Debt Sustainability and Fiscal Consolidation in HANK *

François Langot† Jocelyn Maillard ‡ Selma Malmberg§
Fabien Tripier¶ Jean-Olivier Hairault‖

February 2024

Abstract

This paper develops a methodology to perform stochastic debt-sustainability analysis and fiscal-consolidation program's evaluation in a Heterogeneous-Agent New-Keynesian (HANK) model. The model encompasses heterogeneous households, with three types of skill, non-linear fiscal schemes, and nominal rigidities. As Finance Acts incorporate forecasts over the next years to attest to the budgetary sustainability of their commitments, we use the conditional-forecast method to assess their credibility and the effectiveness of the government policy. We apply this method to the 2024 French Finance Act and highlight the risks surrounding the government strategy to reduce public debt by 2027. We then show that a stronger debt-reduction policy can be implemented without penalizing growth or worsening inequalities if the government cuts social-insurance-based transfers more sharply without cutting social-assistance transfers. Furthermore, we measure the benefits of this policy in terms of reducing the risk burden on public debt.

Keywords: HANK model; Policy evaluation; Debt sustainability; Fiscal policy.

JEL codes: C54; C63; E32; E62; H63; H68.

*Corresponding Author: François Langot, flangot@univ-lemans.fr.
†Le Mans University (GAINS-TEPP, IRA), Paris School of Economics (PSE), and CEPREMAP
‡CEPREMAP; jocelyn.maillard@cepremap.org
§Le Mans University (GAINS-TEPP, IRA) and CEPREMAP; selma@dynare.org
¶Université Paris Dauphine and CEPREMAP; fabien.tripier@dauphine.psl.eu
‖Paris School of Economics (PSE) and CEPREMAP; jean-olivier.hairault@psemail.eu

1 Introduction

The rise in interest rates from 2022 has increased the sustainability risk of public debt which has soared around the world in the wake of the economic crises of the past fifteen years. These circumstances call for fiscal-consolidation programs aimed at stabilizing or indeed reducing public debt. Experience has shown, however, that many of these programs have failed to achieve their objectives for two main reasons. The first reason is that the recessionary impact of these programs on GDP may be so large that there is no reduction in the debt-to-GDP ratio (Blanchard and Leigh (2013, 2014), IMF (2023)). Second, they tend to increase inequality (Ball et al. (2013), Brinca et al. (2021))) and then may lead to electoral outcomes likely to undermine the continuation of these programs (Brender and Drazen (2008)).[1] For these two reasons, a model to evaluate fiscal-consolidation programs must take into account household heterogeneity. It is crucial to assess accurately the macroeconomic impact of these programs, which depends crucially on fiscal/budgetary multipliers poorly measured in representative agent models (Kaplan et al. (2018), Auclert et al. (2023)), and to anticipate the distributional effects of these programs, which may affect households differently according to income and wealth levels. Therefore, in this article, we propose to use a Heterogeneous-Agent New-Keynesian (HANK) model to assess public-debt sustainability and fiscal-consolidation programs.

Besides accounting for the heterogeneity of agents, another challenge in assessing debt-sustainability and fiscal-consolidation programs is defining the economic context in which the program is undertaken. Fiscal consolidation has a direct impact not only on the government's public finances, but also on agents' decision-making rules, and thus on the economy's response to shocks. Assessing the impact of a fiscal consolidation program therefore requires making assumptions about the economic environment in which it will be implemented. This is particularly important because the potentially self-defeating effects of these programs are very short term, in the years immediately following implementation. To address this challenge we resort to conditional-forecast methods, which allows us to identify the set of shocks that are consistent with a set of economic forecasts, given the structural model describing the economy. Conditional forecasts have been applied in VAR (Waggoner and Zha (1999), Antolin-Diaz et al. (2021)) and New-Keynesian models with representative agents (Del Negro and Schorfheide (2013a,b)). We show in this article, how to use these methods for a HANK model using the sequence-space method introduced by Auclert et al. (2021).

The choice of economic forecasts is crucial to the application of conditional-forecast methods. To do this, we propose to use the government forecasts included in Finance Acts. In Finance Acts, governments announce their spending and revenue programs for the years to come, which lead them to make forecasts about aggregate economic indicators (GDP, inflation, interest rates, public debt,...) attesting to the budgetary sustainability of their policies. These forecasts are based on a very large set of information and use both quantitative and qualitative methods.[2] Our aim in this article is not to improve the quality of these forecasts but to assess their overall consistency and evaluate alternative policies through the lens of our HANK model using conditional-forecast methods. By doing so, we provide a new tool for stochastic debt-sustainability analysis. The dynamics of public debt depend on the fiscal situation (specifically, the level of the public deficit) and the macroeconomic environment described by the real interest rate (the difference between the debt-service rate and inflation) and the economic-growth rate (see e.g. Bohn (1998) and Blanchard (2019)). The stochastic dimension of our analysis of debt sustainability comes from the estimation

[1] See Alesina et al. (2021) for a discussion on this issue.

[2] The forecasts contained in the Finance Act 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.

of the structural shocks that hit the economy. The estimation of the distribution of these shocks for the future by means of conditional-forecasting methods allows us to determine distributions for the future debt trajectory in accordance with Blanchard et al. (2021)'s recommendations for stochastic debt-sustainability analysis.[3]

We apply our methodology to 2024 France Finance Act, which includes projections through 2027. As we use a structural approach to identify the sequences of shocks that allow the government forecasts to become realizations, the choice of the model is crucial for our analysis. We develop a HANK model for France with energy goods in consumption and production sectors to include shocks on energy price in model's estimation; and heterogeneous level of education. The role of energy shocks is crucial because the Finance Act aims to put the French economy on a desinflationist path where GDP growth is ensured after the two successive COVID-19 and energy crises. In this context, the advantages of a HANK are twofold. First, a HANK model has the advantage of predicting the observed depressive effect of a positive energy-price shock on (see e.g. Blanchard and Gali (2007)), contrary to a Representative-Agent New-Keynesian (RANK) model, as shown in Auclert et al. (2023).[4] Second, a HANK model allows us to properly capture the greater sensitivity of the poorest to the shock of energy prices, thanks to an incompressible consumption of energy products.[5]. Concerning the labor market, standard modeling of nominal-wage rigidities resulting from a nominal wage set by a union monopoly (see Auclert et al. (2018)) implies that labor supply is homogeneous across heterogeneous agents. However, since the government forecasts strong employment creations, it is also necessary to faithfully model labor-supply behavior, which differs depending on the level of income. It is then necessary to distinguish labor markets according to workers' levels of education to have a union monopoly for each of them, and therefore labor-supply elasticities specific to each type of job. We thus propose to distinguish three labor-market segments to be as close as possible to the differentiated dynamics in wages, hours worked by employees, and the number of jobs in each segment.

Based on calibrated parameters for the steady state and estimated parameters for the shocks' processes over the 2Q2003-4Q2019 period, our HANK model for the French economy identifies the sequences of each structural shock allowing to reproduce the government forecasts (output, inflation, interest rates, hours worked, wages and public debt) conditionally on the government's policies (expenditures and revenues) and energy prices. Solutions are obtained thanks to the first-order approximation around the steady state developed by Reiter (2009), (2010) and the sequence-space Jacobian approach proposed by Auclert et al. (2021). The challenge for conditional forecasts, when applied to economic policies, is that they may be exposed to Lucas (1976) critique: changes in economic policy are likely to modify agents' behavior, making the general-equilibrium model estimated with past data ineffective for predicting future shocks. To tackle this problem, we implement a stability test of policy rules and show how to incorporate a possible shift in policy into the evaluation method. Our estimations reveal that only the government's decision rules are unstable between the pre and after-Finance Act periods. It suggests that after twenty years of rising public debt in France, a new fiscal policy will be implemented by the government to prevent a future debt increase. Our assessment also indicates that all shocks, except for those on government spending, explain over

[3]A key difference between the tool of stochastic debt-sustainability analysis proposed in this article and the one developed in institutions (such as the European Commission, see Bouabdallah et al. (2017)) is that the distributions of shocks are based on the estimation of a general-equilibrium model and not on econometric models without economic structure.

[4]In a RANK model, the energy shock leads households to substitute energy goods by domestically-produced goods, which counterfactually sustains GDP growth in the home country.

[5]The model generates a share of the energy goods in the consumption basket decreasing with household incomes as in the data, but also a price elasticity increasing with incomes, making it difficult for the poorest to avoid energy-price increases.

80% of GDP deviations from the trend. As the variance explained by these shocks is quantitatively significant, they provide an initial assessment of the uncertainty surrounding the 2024 Finance Act and the government's bet to stabilize public debt through high GDP growth, rather than through more steadfast adjustments on its spending and revenues.

This risk to the trajectory of French public debt is particularly worrying in the context of rising interest rates from 2022. Indeed, France has particularly high levels of public debt and deficit and is subject to the European Union's Stability and Growth Pact rules. Could France reduce its indebtedness more sharply than forecasted in the Finance Act? The advantage of our method of evaluation is that we can use the model's conditional forecasts to compare the government's policy with alternative policies. Using the structural shocks estimated for the forecast period, we can compare the future trajectories of the French economy according to several fiscal and budgetary policies in the same economic context defined by these structural shocks. We use our model to determine the extent to which an alternative policy to that proposed by the government would reduce debt without penalizing economic growth or exacerbating inequality. We show that a strategy based on deeper cuts in public consumption expenditure would not be effective because of the economic recession it would cause. A strategy based on deeper cuts in public transfers has no detrimental effect on economic growth, but depending on the nature of the transfer cuts, it may exacerbate inequality. We show that if the reduction in public transfers only concerns transfers based on social-security contributions (i.e. Bismarkian type), and if assistance transfers (i.e. Beveridgian type) are left unchanged, then it is possible to achieve a large reduction in the debt-to-GDP ratio (4.6 percentage points more than the Finance Act) without increasing consumption inequalities or reducing economic growth compared to the Finance Act.

Literature. Our paper contributes to several strands of the literature. We contribute to the literature on policy evaluations based on conditional forecasts. Using external information to set the evolution of economic aggregates, conditional forecasts identify shock realizations that make the equilibrium model's paths consistent with the paths based on this external information. A large set of studies using conditional forecasts have focused on the analysis of economic uncertainty when the path of the future interest rate is given, whether based on VAR models (Waggoner and Zha (1999) and Antolin-Diaz et al. (2021)) or on DSGE models (Del Negro and Schorfheide (2013b)). Our contribution consists of identifying the structural shocks of a HANK model using the conditional-forecast method and data provided by a government's Finance Act forecasts. The solution to this identifying problem is obtained through Auclert et al. (2021)'s sequence-space Jacobian methodology.[6] We also contribute to the literature on the quantitative analysis of HANK models. Following Kaplan et al. (2018) and Auclert et al. (2021) that have demonstrated the empirical performance of these HANK models and their relevance for macroeconomic policy evaluations[7], a set of papers illustrate how to apply these models to macroeconomic policy analysis. Auclert et al. (2018) provide a complete analysis of fiscal and monetary multipliers in HANK models and discuss the advantage of

[6] Many new methods have been developed to more easily use HANK models. In continuous time, Achdou et al. (2022) have proposed 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. (2021) approach integrates the set of tools necessary for macroeconomists 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. As such, we use this approach.

