)$	0.0571	0.00505	[0.0518, 0.0684]
Preference	$\beta$	$\rho$	$\beta(0.8, 0.05)$	0.887	0.0158	[0.860, 0.912]
		$\sigma$	$inv\Gamma(0.05, 1.0)$	0.00468	0.000683	[0.00376, 0.00600]

Table 11: Bayesian estimation results of the parameters of the  $AR(1)$  processes

Because our model is not formulated in a linear state-space way, the Kalman filter cannot be used to evaluate the log-likelihood. Instead, and consistently with Auclert et al. (2021a), the log-likelihood of our model is computed using the covariance matrix linking the model's variables. This covariance matrix relies on the Jacobian of the model which can be obtained using the sequence space method. Note that because we do not estimating structural parameters that affect the Jacobian of the system, the same Jacobian can be reused throughout the entire process of estimation, which saves some computing time.

## C Shock decomposition

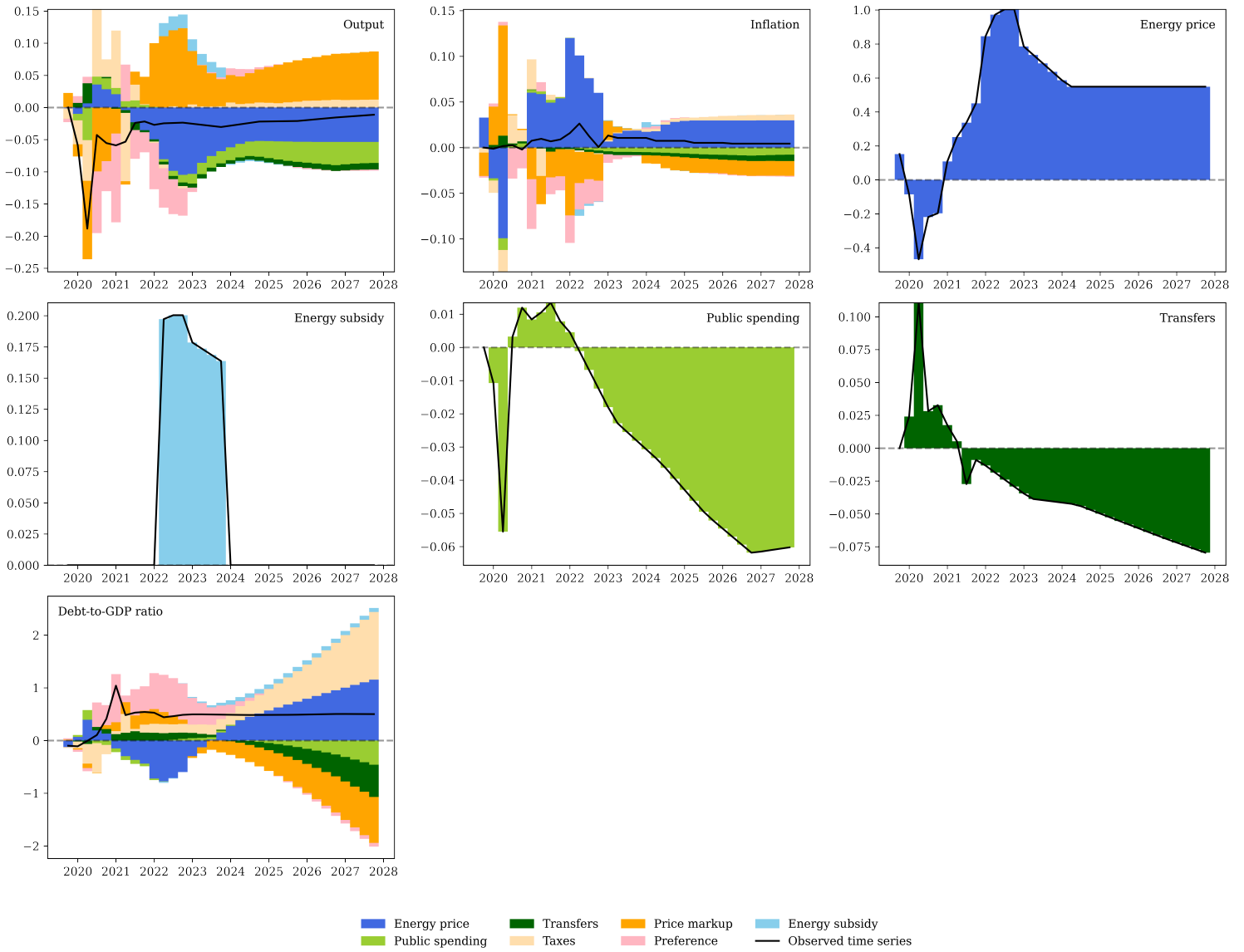


Figure 8: Shock decomposition since 4Q2019



## D 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. Given that all shocks have an innovation normally distributed ( $\varepsilon^Z \rightsquigarrow N(0, \sigma_Z^2)$  for  $Z = \beta, \mu, \vartheta, G, T, P_{FE}$ ), we use the standard deviation of these estimated shocks over the sample 1Q2022-4Q2027 to compute the confidence intervals of the model’s forecasts, under the restriction that the subsidy on energy consumption has no uncertainty. First, given that the standard deviation of government and transfer innovations ( $\varepsilon^G$  and  $\varepsilon^T$ ) are

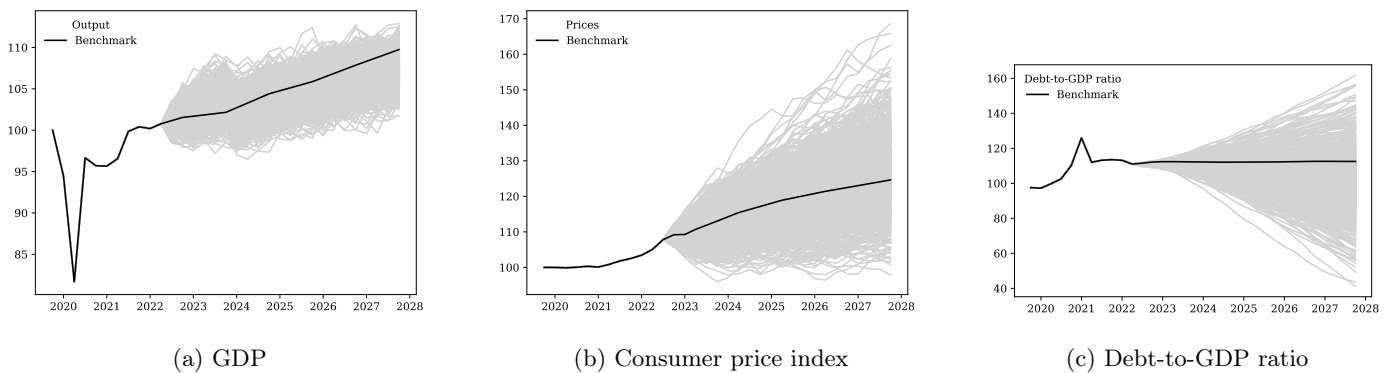
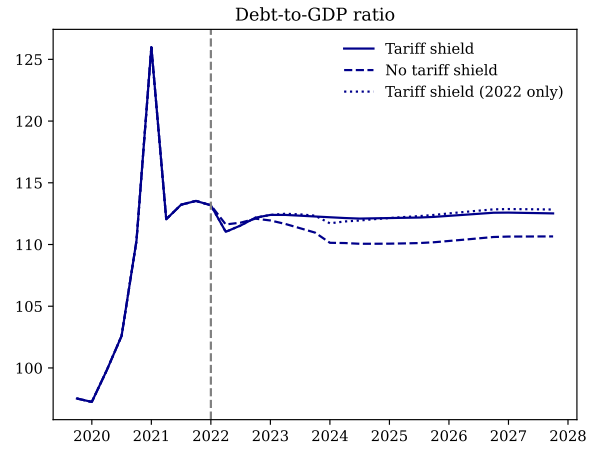
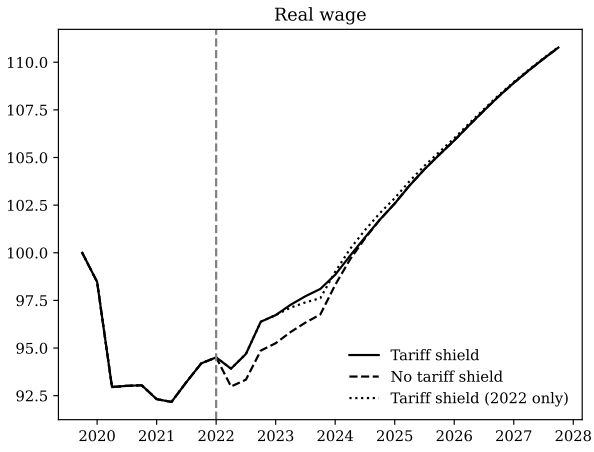
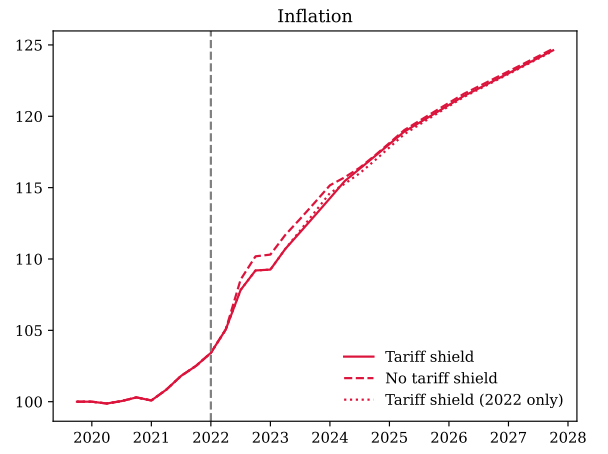
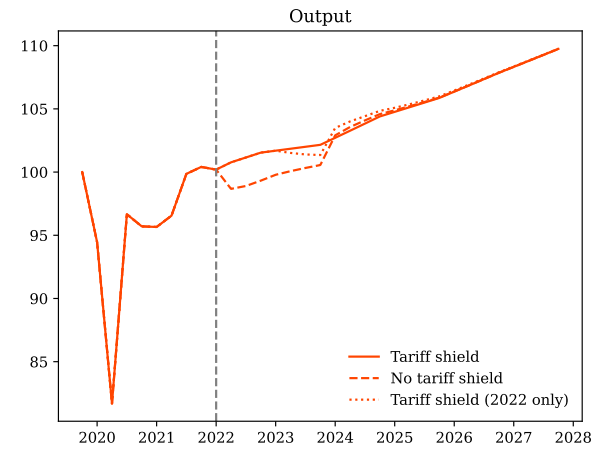