[7] These works follow the seminal contributions of Aiyagari (1994) and Krusell and Smith (1998), and develop quantitative models with heterogeneous agents, which also included market frictions, as price and wage rigidities, relevant for business cycle analysis.

these models compared to usual RANK models. Auclert et al. (2023), Pieroni (2023) or Bayer et al. (2023) and Langot et al. (2023) use HANK models to analyze the impact of the recent energy crisis.[8] Our paper extends these analyses by estimating a HANK model to explain the business cycle and inequality dynamics of the French economy which is a member of a monetary union. Therefore, the Taylor rule is 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 fiscal-consolidation programs, which has been extensively studied empirically e.g. Alesina et al. (2015), Ball et al. (2013), Blanchard and Leigh (2013), IMF (2023), and Brinca et al. (2021) in a neoclassical macro-model with heterogeneous agents and incomplete insurance markets. As Brinca et al. (2021), we analyze the incidence of fiscal consolidation on output and inequality, but in an estimated model which takes into account nominal rigidity and monetary policy.

The remainder of the article is organized as follows. Section 2 presents the model. Section 3 describes the quantitative methodology and the estimation results. Section 4 presents the method of conditional forecasts and analyzes the quantitative results. Section 5 discusses the debt sustainability implied by the Finance Act and section 6 assesses alternative fiscal-consolidation programs. Section 7 quantifies the level of risk associated with the debt-to-GDP ratio in the Finance Act and shows how it can be reduced through alternative fiscal consolidation programs. Finally, Section 8 concludes.

2 The Model

The model is an extended version of the ones of Auclert et al. (2018), (2021), and (2023), Pieroni (2023) and Langot et al. (2023).

2.1 Households

There are three types of household skills $s \in \{l, m, h\}$: low (l), medium (m), and high, (h). Within each skill group, households experience idiosyncratic productivity shocks e at the origin of income, wealth, and consumption heterogeneity.

Household decision rules are independent of skill-type s. Hence, we drop the s subscript. These decisions are deduced from the following maximization problem

$$\begin{aligned} V_t(e, a_-) &= \max_{c,n,a\geq 0} \left\{ u(c) - v(n) + \beta_t \sum_{e'} \mathcal{P}(e, e') V_{t+1}(e', a) \right\} \\ s.t. \quad a_t &= a_{t-1} + y_t(a, e) - (1+\tau_c)(1 - s_{H,t}) p_{FE,t} \underline{c}_{FE} - (1+\tau_c) c_t \end{aligned}$$

where the subsistence level for the energy consumption is $\underline{c}_{FE}$, s_H stands for a tariff shield ("bouclier tarifaire"), and p_{FE} is the relative price of energy. The discount factor β_t changes over time to account for demand shocks and is assumed to follow a stationary AR(1) process. The net income $y(a, e)$ and the taxable labor income net of social contributions $z(a, e)$ are defined as follows

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

[8] In Auclert et al. (2023), there is no incompressible consumption and no public debt dynamics, whereas Pieroni (2023) introduces incompressible consumption, but not public debt dynamics. These two papers do not present policy evaluations but theoretical analyses of hypothetical policies. The analysis of Bayer et al. (2023) does not provide an estimation of the model based on time series of aggregates.

where $1+r_t = \frac{1+i_{t-1}}{1+\pi_t}$ and $\pi_t = \frac{P_t}{P_{t-1}} - 1$ and dividends d are distributed non-uniformly across households according to the function $\bar{d}'(e) > 0$. The tax rate on firms' profits is τ_f. The social contributions are proportional to labor incomes, with a contribution rate τ_l. A first component of the transfers, T, is indexed to labor income and taxable (pensions and unemployment benefits), the indexation being defined by $\bar{T}'(e) > 0$. $T\bar{T}(e)$ is thus the Bismarckian part of transfers that the household receives. The second component of transfers, τ, is larger for poorer households. It corresponds to the Beveridgian part of transfers. The government through its policy rules determines the total aggregate amounts of these two transfers. They may change over time to account for transfer shocks, assumed to follow a stationary AR(1) process. Total progressive taxes paid on labor income are

$$\mathcal{T}_{I,t}(a,e) = z_t(a,e) - (1-\mu)(z_t(a,e))^{1-\lambda}$$

where λ determines the degree of progressivity of the tax system. A tax scheme is commonly labeled progressive (regressive) if the ratio of marginal to average tax rates is larger (smaller) than one for every level of income z

$$\frac{\mathcal{T}_I'(z)}{\mathcal{T}_I(z)/z} = \frac{1-(1-\mu)(1-\lambda)z^{-\lambda}}{1-(1-\mu)z^{-\lambda}}$$

The Coefficient of Residual Income Progression ($CRIP$) is

$$CRIP(z) = \frac{\partial(1-\mu)z^{1-\lambda}}{\partial z}\frac{z}{(1-\mu)z^{1-\lambda}} = (1-\mu)(1-\lambda)z^{-\lambda}\frac{z}{(1-\mu)z^{1-\lambda}} = \frac{1-\mathcal{T}_I'(z)}{1-\mathcal{T}_I(z)/z} = 1-\lambda$$

Note that the progressive taxes become transfers if $\mathcal{T}_I(z) < 0$ i.e. when $z < (1-\mu)^{\frac{1}{\lambda}}$.

We assume that $u(c) = \log(c)$, $v(n) = \varphi_{s,t}\frac{n^{1+\nu}}{1+\nu}$. The labor disutility parameters $\varphi_{s,t}$, which are skill specifics, change over time in order to account for labor supply shocks and are assumed to follow a stationary AR(1) process.

Households can buy differentiated but imperfectly substitutable goods c_i

$$c_t = \left(\int c_{i,t}^{\frac{\varepsilon_d - 1}{\varepsilon_d}} di\right)^{\frac{\varepsilon_d}{\varepsilon_d - 1}}$$

sold at price P. ε_d measure the elasticity of substitution between goods i. Each of these differentiated good c_i is a basket of characteristics given by

$$\begin{aligned} c_{i,t} &= \left(\alpha_E^{\frac{1}{\eta_E}}(c_{iFE,t} - \underline{c}_{FE})^{\frac{\eta_E - 1}{\eta_E}} + (1-\alpha_E)^{\frac{1}{\eta_E}}(c_{iH,t})^{\frac{\eta_E-1}{\eta_E}}\right)^{\frac{\eta_E}{\eta_E-1}} \\ &= \left(\alpha_E^{\frac{1}{\eta_E}}(\widetilde{c}_{iFE,t})^{\frac{\eta_E - 1}{\eta_E}} + (1-\alpha_E)^{\frac{1}{\eta_E}}(c_{iH,t})^{\frac{\eta_E-1}{\eta_E}}\right)^{\frac{\eta_E}{\eta_E-1}} \end{aligned}$$

where c_{iFE} is the energy consumption good, which should exceed the subsistence level $\underline{c}_{FE}$, and c_{iH} the domestically produced consumption good. With $p_{H,t} = P_{H,t}/P_t$ and $p_{FE,t} = P_{FE,t}/P_t$, this basket goods $c_{i,t}$ satisfies household's preferences if $c_t = p_{H,t}c_{H,t} + (1-s_{H,t})(1+\tau_P)p_{FE,t}\widetilde{c}_{FE,t}$, with $\widetilde{c}_{FE,t} \equiv c_{FE,t} - \underline{c}_{FE}$, where c represents total household consumption.

2.2 Unions

For each type $s \in \{l, m, h\}$, 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 for the skill group s is

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

where $W^s_t = \left(\int_k \left(W^s_{k,t} \right)^{1-\varepsilon^s} dk \right)^{\frac{1}{1-\varepsilon^s}}$ and the equilibrium distribution satisfies $\sum_s \omega^s \int_e \int_a d\Gamma^s = 1$. The unions' decisions for the nominal wages lead to the NKPCs:

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

with tax distortion $td^s_t = \frac{(1-\tau_{inc})(1-\tau_{ssc})}{1+\tau_c}$, union markup $\mu^s_w = \frac{\varepsilon_s}{\varepsilon_s - 1}$ and wage rigidity parameters $\kappa^s_w \equiv \frac{\varepsilon^s}{\psi^s_W}$ that are specific to each s. Remark that the average value of a net wage increase in terms of consumption units, $\widetilde{u}'_t(c^s, \overline{\mathcal{T}}^s) \equiv \int_{e,a_-} u'(c^s) e_t (1 - \overline{\mathcal{T}}^s) d\Gamma^s(e, a_-)$ with $\overline{\mathcal{T}}$ the average tax rate, is deduced from the households behaviors and computed at the equilibrium.[9]

2.3 Goods Supply

2.3.1 Basic-good producers' decisions

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

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

$$s.t. \quad \left\{ \begin{array}{rcl} Y_{N,t} & \leq & \left(\alpha_l^{\frac{1}{\varepsilon_N}} \left(A^l_t N^l_t \right)^{\frac{\varepsilon_N - 1}{\varepsilon_N}} + \alpha_m^{\frac{1}{\varepsilon_N}} \left(A^m_t N^m_t \right)^{\frac{\varepsilon_N - 1}{\varepsilon_N}} + \alpha_h^{\frac{1}{\varepsilon_N}} \left(A^h_t N^h_t \right)^{\frac{\varepsilon_N - 1}{\varepsilon_N}} \right)^{\frac{\varepsilon_N}{\varepsilon_N - 1}} \\ N^s_t & = & \sum_i \omega^s \pi^s_i e^s_{i,t} n^s_{i,t} \quad \forall s \in \{l, m, h\} \end{array} \right.$$

where ω^s is the fraction of s-type in the population, $\sum_i \pi^s_i e^s_i = \varpi^s$ is the average productivity of each population and A^s a s-type productivity shock assumed to follow a stationary AR(1) process $\forall s = l, m, h$.

The optimal labor demands are

$$N^s_t = \frac{\alpha_s}{A^s_t} \left(\frac{W^s_t / (A^s_t \varpi^s)}{MC_{N,t}} \right)^{-\varepsilon_N} Y_{N,t} \quad \text{with} \quad MC_{N,t} = \left(\sum_s \alpha_s \left(\frac{W^s_t}{A^s_t \varpi^s} \right)^{1-\varepsilon_N} \right)^{\frac{1}{1-\varepsilon_N}} \quad \forall s \in \{l, m, h\}$$

As all s-type employees work the same number of hours (Unions), then $n^s_{i,t} = n^s_{i',t} \equiv n^s_t$, $\forall i, i'$. After normalizing $n^s_t = 1$ (α_s are found to match this restriction),[10] $N^s_t = \sum_i \omega^s \pi^s_i e^s_{i,t}$, knowing $\sum_s \omega_s = 1$. Assuming perfect competition in this market, profits and free-entry conditions lead to:

$$\Pi_{N,t} = (W_t - MC_{N,t}) Y_{N,t} = 0 \quad \Rightarrow \quad W_t = MC_{N,t} \quad \Leftrightarrow \quad w_t = mc_{N,t}, \quad \text{with} \left\{ \begin{array}{rcl} w_t & = & \frac{W_t}{P_t} \\ mc_{N,t} & = & \frac{MC_{N,t}}{P_t} \end{array} \right.$$

[9] See Appendix A for details on the derivation of the Phillips curve.

[10] See Appendix B for more details

2.3.2 Intermediate-good producers' decisions

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

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

The optimal demands of production factors are:

$$Y_{N,t} = (1-\alpha_f) \left(\frac{W_t}{MC_{H,t}} \right)^{-\sigma_f} Y_{H,t}, \qquad E_t = \alpha_f \left(\frac{P_{FE,t}}{MC_{H,t}} \right)^{-\sigma_f} Y_{H,t}$$

with a marginal cost defined as follows

$$MC_{H,t} \;\; = \;\; Z_t^{-\frac{1}{\sigma_f}} \left(\alpha_f (P_{FE,t})^{1-\sigma_f} + (1-\alpha_f) W_t^{1-\sigma_f} \right)^{\frac{1}{1-\sigma_f}}$$

Assuming perfect competition in this market, profits and free-entry conditions lead to:

$$\Pi_{H,t} = (P_{H,t} - MC_{H,t}) Y_{H,t} = 0 \;\; \Rightarrow \;\; P_{H,t} = MC_{H,t} \;\; \Leftrightarrow \;\; p_{H,t} = mc_{H,t}, \;\; \text{with} \left\{ \begin{array}{rcl} p_{H,t} & = & \frac{P_{H,t}}{P_t} \\ mc_{H,t} & = & \frac{MC_{H,t}}{P_t} \end{array} \right.$$

2.3.3 Final-good producers' decisions

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

$$\min_{Y_{H,t}, Y_{FE,t}} \{P_{H,t} Y_{H,t} + (1-s_{H,t}) P_{FE,t} Y_{FE,t}\} \quad s.t. \quad Y_{F,t} \leq \left(\alpha_E^{\frac{1}{\eta_E}} (Y_{FE,t})^{\frac{\eta_E - 1}{\eta_E}} + (1-\alpha_E)^{\frac{1}{\eta_E}} (Y_{H,t})^{\frac{\eta_E - 1}{\eta_E}} \right)^{\frac{\eta_E}{\eta_E - 1}}$$

The optimal decisions satisfy

$$Y_{FE,t} = \alpha_E \left(\frac{(1-s_{H,t}) P_{FE,t}}{MC_{F,t}} \right)^{-\eta_E} Y_{F,t}, \qquad Y_{H,t} = (1-\alpha_E) \left(\frac{P_{H,t}}{MC_{F,t}} \right)^{-\eta_E} Y_{F,t}$$

with a marginal cost defined as follows

$$MC_{F,t} \;\; = \;\; \left(\alpha_E ((1-s_{H,t} P_{FE,t})^{1-\eta_E} + (1-\alpha_E) (P_{H,t})^{1-\eta_E} \right)^{\frac{1}{1-\eta_E}}$$

Assuming perfect competition in this market, profits and free-entry conditions lead to:

$$\Pi_{F,t} = (P_{F,t} - MC_{F,t}) Y_{F,t} = 0 \;\; \Rightarrow \;\; P_{F,t} = MC_{F,t} \;\; \Leftrightarrow \;\; p_{F,t} = mc_{F,t}, \;\; \text{with} \left\{ \begin{array}{rcl} p_{F,t} & = & \frac{P_{F_t}}{P_t} \\ mc_{F,t} & = & \frac{MC_{F,t}}{P_t} \end{array} \right.$$

2.3.4 Retailers' decisions

There is a continuum of retailers indexed by i. Each retailer i produces an imperfectly substitutable consumption good. Each retailer i sets its price (Monopolistic competition). Each retailer produces using final goods $Y_t = Y_{F,t}$. Retailers produce $y_{i,t}$ differentiated goods which are combined to produce the basket good

$$Y_t = \left(\int y_{i,t}^{\frac{\varepsilon_{d,t}-1}{\varepsilon_{d,t}}} di \right)^{\frac{\varepsilon_{d,t}}{\varepsilon_{d,t}-1}}$$

We assume the elasticity of substitution across goods changes over time, i.e. $\varepsilon_{d,t}$ depends on t. These variations in $\varepsilon_{d,t}$ lead to price-markup shock (a disturbance to the desired markup of retailers' prices over their marginal costs) because the markup is given by $\mu_t = \frac{\varepsilon_{d,t}}{\varepsilon_{d,t}-1}$. We assume that μ_t follows a stationary AR(1) process.

The i-retailer's objective is to maximize the profits

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

This leads to the following NKPC:

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

with $mc_t = \frac{P_{F,t}}{P_t}$ and $\kappa_P = \frac{\varepsilon_d}{\psi_P}$. The firm's profit (its dividends) is defined by

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

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

2.4 Central Bank

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

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

with the European inflation defined as

$$\pi_t^{EU} = \mu_{FR} \pi_t + (1-\mu_{FR}) \pi_t^{REU} \quad \text{where} \quad \pi_t^{REU} = \rho_\pi \pi_t + \pi_t^{REU*}$$

where π_t^{REU} is the inflation in the rest of the Euro area, μ_{FR} the share of the French economy in the Euro area, and π_t^{REU*} the uncorrelated component of EU inflation with French inflation (an *iid* process by assumption). Therefore, the "effective" Taylor rule for the French economy is

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

2.5 Interest rate and risk premium

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

$$i_t = i_t^* + \vartheta_t$$

where ϑ_t is an exogenous wedge that can be either positive (due to risk premium) or negative (due to the maturity composition of government debt). We assume that ϑ_t follows a stationary AR(1) process. The Fisher rule leads to $1 + r_t = \frac{1+i_{t-1}}{1+\pi_t} = \frac{1+i_{t-1}^* + \vartheta_{t-1}}{1+\pi_t}$.

2.6 Government

Government revenues and expenditures are denoted respectively R_t and D_t. Public debt (B_t) finances the differences:

$$\begin{aligned}
R_t &= \sum_s \int_a \int_e \mathcal{T}_I^s(a,e) d\Gamma^s(a,e) + \tau_{kt} r a_t + P_t \tau_c c_t + \tau_c p_{FE,t} \underline{c}_{FE} \\
D_t &= G_t + \Xi_t + s_{H,t} p_{FE,t}(Y_{FE,t} + (1+\tau_c)\underline{c}_{FE}) \\
b_t &= (1+r_t) b_{t-1} - R_t - R_t^c + D_t + D_t^c
\end{aligned}$$

where $b = B/P$ is the real public debt, $G_t = \left(\int g_{i,t}^{\frac{\epsilon_d - 1}{\epsilon_d}} di\right)^{\frac{\epsilon_d}{\epsilon_d - 1}}$ the real government consumption and Ξ_t the real transfers. To ensure public-debt dynamics's stability, the lump-sum transfer incorporates a fiscal brake

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

such that Ξ_t is reduced when debt is larger than its steady-state level. Υ_t is the observed transfers paid by the government to households (Beveridgian $\int \tau\bar{\tau}(e) d\Gamma^e(e)$ and Bismarckian $\int T\overline{T}(e) d\Gamma^e(e)$ components of transfers) and e_τ is a measurement error. We assume that Υ_t and e_τ follow stationary AR(1) processes.

2.7 Equilibrium

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

$$\begin{aligned}
\text{asset market:} &\quad b_t = \mathcal{A}_t \equiv \sum_s \int_{a_-} \int_e a_t^s(a_-, e) d\Gamma^s(a_-, e) \\
\text{labor market:} &\quad N_t = \mathcal{N}_t \equiv \sum_s \int_{a_-} \int_e n_t^s(a_-, e) d\Gamma^s(a_-, e) \\
\text{energy market:} &\quad \overline{E_t} = \mathcal{E}_t \equiv Y_{FE_t} + \underline{c}_{FE} + E_t
\end{aligned}$$

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

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

where $p_{FE,t}$ follows a stationary AR(1) process.

3 Model Estimation

The equilibrium defined in section 2.7 can be summarized by the following system:

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

where $\Phi(S_{t+1}, S_t, S_{t-1}) = 0$ regroups all the equations describing firm, union, government, and central-bank behaviors, with S_t the vector of aggregate variables controlled by these agents, $\mathbf{Y}$ gathering the time series of unknown aggregate variables and $\mathbf{Z}$ of exogenous aggregate shocks.[11]

In step 1, we calibrate parameters that determine the steady state of the economy using (1) for $x_{t+1} = x_t = x$, $\forall x \in \{S_t, \mathcal{A}_t, b_t, \mathcal{N}_t, N_t\}$. In step 2, we then estimate the parameters that govern the dynamics of the aggregate shocks using Bayesian techniques and a linear approximation of (1) given by

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

where $\overline{\mathbf{Y}}$ and $\overline{\mathbf{Z}}$ are the steady state values of $\mathbf{Y}$ and $\mathbf{Z}$. $\mathbf{G}$ is the complete Jacobian of the dynamic system. $\mathbf{G}$ depends on calibrated parameters determined in step 1. If all the exogenous shocks of the model have the following MA(∞) representation, $dZ_t = \sum_{s=0}^{\infty} \mathbf{m}_s^Z \varepsilon_{t-s}^Z$, then the solution of the HA model can be represented by a MA(∞) that involves $\mathbf{G}$ and $\mathbf{m}$:

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

Replacing ∞ by T "large" and using the Jacobians, one can estimate the parameters $(\rho^Z)^s = [\mathbf{m}^z]_s$ if the Z_t follow AR(1) processes, using a Bayesian method and a data set. This representation of the model's solution allows us to decompose the variances of endogenous variables as well as to analyze the historical decomposition of time series.

Let the model solution be $\mathcal{Y}_t = \mathcal{M}(\mathcal{E}_t|\Theta, \Phi)$. The growth-path equilibrium gives a first set of restrictions that allows us to calibrate Φ via $\overline{\mathcal{Y}} = \mathcal{M}_{ss}(0|\Phi) \rightarrow \Phi = \mathcal{M}_{ss}^{-1}(\overline{\mathcal{Y}})$, where $\mathcal{M}_{ss}$ denote the set of model's restrictions at the steady state. Deviations around the trend provide a second set of restrictions that are used to estimate Θ through $\mathcal{Y}_t = \mathcal{M}(\mathcal{E}_t|\Theta, \Phi)$ and the data $\{\mathcal{Y}_t\}_{t=t_0}^T$.

3.1 Calibrated parameters Φ

The first subset Φ_1 of the vector Φ is calibrated using external information. Results are reported in Table 1.

The second subset Φ_2 of the vector Φ takes values based on some steady-state restrictions of the model and are deduced in order to solve

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

where Ψ_z, for $z = s, d$, is the set of simulated/targeted moments. The results are reported in Table 2

The calibrations implied by the model steady state are described in Appendix B. The Marginal Propensities 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 if 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. Panel (c) of Figure 1 shows that the agents with low incomes have more difficulty reducing their energy consumption when the price increases. This result comes from the largest share of incompressible consumption in their energy consumption. Finally, panel (d) of Figure 1 shows that the energy MPCs decline with income. Finally, this calibration results in 31% of households being financially constrained.