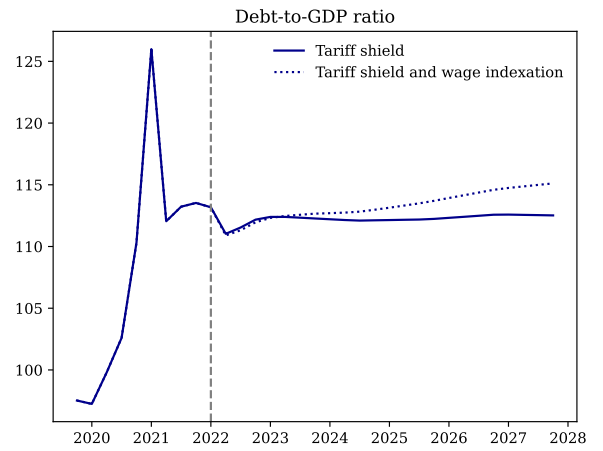
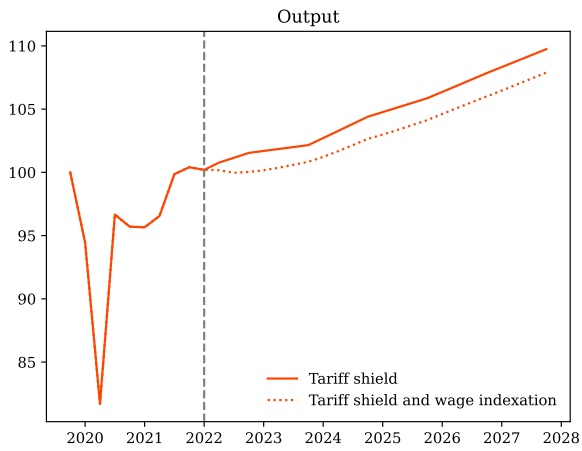
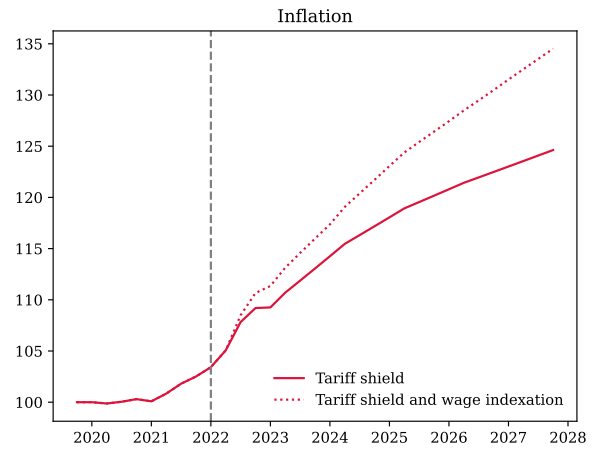
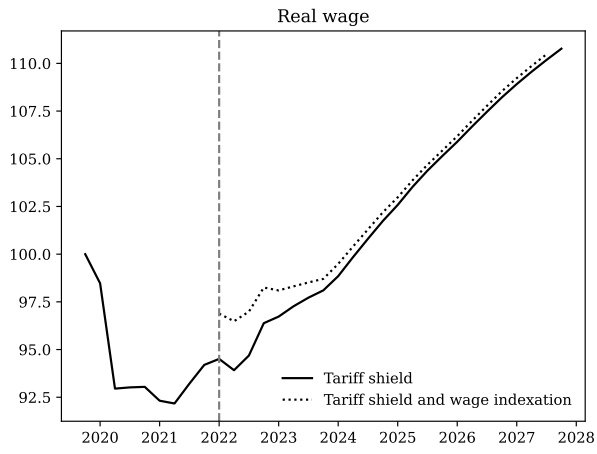
Figure 9: Uncertainty on Model’s Forecasts