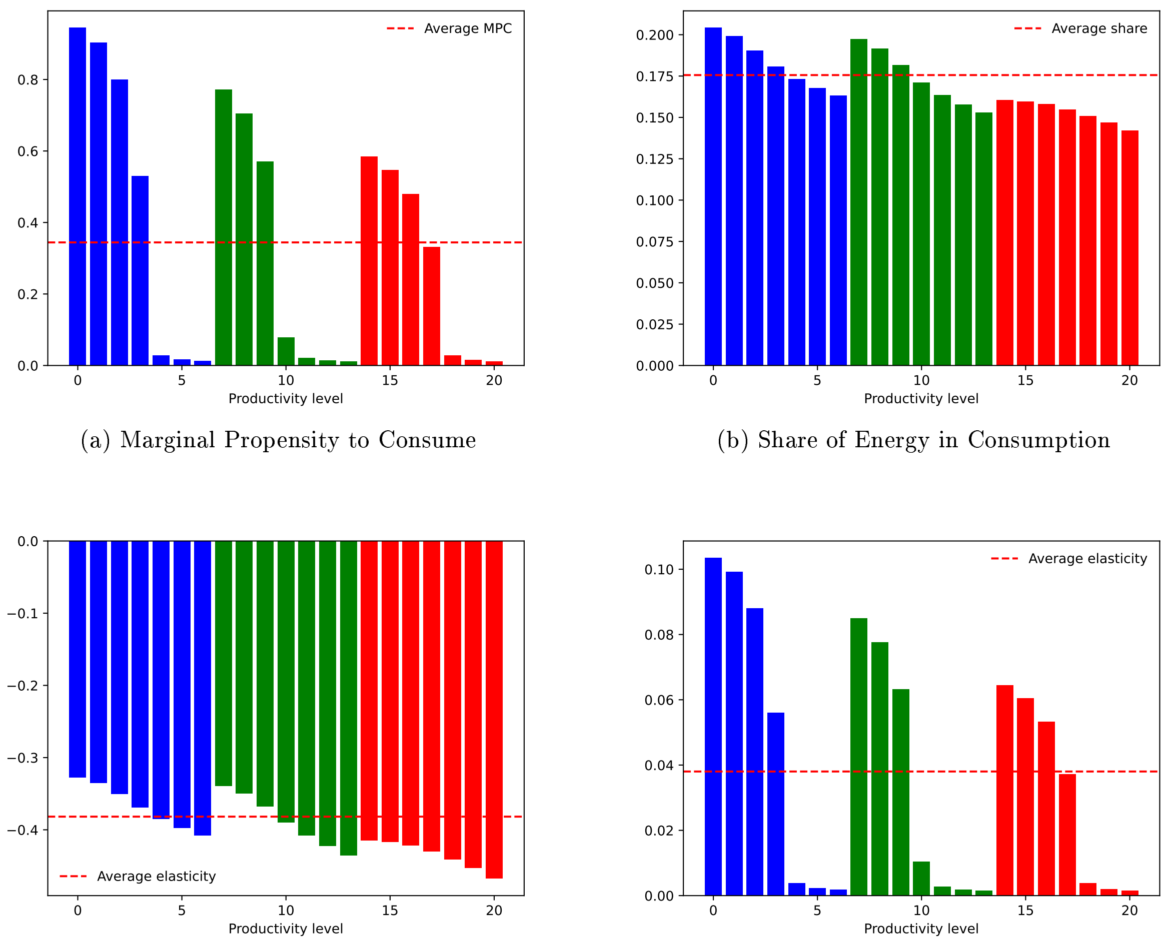
[11]The dynamic paths of this economy are solved using the method developed by Auclert et al. (2021).

Preferences	**Values**	**Targets**
Discount factor β	0.9888	Real interest rate $r = 0.74\%$ per quarter
Frisch elasticity of labor supply φ	1	Chetty et al. (2012)
Elasticity of intertemporal substitution σ	1	Log-utility for consumption
Incompressible energy consumption $\underline{c}$	0.041	20% of households' energy consumption
Wage markup μ_w	1.1	Auclert et al. (2021)
Low-skill labor desutility ϕ_l	0.3634	Low-skill wage
Middle-skill labor desutility ϕ_l	0.3278	Middle-skill wage
High-skill labor desutility ϕ_l	0.1482	High-skill wage
Elasticity of substitution between production inputs η_E	0.5	Negative impact on GDP of energy-price shock
Share parameter (energy, intermediate good) α_E	0.043	Sharing rule: a half of energy to households
Production	**Values**	**Targets**
Elasticity of substitution between production inputs σ_f	η_E	Simplifying assumption
Share parameter (energy, labor) α_f	0.056	Sharing rule: a half of energy to firms
Firm markup μ	1.2	Auclert et al. (2021)
Productivity parameters A_s	1	Normalization
Aggregate targets	**Values**	**Targets**
Energy price	0.105%	Share of energy in GDP of 3.18%
Public debt B	5.418	Debt-to-GDP ratio 100% with annual GDP
Public spending G	0.236	Public spending-to-GDP ratio = 17.5%
Transfers	0.192+0.242	Transfers-to-GDP ratio (Bev. + Bism.) = 32.1%
Nominal rigidity	**Values**	**Targets**
Price rigidity κ	0.95	Arbitrary higher than Auclert et al. (2018)
Wage rigidity κ_w	0.1	Auclert et al. (2018)
Monetary policy	**Values**	**Targets**
Taylor rule coefficient $\phi_\pi(\mu_{FR} + (1-\mu_{FR})\rho_\pi))$	1.2	With $\phi_\pi = 1.5$, $\mu_{FR} = 20\%$, and $\rho_\pi = 0.75$
Persistence of monetary policy ρ_r	0.85	Carvalho et al. (2021)

Table 1: **Parameters Φ_1 based on external information**

Parameter Φ_2	**Value**	**Moment Ψ_z**	**Data**	**Model**
Beveridgian transfer rule $\bar{\tau}(e) = e^{a_{beve}}$	$a_{beve} = -0.47$	Beveridgian Transfer D10/D1	0.36	0.36
Bismarckian transfer rule $\bar{T}(e) = e^{a_{bism}}$	$a_{bism} = 0.815$	Bismarckian Transfer D10/D1	5.43	5.43
Dividends rule $\bar{d}(e) = e^{a_{div}}$	$a_{div} = 1.775$	Dividends D10/D1	66.25	65.34
Productivity-persistence low-skill	$\rho_l = 0.97$	Gross income D10/D1	11.67	11.64
Productivity-persistence middle-skill	$\rho_m = 0.965$	Gross income D5/D1	2.94	2.73
Productivity-persistence high-skill	$\rho_h = 0.94$	Average productivity persistence	0.966	0.966
Productivity-variance low-skill	$\sigma_l = 0.36$	Net consumption D10/D1	3.07	3.12
Productivity-variance middle-skill	$\sigma_m = 0.64$	Net Consumption D5/D1	1.49	1.49
Productivity-variance high-skill	$\sigma_h = 1.4$	Net income D10/D1	4.16	3.72
Level of the income tax $(1-\tau_z)z^{1-\lambda}$	$\lambda = 0.089$	Net income D5/D1	1.57	1.42
Progressivity of the income tax $(1-\tau_z)z^{1-\lambda}$	$\tau_z = 0.35$	Income-tax revenues/GDP	0.115	0.115
Level of VAT	$\tau_c = 0.213$	VAT revenues/GDP	0.17	0.17
Level of social security contribution	$\tau_l = 0.242$	Social-security contribution revenues/GDP	0.195	0.195
Level of the corporate tax	$\tau_f = 0.35$	Corporate-tax revenues/GDP	0.045	0.045

Table 2: **Parameters Φ_2 based on steady-state restrictions**



(a) Marginal Propensity to Consume

(b) Share of Energy in Consumption

(c) Price Elasticity, Energy

(d) Income Elasticity, Energy

Figure 1: Heterogeneous households' behaviors

3.2 Estimated parameters

As in all dynamic models, the impact of each shock depends on how the agents expect them to persist. The vector of parameters

$$\Theta = \left\{\rho^Z, \sigma^Z | \text{for } Z \in \{\beta, \mu, P_{FE}, \varepsilon, \vartheta, \{\varphi_s\}_{s=l,m,h}, \{A_s\}_{s=l,m,h}, G, T, e_\tau\}\right\}$$

is estimated using a Bayesian method

$$\widehat{\Theta} = \text{argmax } \mathcal{L}\left(\Theta | \{\mathcal{Y}_t\}_{t=t_0}^T, \Phi\right) \quad \text{where} \quad \mathcal{Y}_t = \mathcal{M}(\mathcal{E}_t | \Theta, \Phi)$$

given that $\mathcal{M}$ is deduced from equation (2). In order to have a "just-identified" system, the number of time series used in the estimation is equal to the number of shocks introduced in the model. Therefore, to identify the 14 shocks, we use the data set

$$\mathcal{Y} = \left\{Y_{,t}\, \pi_t, P_{FE,t}, i_t^*, i_t, \{N_{s,t}\}_{s=l,m,h}, \{\pi_{s,t}^w\}_{s=l,m,h}, G_t, T_t, \frac{b_t}{Y_t}\right\}_{t=t_0}^T$$

over the sample $t_0 = 2Q2003$ to $T = 4Q2019$.[12,13] Table 3 summarizes this mapping between data and shocks. We assume that the energy-consumption subsidy (the tariff shield) are present between 1Q2022 and 4Q2023.

$\mathcal{Y}$	GDP	Inf.	Int. rates BCE	Int. rates debt	Energy price	Government cons.	Government trans.	Debt-to-GDP
	Y_t	π_t	i_t	i_t^*	$P_{FE,t}$	G_t	T_t	$\frac{b_t}{Y_t}$
$\mathcal{E}$	β	μ	ε	ϑ	P_{FE}	G	T	e_τ
$\mathcal{Y}$		Hours l	Hours m	Hours h	Wages l	Wages m	Wages h	
		$N_{l,t}$	$N_{m,t}$	$N_{h,t}$	$\pi_{l,t}^w$	$\pi_{m,t}^w$	$\pi_{h,t}^w$	
$\mathcal{E}$		φ_l	φ_m	φ_h	A_l	A_m	A_h	

Table 3: Identification: Data ($\mathcal{Y}$) — Shocks ($\mathcal{E}$)

The autocorrelations of these AR(1) processes and the standard deviations of their innovations are reported in Table 4 (see details in Appendix C).

3.3 Variance decomposition

This section presents the variance decomposition of the estimated model for the period of estimation 1Q2003-4Q2019.[14] The variance decomposition of the main macroeconomic variables allows us to evaluate which are the dominant shocks for explaining the business cycle over the entire period. It gives the contribution of each shock in explaining the deviations of each endogenous variable from its long-term value.[15]

Over the estimation period as a whole (see Table 5)[16], shocks to household demand are the main source of output fluctuations (44%). Next, shocks to productivity and firm-markup shocks each

[12] Appendix B 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.

[13] Additional details on the estimation procedure can be found in appendix C. See also Langot et al. (2023)

[14] the historical decomposition is also presented in Appendix

[15] Fluctuations represent the differences between the current values of economic variables and their long-term values.

[16] In the appendix D, we present the variance decomposition over all the sample for output, inflation debt-to-GDP ratio and hours worked by wage level.

Shock	Z	**Persistence** ρ^Z Mean	**Standard dev.** σ^Z Mean	**Variance** $\frac{(\sigma^Z)^2}{1-(\rho^Z)^2} \times 100$
Preference	β	0.778482	0.009143	0.02121870
		(0.025231)	(0.001438)	
Price markup	μ	0.827839	0.023420	0.17430147
		(0.025517)	(0.002331)	
Energy price	p_{FE}	0.793492	0.116112	3.64013832
		(0.022682)	(0.009058)	
Monetary policy	ε	0.575467	0.006381	0.00608774
		(0.040994)	(0.000498)	
Spread	ϑ	0.832970	0.001172	0.00044864
		(0.034203)	(0.000126)	
Disutility l	φ_l	0.771044	0.020303	0.10165741
		(0.048294)	(0.002861)	
Disutility m	φ_m	0.772314	0.018561	0.08537402
		(0.046330)	(0.002492)	
Disutility h	φ_h	0.692028	0.032577	0.20365890
		(0.058132)	(0.003967)	
Productivity l	A^l	0.819040	0.024635	0.18436577
		(0.029585)	(0.002089)	
Productivity m	A^m	0.795198	0.018561	0.09370358
		(0.029001)	(0.001954)	
Productivity h	A^h	0.844523	0.025028	0.21842485
		(0.032298)	(0.002205)	
Government consumption	G	0.714310	0.004220	0.00363613
		(0.056981)	(0.000379)	
Transfers	T	0.797681	0.005315	0.00776707
		(0.044078)	(0.000465)	
Measurement error	e_τ	0.773476	0.015915	0.06304835
		(0.047124)	(0.004046)	

Table 4: Estimated parameters of the $AR(1)$ processes

account for around 16% of these variations. Fluctuations in oil prices account for 6% of production variations.[17] More than half of inflation fluctuations are explained by oil-price fluctuations (56%), and 15% by markup fluctuations. The high contribution of energy to inflation fluctuations is due to the price rigidity, which means that domestic prices only react with delay to shocks, particularly those that are very persistent, whereas energy prices are determined by very volatile shocks. Indeed, the estimated variance of oil-price shocks is ten times higher than that of markup shocks and a hundred times higher than that of preference shocks (respectively 3.64, 0.17, and 0.021, see Table 4). Productivity shocks explain 9% of inflation variations, followed by demand shocks for less than

	output	inflation	debt	int. rate	debt rate	empl L	empl M	empl H	wage L	wage M	wage H
β	43.8%	7.6%	25.8%	14.4%	14.2%	28.3%	27.5%	23.9%	13.8%	14.9%	10.5%
μ	16.0%	15.2%	20.6%	11.5%	11.3%	10.5%	9.4%	9.5%	6.4%	7.2%	6.6%
p_{FE}	5.9%	56.1%	29.3%	50.4%	50.3%	35.4%	37.9%	32.8%	41.5%	40.5%	35.5%
ε	4.0%	1.4%	4.2%	2.2%	1.9%	3.0%	2.9%	1.9%	3.7%	3.7%	2.1%
ϑ	0.8%	0.2%	1.3%	0.3%	2.4%	0.6%	0.6%	0.3%	0.6%	0.5%	0.3%
φ_l	1.0%	1.0%	0.8%	1.2%	1.1%	6.8%	0.0%	0.0%	13.5%	0.5%	0.4%
φ_m	3.8%	3.3%	1.7%	2.8%	2.4%	0.3%	7.6%	0.1%	1.3%	15.4%	0.9%
φ_h	0.7%	0.6%	0.4%	0.7%	0.6%	0.0%	0.0%	13.3%	0.3%	0.3%	25.8%
A^l	4.4%	2.2%	2.0%	3.2%	3.1%	9.2%	0.2%	0.2%	4.3%	1.9%	1.7%
A^m	10.1%	5.9%	1.6%	4.3%	4.1%	0.4%	8.1%	0.4%	2.5%	4.7%	2.2%
A^h	1.7%	0.7%	0.2%	1.0%	0.9%	0.0%	0.0%	14.2%	0.5%	0.4%	3.5%
G	1.6%	0.1%	0.1%	0.0%	0.0%	1.1%	1.1%	0.8%	0.2%	0.2%	0.1%
T	0.1%	0.2%	0.2%	0.3%	0.2%	0.1%	0.1%	0.1%	0.6%	0.5%	0.2%
e_τ	6.2%	5.7%	11.9%	7.7%	7.3%	4.3%	4.6%	2.6%	10.9%	9.4%	10.2%

Table 5: Variance decomposition. Share of the deviation from the steady state explained by each shock: mean value for the sample 2003Q1-2019Q4.

8% and labor supply for 5%. Debt dynamics are determined by these main determinants of output and inflation fluctuations. Its variations are explained by shocks to energy prices (29%), consumer demand (26%) and markup (21%) , followed by shocks to labor supply (5%), productivity (4%) and interest rates (2%). The three main macroeconomic shocks (oil price, demand and markup) also explain most of the fluctuations in labor markets. They account for 74% of variations in unskilled jobs, 75% in intermediate jobs, and 66% in skilled jobs.

4 Conditional Forecasts

The originality of our quantitative method is to propose an ex-ante evaluation, i.e. a method that can be used in real time to help governments make their economic-policy decisions. Our method integrates the forecasts contained in the Finance Act into a general-equilibrium model to estimate the sequences of the different shocks that must perturb the French economy so that the Finance Act forecasts become realizations, in the spirit of the conditional-forecast methodology presented by Del Negro and Schorfheide (2013a).[18] This structural approach provides an evaluation of a

[17]Other shocks play a minor role: 5% for labor-supply shocks and interest-rate shocks and 1.6% for public spending shocks.

[18]Therefore, the shocks estimated for the five years 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 (2013a), Adolfson et al. (2005) or Gelfer (2019). Conditional forecasts have focused on the monetary policy interest rate in VAR (Waggoner and Zha (1999)

policy on the economic indicators (aggregates and inequalities). Our methodological contribution consists of estimating conditional forecasts based on the government's forecasts for public finance and macroeconomic aggregates using Auclert et al. (2021)'s sequence-space Jacobian methodology and then evaluating policy using counterfactual scenarios deduced from our HANK model.

4.1 Methodology

We develop a method that provides an ex-ante evaluation of policies planned to be implemented in the future. This method can be used before the observations of the macroeconomic series, i.e. when the policymaker must make her choice.[19] At the time of the decision, we do not observe data "after" the policy changes. Instead of these observed data, we use the "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.[20] 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.

Our benchmark scenario will constrain our HANK model to reproduce these government forecasts concerning output, inflation, interest rates and public debt, conditionally on the paths for government's expenditures and revenues also contained in the Finance Act. We also use the forecasts on changes exogenous to the model (e.g. the changes in the energy price or risk premium) in order to reveal their size, 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 Schorfheide (2013a)).[21] This type of adjustment will be taken into account in our analysis: we evaluate the new government's decision rules that allow the model to account for forecasted government policy. These "new" policy rules can be statistically different from the ones estimated on the initial sample.[22] The changes in the parameters of the government's decision rules are assumed to be unexpected.

and Antolin-Diaz et al. (2021)) and DSGE models (Adolfson et al. (2005) and Del Negro and Schorfheide (2013a)).

[19] When the parliament approves the government's budget, the government commits itself to its expenditures and revenues by presenting the implications of these commitments on the output, inflation, interest rates and public debt.

[20] 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).

[21] Leeper and Zha (2003) define the size of the policy changes that can be defined as being "modest", in the sense that the re-optimization of the model does not lead to a significant change in the forecasts. See also Adolfson et al. (2005) for a more general measure using DSGE models. See Gali (2011) for a critical analysis of conditional forecasts.

[22] This means that the changes in the government policy are significant, leading agents to modify their beliefs.

4.2 Lucas (1976) critique

In order to provide an intuition of our approach, let us consider a simple illustrative equilibrium of a log-linear economy described by the following equation set:

$$\left.\begin{array}{rcll} c_t &=& a\mathbb{E}_t c_{t+1} + by_t + \gamma_t & \text{with } |a|<1, \text{ and } \gamma_t \sim iid(0,1) \\ y_t &=& \rho y_{t-1} + \sigma\varepsilon_t & \text{with } |\rho|<1, \text{ and } \varepsilon_t \sim iid(0,1) \\ \gamma_t &=& \rho_\gamma \gamma_{t-1} + \sigma_\gamma e_t & \text{with } |\rho_\gamma|<1, \text{ and } e_t \sim iid(0,1) \end{array}\right\} \Rightarrow c_t = \frac{b}{1-\rho a} y_t + \frac{b}{1-\rho_\gamma a}\gamma_t \quad (3)$$

This model distinguishes two types of exogenous variables: y_t can be manipulated by the government (policy changes), whereas γ_t cannot (preferences or technology shocks).

In order to provide quantitative policy evaluations, one must estimate this model. The dataset $\mathcal{Y}_T = \{c_t, y_t\}_{t=0}^T$ allows the model $\mathcal{M}$ to identify the sequences $\mathcal{E}_T = \{\varepsilon_t, e_t\}_{t=0}^T$, given the estimated parameter set $\widehat{\Theta} = \{\widehat{a}, \widehat{b}, \widehat{\rho}, \widehat{\sigma}, \widehat{\rho}_\gamma, \widehat{\sigma}_\gamma\}$. The solution is deduced from

$$\mathcal{Y}_T = \mathcal{M}(\mathcal{E}_T|\widehat{\Theta}) \quad \Rightarrow \quad \mathcal{E}_T = \mathcal{M}^{-1}(\mathcal{Y}_T|\widehat{\Theta}) \quad \text{with} \quad \widehat{\Theta} = \text{Argmax } \mathcal{L}(\Theta|\mathcal{Y}_T)$$

Remark that the identification of $\{\varepsilon_t\}_{t=0}^T$ does not depend on the model contrarily to the sequence $\{e_t\}_{t=0}^T$, leading to $\{\gamma_t\}_{t=0}^T$ simply because γ_t is unobservable.

Using this model's estimation, one can build forecasts. The forecast $\{c_{T+h}\}_{h=1}^H$ is defined by:

$$\mathbb{E}_T c_{T+h} = \frac{\widehat{b}}{1-\widehat{a}\widehat{\rho}}\widehat{\rho}^h y_T + \frac{\widehat{b}}{1-\widehat{\rho}_\gamma \widehat{a}}\widehat{\rho}_\gamma^h \gamma_T$$

Without any information on the data at periods $T+h$, $\forall h > 0$, the model used to forecast is assumed to be the one estimated on historical dataset $\mathcal{Y}_T$.

Conditional forecasts. A conditional forecast uses information on future realizations of c_t and y_t, $\mathcal{Y}_{T+H} = \{c_{T+h}, y_{T+h}\}_{h=1}^H$, in order to reveal the sequences of $\mathcal{E}_{T+H} = \{e_{T+h}, \gamma_{T+h}\}_{h=1}^H$ satisfying $\mathcal{Y}_{T+h} = \mathcal{M}(\mathcal{E}_{T+h}|\widehat{\Theta})$. Given that the Finance Act can propose new policies, the government's decision rules can change compared to the ones observed in the past and estimated over the sample $t \in [0,T]$. Therefore, to take seriously this potential problem, first underlined by Lucas (1976), we must distinguish two cases.

Case 1: stability of the government's decision rules. In the first step, the government announces its policy and thus sets $\{y_{T+h}\}_{h=1}^H$. Using the model (3), the sequence of $\{\varepsilon_{T+h}\}_{h=1}^H$ is identified using $\varepsilon_{T+h} = \frac{1}{\widehat{\sigma}}(y_{T+h} - \widehat{\rho} y_{T+h-1})$. This forecast is not biased if and only if $\varepsilon_{T+h} \in CI$ of $\mathcal{N}(0,1)$. If this is the case, then the stability of the parameters $\{\rho, \sigma\}$ is not rejected by the new announcements of the government.