small, the large surfaces of the confidence bands reported in Figure 9 underline that the innovations of the shocks on  $\{\beta, \mu, \vartheta, P_{FE}\}$  have a large variance leading to uncertainty on forecasts.

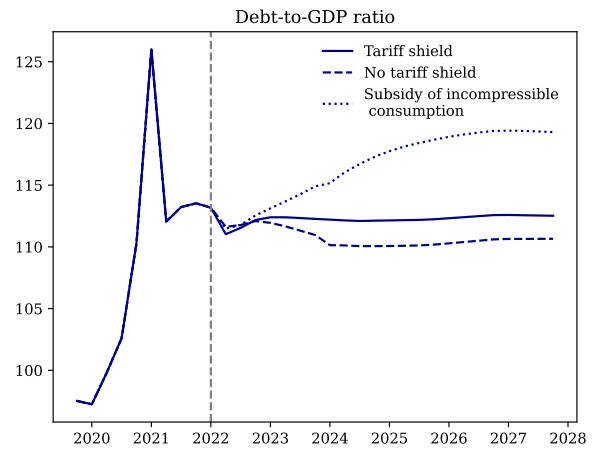
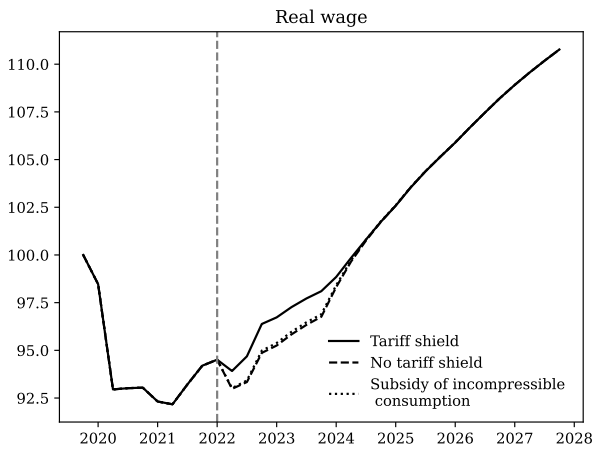
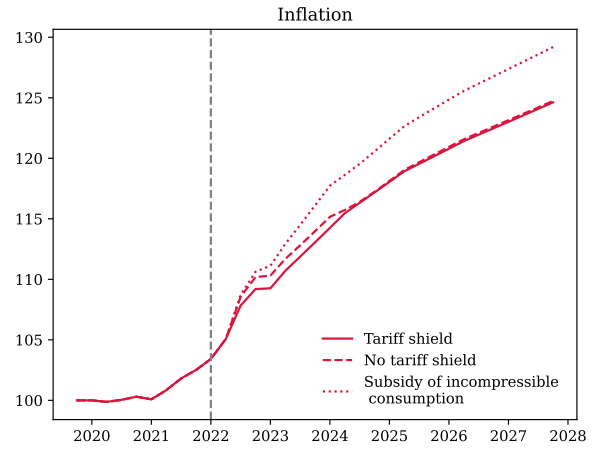
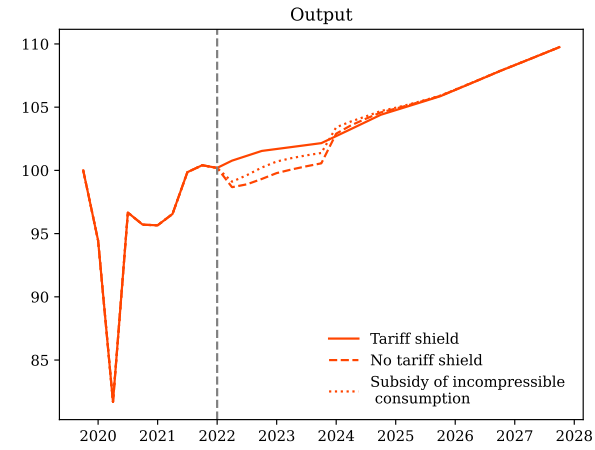
## E Tariff shield: Aggregates since 4Q2019