If the stability of the government's decision rule is not rejected, the sequence $\{e_{T+h}\}_{h=1}^H$ can be identified through $\gamma_{T+h} = \frac{1-\widehat{\rho}_\gamma \widehat{a}}{\widehat{b}} c_{T+h} - \frac{1-\widehat{\rho}_\gamma \widehat{a}}{1-\widehat{\rho}\widehat{a}} y_{T+h}$ and $e_{T+h} = \frac{1}{\widehat{\sigma}_\gamma}(\gamma_{T+h} - \widehat{\rho}_\gamma \gamma_{T+h-1})$. If $e_{T+h} \in CI$ of $\mathcal{N}(0,1)$, then the stability of the parameters $\{\rho_\gamma, \sigma_\gamma\}$ is not rejected, i.e. the behaviors of households and firms are also stable.

Case 2: instability of the government's decision rules. If the government's decision rules are unstable, then they can be rewritten as follows:

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

Therefore, when the government announces $\{y_{T+h}\}_{h=1}^{H}$, the sequence of $\{\varepsilon_{T+h}\}_{h=1}^{H}$ must be identified using $\varepsilon_{T+h} = \frac{1}{\widetilde{\sigma}}(y_{T+h} - \widetilde{\rho} y_{T+h-1})$. If we assume that $\{a, b, \rho_\gamma, \sigma_\gamma\}$ does not change when the policy rule is modified, then agents revise their expectations by integrating the new value of $\widetilde{\rho}$ and forecast their consumption as follows:[23] $\mathbb{E}_T c_{T+h} = \frac{\widehat{b}}{1-\widehat{a}\widetilde{\rho}}\widetilde{\rho}^h y_T + \frac{\widehat{b}}{1-\widehat{\rho}_\gamma \widehat{a}}\widehat{\rho}_\gamma^h \gamma_T$. The conditional forecasts, i.e. the forecasts using the information set $\mathcal{Y}_{T+H}$, allow us to identify the sequence $\{\widetilde{e}_{T+h}\}_{h=1}^{H}$ through

$$\widetilde{\gamma}_{T+h} = \frac{1-\widehat{\rho}_\gamma \widehat{a}}{\widehat{b}} c_{T+h} - \frac{1-\widehat{\rho}_\gamma \widehat{a}}{1-\widetilde{\rho} a} y_{T+h} \quad \text{and} \quad \widetilde{e}_{T+h} = \frac{1}{\widehat{\sigma}_\gamma}(\widetilde{\gamma}_{T+h} - \widehat{\rho}_\gamma \widetilde{\gamma}_{T+h-1})$$

The stability of $\{a, b, \rho_\gamma, \sigma_\gamma\}$ is not rejected if $\widetilde{e}_{T+h} \in CI$ of $\mathcal{N}(0,1)$.[24]

Application. In our more complex model, we access the quantitative relevance of the Lucas (1976) critique by simply testing if $\varepsilon_{T+h} \in CI$ of $\mathcal{N}(0,1)$ and $e_{T+h} \in CI$ of $\mathcal{N}(0,1)$, after having identified these two sequences $\{\mathcal{E}_{T+h}\}_{h=1}^{H}$ using $\mathcal{E}_{T+H} = \mathcal{M}^{-1}(\mathcal{Y}_{T+H}|\widehat{\Theta})$. If this is the case, then the Lucas (1976) critique is not quantitatively relevant and the sequences are not biased.

On the contrary, if $\varepsilon_{T+h} \notin CI$ of $\mathcal{N}(0,1)$, then a new rule for the processes of the exogenous policy shocks $\mathcal{X}_t$ must be re-estimated. We re-estimate this rule using maximum-likelihood technics $\widetilde{\Theta}_x = \text{argmax } \mathcal{L}\left(\Theta_x | \{\mathcal{X}_{T+h}\}_{h=T}^{T+H}, \Phi\right)$ for $\mathcal{X}_{T+h} \in \mathcal{Y}_{T+h}$. Therefore, the identification of $\mathcal{E}_{T+H}$ is now made through $\mathcal{E}_{T+h} = \mathcal{M}^{-1}(\mathcal{Y}_{T+h}|\{\widehat{\Theta}_{-x}, \widetilde{\Theta}_x\})$. In this case, the Lucas (1976)'s criticism is quantitatively relevant and the identification process of the shock innovations must be "corrected" in order to be unbiased.

4.3 Assessing the changes in policy rules

Figure 2 shows the confidence intervals for the innovations of the government decision rules (grey areas), the mean of these shocks (red line) and the sequences of the innovations (black lines) identified by the models to allow it to match the government forecasts.

For all shocks, we compare the simulations based on the models where $\{\rho, \sigma\}$ are or are not re-estimated. The re-estimation of $\{\rho, \sigma\}$ is based on data $\{G_t, T_t\}$ accounting for the commitments for the sample $t \in [4Q2019; 4Q2027]$, described in the Finance Act. Except for government-consumption and government-transfer shocks (see the innovations of household and firm shocks displayed in Figure 21), it is not possible to reject the assumption of invariance of the laws of these innovations. Therefore, in the evaluations of the French Finance Act, based on conditional forecasts, we use the new values for $\{\widetilde{\rho}, \widetilde{\sigma}\}$ reported in Table 6 as it allows agents' expectations to be modeled satisfactorily.

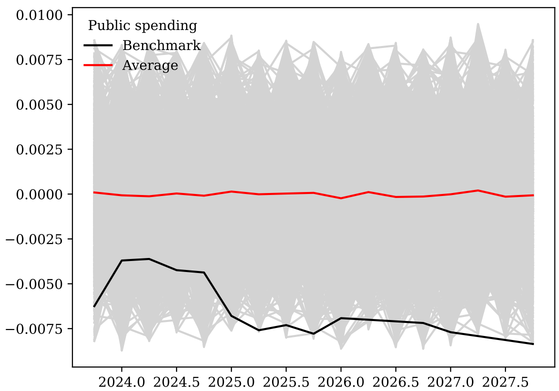
	G	T
$\widetilde{\rho}$	0.95953	0.90391
$\widetilde{\sigma}$	00867	0.02299

Table 6: Estimated parameters over 4Q-2019 to 4Q-2027

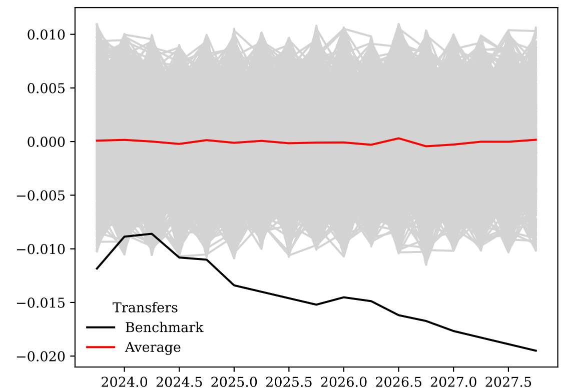
Although in the confidence interval, panels (d), (i), (m), (p), (s) and (v) in Figure 21 in Appendix E, suggest that the Finance Act is highly optimistic regarding markups and the high-skill worker

[23] The bias without expectation's revision is $\mathbb{E}_T[c_{T+h}|\widehat{\rho}] - \mathbb{E}_T[c_{T+h}|\widetilde{\rho}] = \left(\frac{\widehat{\rho}^h}{1-\widehat{a}\widehat{\rho}} - \frac{\widetilde{\rho}^h}{1-\widehat{a}\widetilde{\rho}}\right)\widehat{b} y_T$

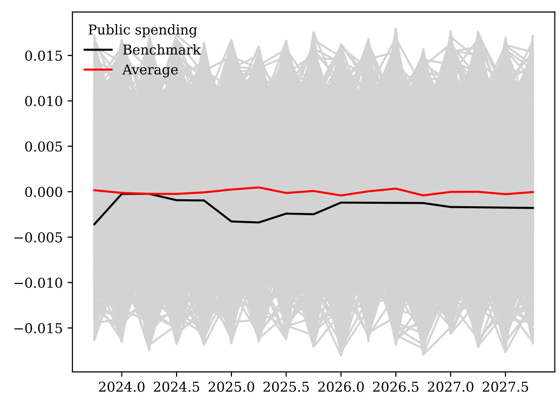
[24] The bias between "true" $(\widetilde{\gamma}_{T+h}, \widetilde{e}_{T+h})$ and "naive" (γ_{T+h}, e_{T+h}) shocks is given by $\widetilde{\gamma}_{T+h} - \gamma_{T+h} = \widehat{a}(\widehat{\rho} - \widetilde{\rho})\frac{1-\widehat{\rho}_\gamma \widehat{a}}{(1-\widehat{\rho}\widehat{a})(1-\widetilde{\rho}\widehat{a})} y_{T+h}$ implying that $widetilde{e}_{T+h} - e_{T+h} = \frac{1}{\widehat{\sigma}_\gamma}\widehat{a}(\widehat{\rho} - \widetilde{\rho})\frac{1-\widehat{\rho}_\gamma \widehat{a}}{(1-\widehat{\rho}\widehat{a})(1-\widetilde{\rho}\widehat{a})}[(\widetilde{\rho} - \widehat{\rho}_\gamma) y_{T+h-1} + \widetilde{\sigma}\varepsilon_{T+h}]$.



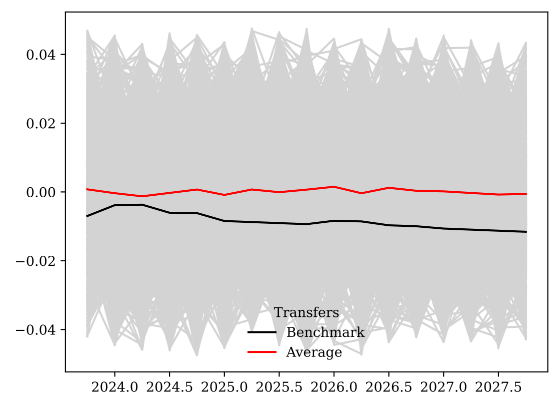
(a) Govt. consumption (A)



(b) Govt. transfers (A)



(c) Govt. consumption (B)



(d) Govt. transfers (B)

Figure 2: Innovations of government decision rules. (A) before and (B) after re-estimation.

labor-market paths. The underlying sequence of productivity shocks declines continuously.[25] In the evaluations of the French Finance Act, based on conditional forecasts, we therefore use the re-estimated model because it allows agents' expectations to be modeled satisfactorily.

5 Assessing the Debt Substainability of the Finance Act

5.1 Shocks Underlying the Government's Forecasts

Figures 3 and 4 represent the deviations from the steady-state values of all time series in $\mathcal{E}$. The interest rate is quarterly and corresponds to an annual interest of 3%, with an annual spread equal to 1%, thus implying a BCE annual interest rate equal to 2%.

Panel (a) of Figure 3 shows that the discount factor (β_t) takes values above its steady-state value over the entire forecast period, consistent with the innovation history of panel (d) of Figure 2 (all innovations' realizations over 4Q-2023 to 4Q-2027 are above zero). Panel (a) of the Figure shows that the values of β_t goes from 1.024 to 0.999 during the forecast period (these numbers are obtained by adding the values in the panel (a) of the Figure 3 to the value of β at the steady state). This underlines that the households' demand is depressed over the forecast periods by an exceptionally high preference for saving.

Panel (b) of Figure 3 shows that the price markup (μ_t) takes values below its steady-state value over the entire forecast period, consistent with the innovation history of the panel (c) of Figure 21 (all innovations' realizations over 4Q-2023 to 4Q-2027 are below zero). Using data of panel (b) of Figure 3, we deduce that μ_t will take values between 1.111 and 1.125 i.e. a markup almost divided by 2 over the forecast period (from 20% to 11% or 12%).

Panel (c) of Figure 3 shows that the energy price ($P_{FE,t}$) takes values above its steady state value over the entire forecast period, consistent with the innovation history of panel (d) of Figure 21 (all innovations' realizations over 4Q-2023 to 4Q-2027 are above zero). Using data of panel (c) of Figure 3, we deduce that the energy price will be between 18% and 29% above its steady-state value. This estimate corresponds to a variation of oil price going from 50.3€to 46€(in prices of 1995) from 3Q2023 to 4Q2027, given that the average value of oil price between 1Q-2003 to 4Q-2019 is equal to 38.9€.

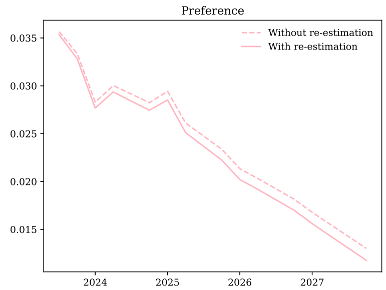
Panel (d) of Figure 3 shows that the government consumption (G_t) takes values below its steady-state value over the entire forecast period, consistent with the innovation history of the panel (c) of the Figure 2 (all innovations' realizations over 4Q-2023 to 4Q-2027 are below zero). Using data of the panel (d) of Figure 3, we deduce that G_t will take values consistantly around -0.005 over the forecast period, meaning a reduction of around 0.5% of the government consumption with respect to its 4Q2019 value (the reference point).

Panel (e) of Figure 3 reports the values for government transfers (T_t), showing that they are 4% to 5% below their 4Q2019 value (the reference point), consistently with the innovation history of the panel (d) of the Figure 2 (all innovations' realizations over 4Q2023 to 4Q2027 are below zero).

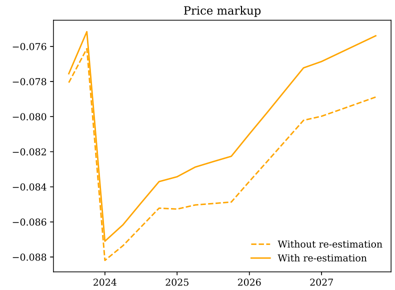
The values of energy subsidies corresponding to the tariff shield are reported in panel (f) of Figure 3. This subsidy corresponds to an energy-price cut approximately equal to 12% until 4Q2023.

If the monetary policy shock oscillates around zero, suggesting very little variation in it (see panel (g) of Figure 3), the risk premium paid by the government when it repays its debt is on the other hand continuously below of its long-term value, even if it rises towards it at the end of the forecast period (see panel (h) of the Figure 3). Over the forecast period, the spread will be

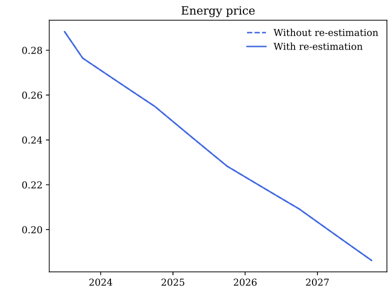
[25]Figures 27 to 30 in the Appendix G show the forecasts of endogenous variables and their confidence intervals under the assumption that all innovations of the exogenous variables are drawn in their estimated distributions.



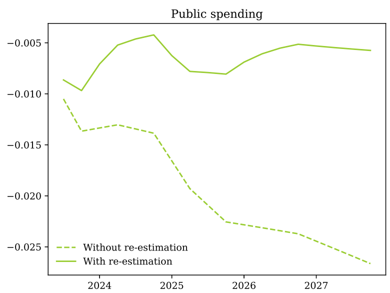
(a) Discount rate



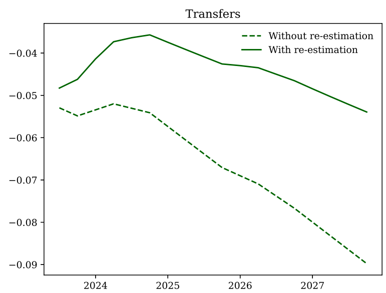
(b) Mark-up



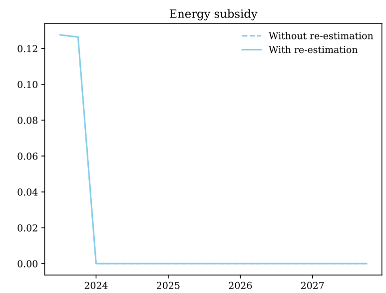
(c) Energy price



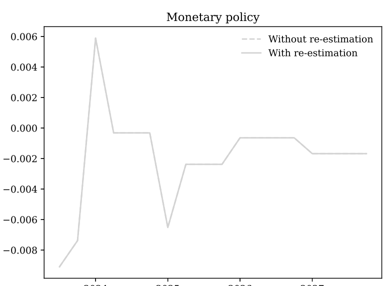
(d) Govt. consumption



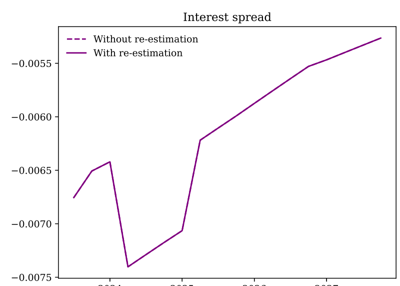
(e) Govt. transfers



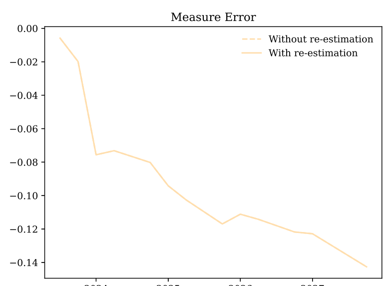
(f) Tariff shield



(g) Nominal interest rate



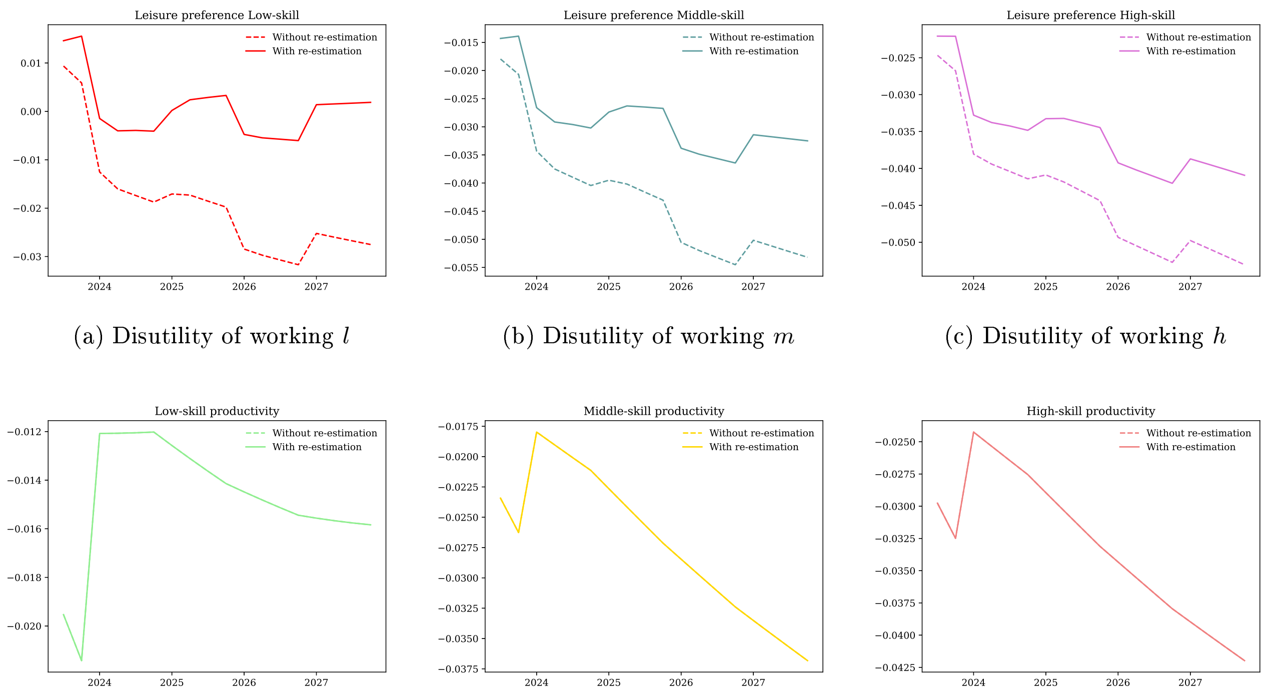
(h) Spread



(i) Measurement error

Figure 3: Time series of estimated shocks. The lines correspond the estimated shocks when the model is re-estimated (B). Dotted line correspond the estimated shocks when the model is not re-estimated (A)

lower by 0.6 percentage point per quarter on average (2.4 percentage points per year) compared to its long-term value which is 0.24 % per quarter (1% per year). The real interest rate paid by the government to repay its debt (this rate will be on average 0.6% per year) will therefore be lower than the real ECB-interest rate over the entire forecast period (this rate will be on average 2%).



(a) Disutility of working l (b) Disutility of working m (c) Disutility of working h

(d) Work efficiency l (e) Work efficiency m (f) Work efficiency h

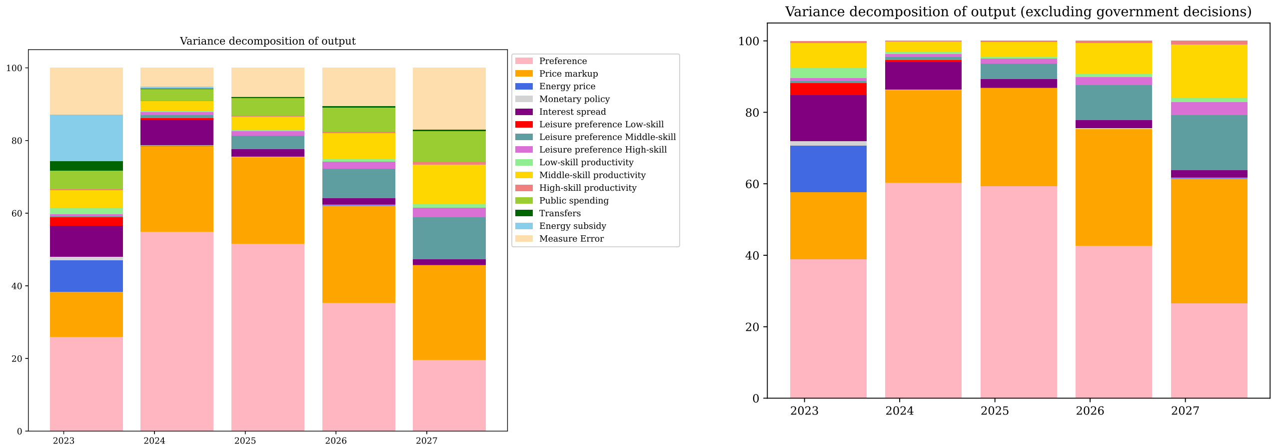
Figure 4: Time series of estimated shocks . The lines correspond the estimated shocks when the model is re-estimated (B). Dotted line correspond the estimated shocks when the model is not re-estimated (A)

Finally, panels (d), (e) and (f) of Figure 4 show that the labor productivity of all employees declines (when removing the historical trend) over the forecast period: between 1 and 2% for workers receiving low wages, and between 2 and 4% for those receiving middle and high salaries. If the decline in productivity is shared by all types of workers, the same is not true for the labor-disutility evolution (see Panels (a), (b) and (c) of Figure 4). It is stable for low-wage workers while it decreases up to 4% for those with middle and high wages.