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



# G Subsidizing incompressible energy consumption: Aggregates since 4Q2019



## H IRFs by productivity levels

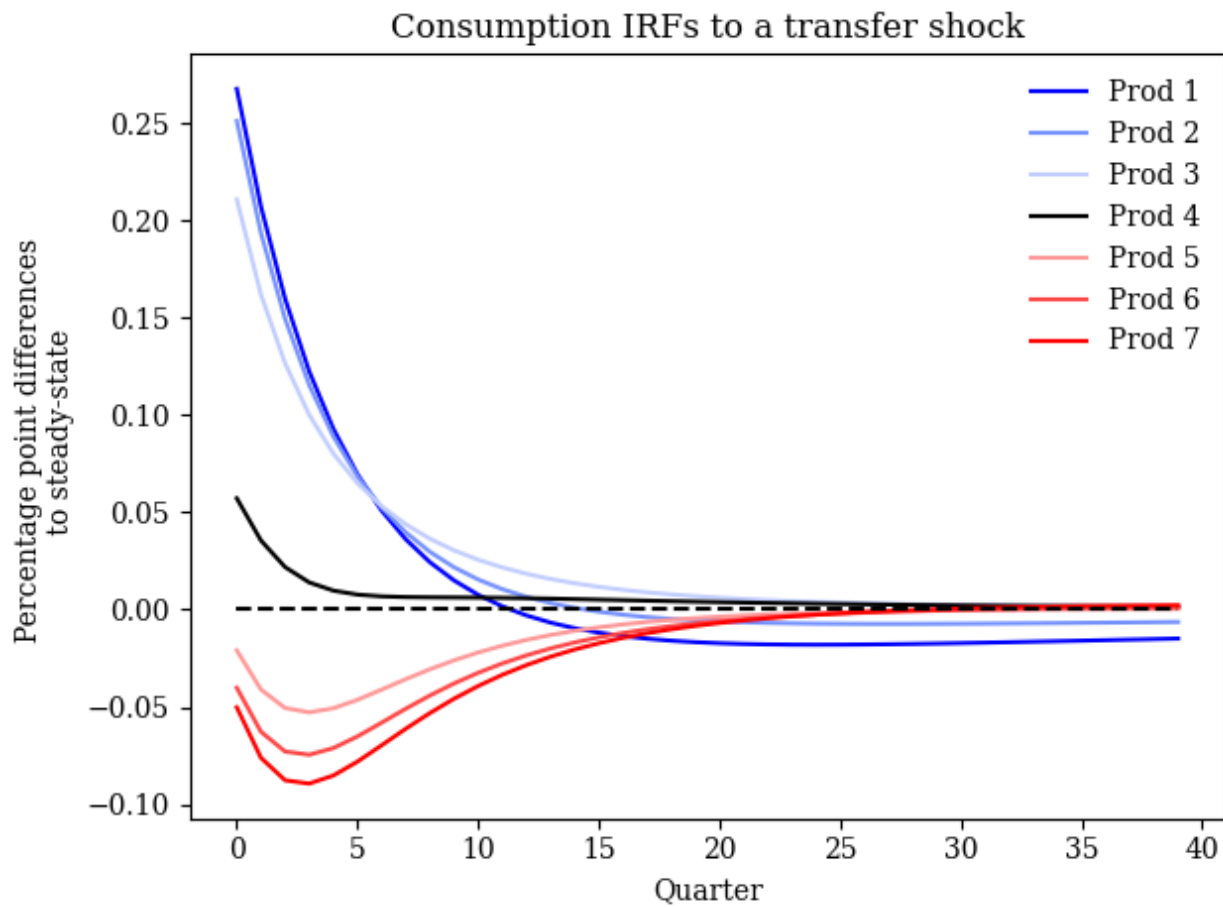


Figure 10: Consumption impulse response function of each type of household.