5.2 Variance and contribution decomposition

Figure 5 (panel (a)) indicates that budgetary decisions only explain around 20% of GDP forecast during the period. Thus, environmental shocks explain the largest share. This then makes the Finance Act forecasts uncertain as they rely heavily on shocks not controlled by the government. The panel (a) of Figure 5 gives the exhaustive decomposition of the variance of GDP according to the 15 sources of fluctuation integrated into CepreHANK. In 2027, the sum of the contributions of public consumption and transfer shocks, to which we also add the contribution of measurement error, amounts to $8.4\% + 0.4\% + 17.0\% = 25.8\%$.[26]

[26] The complete statistics of the variance decomposition are in the Tables 14 and 15 of the Appendix D.



(a) All shocks (b) Net of Gvt. shocks

Figure 5: Variance decomposition: Output. After re-estimation (B)

To extract the shocks that are not in the government budget, we then report in panel (b) of the Figure 5 the remaining effects (which are then re-normalized to 100%). If we exclude budgetary shocks, shocks to demand, markup, energy price, labor supply and productivity explain the majority of variations in GDP, monetary policy shocks and risk premium on public debt having, for their part, only a modest contribution.

Figure 6 gives the contribution of each shock in the quarterly forecast of each variable. Three variables are purely exogenous: public consumption, public transfers, and energy prices. The temporary energy subsidy (tariff shield) is also completely independent of other variables. It appears that energy-price shocks have a large contribution to inflation dynamics (price and wages). Demand and markup shocks explain a large part of output dynamics. Finally, the shocks on the disutility of working and productivity have significant contributions to total hours worked.

5.3 Evaluating the Uncertainty Around a Finance Act

In order to bring government forecasts into a context where extreme realizations of environmental variables are less likely, we construct counterfactual scenarios in which the standard deviation of one of these environmental variables is reduced by 25%. This leads us to multiply the sequence of estimated shocks affecting this environmental variable over the forecast horizon by 75%. We can then express in terms of GDP losses or gains (or debt increase or reduction) the macroeconomic impact of government overconfidence (or under-confidence) in future economic conditions and its repercussions on inequality trends.

For the government's projections to become realizations, our analysis highlights the necessary combination of "favorable winds", facilitating the objective of GDP growth and restoration of the balance of public finances (shocks on markup, labor supply and risk premium), and "unfavorable winds" (shocks on productivity and demand), making this objective more difficult to achieve. These are the conditions that deserve to be assessed to judge the credibility of the Finance Act. A summary of the results are shown in Table 7 while details are presented in Appendix F.

The Finance Act forecasts a rather optimist annual increase of GDP of 1.64% between 2003 to 2027. As we can observe, the output growth can vary between +0.12pp to -0.11pp depending

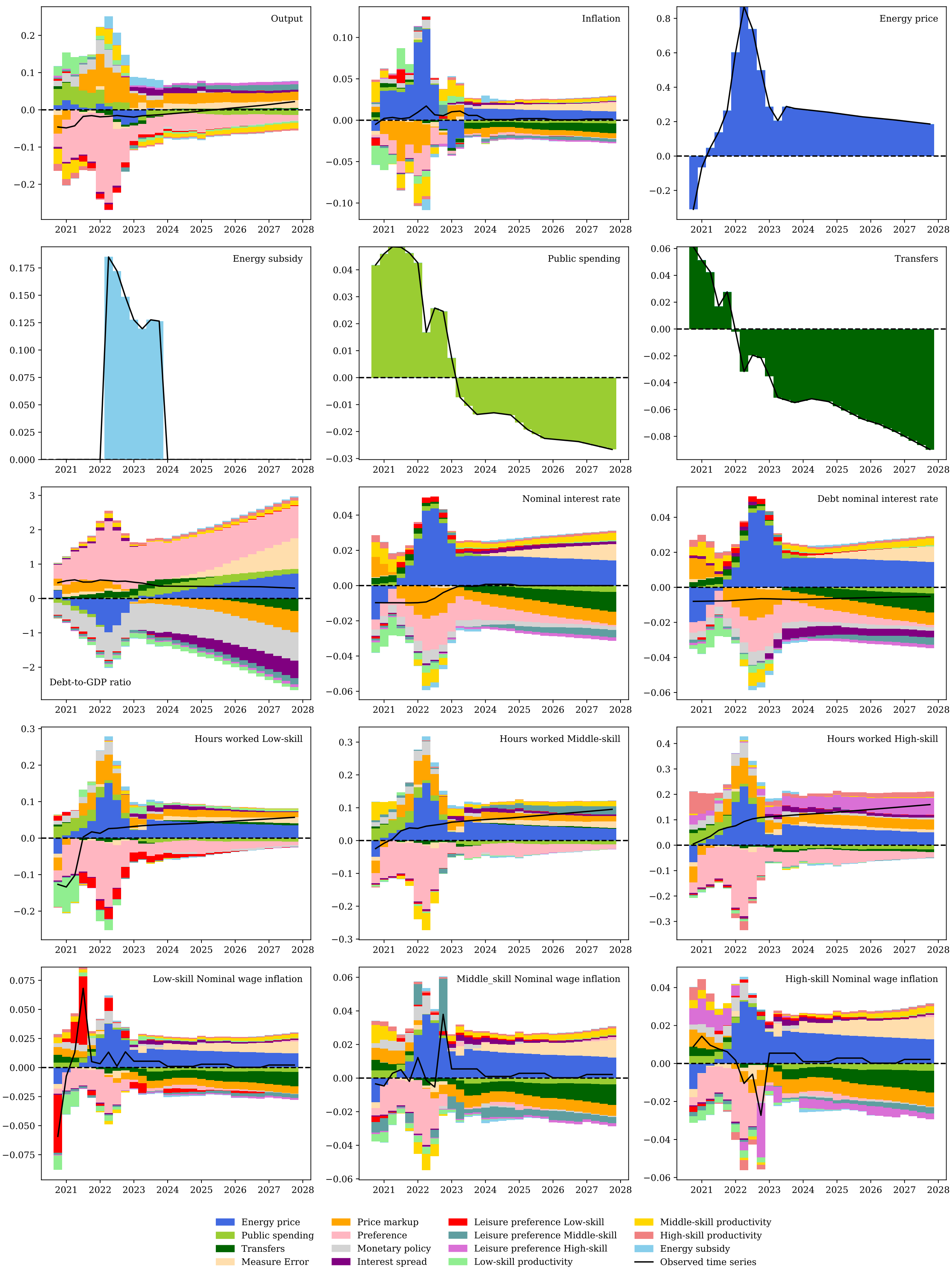


Figure 6: Shock Decomposition. After re-estimation (B)

	Benchmark	Markup	Spread	Disutility	Preference	Productivity
Output	1.64%	1.53%	1.62%	1.53%	1.73%	1.76%
Debt-to-GDP	108.3%	111.0%	111.1%	109.0%	105.7%	107.8%
inflation rate	2.42%	3.05%	2.29%	2.79%	2.81%	2.08%
Total employment	0.71%	0.62%	0.69%	0.63%	0.78%	0.65%
Low-skill employment	0.52%	0.45%	0.51%	0.52%	0.58	0.49%
Middle-skill employment	0.83%	0.75%	0.81%	0.72%	0.90%	0.76%
High-skill employment	0.90%	0.74%	0.85%	0.62%	0.99%	0.79%

Note: Results are presented as average annual growth over the period 2023Q1-2027Q4 for output and employment. Inflation is given annual percentage while the debt-to-GDP ratio corresponds to the value in 2027Q4.

Table 7: Uncertainty assessment: impact of smaller shocks

on the scenario. A decrease of price-markup or labor-disutility shocks (i.e. an increase of markup and labor disutility) would cause the highest fall while the diminution of the productivity shock (i.e. an increase of productivity) would lead to an important increase of GDP. The government plans for the debt-to-GDP ratio to decrease to 108.3% in 2027Q4. However, a decrease of labor-disutility or interest-spread shocks by 25% would completely overturn any planned decrease, with debt-to-GDP ratio remaining at 111%. On the contrary, a diminution of the preference shock, meaning households increasing consumption, would allow the government to decrease debt more easily, to 105.7% of GDP. Then, annual inflation is forecasted to be at 2.42% over the considered period. However, an increase of the markup would make it go above 3%. A better productivity would diminish labor costs and as such have the opposite effect, bringing inflation down to 2.08%. Finally, the government forecasts an increase of employment of 0.71% per year. Preferences more favorable to consumption would help employment growth, causing it to increase to 0.78%. On the contrary, a higher interest spread or a highest disutility of labor would logically bring employment down (increasing respectively of 0.62% and 0.63%).

Thus, this exercise shows that the size of shocks is of great importance for the success of the government forecasts. Even rather small changes can lead to large consequences in terms of output, debt, inflation or employment.

6 Assessing Fiscal Consolidation Programs

In its Finance Act, the French government plans for a small decrease of debt-to-GDP ratio by 2027 to 108.3% thanks to a strong increase in GDP growth. Nevertheless, the previous section showed that uncertainty around the realization of the Finance Act forecasts is high. Besides, debt-sustainability problems may put into questions the strategy of the government and lead to calls to decrease debt through public-spending reduction programs. As such, it is important to consider more substantial fiscal-consolidation programs that will enable France to achieve a larger reduction in its public debt. Simply put, could France reduce its indebtedness more sharply than forecasted in the Finance Act?

Public-debt sustainability is at the center of policy discussions today as, in most developed countries as France, debt interest rate is getting close or above the growth rate of the economy; debt is at particularly high level following fiscal packages linked to the Covid-19 crisis; and fiscal space is required to face new challenges as climate change (Blanchard (2023)). However, the difficulties of decreasing debt have been underlined for years. Empirical studies have notably found that policies focusing on decreasing debt have often hindered economic growth (Blanchard and Leigh (2013), Alesina et al. (2015) andIMF (2023)) while Ball et al. (2013) and Brinca et al. (2021) show how fiscal consolidation programs are usually correlated with an increase in inequalities, calling into question the social and political acceptability of these policies. Therefore, before examining these fiscal consolidation programs, it is worth first analyzing the changes in inequalities predicted by the model given the forecasts contained in the Finance Act.

6.1 Induced Inequality Dynamics

Changes in consumption inequalities are reported in Figure 8. Panel (a) gives the quarterly consumption of workers who only have access to low-skill jobs. As there is a distribution of low-skill jobs, this worker may have remuneration among the lowest 10% (called Bottom 10%), or equal to the median (Median) or even among the highest 10% (Top 10%).[27] The figure then reports the consumption levels associated with these three salary levels for the distribution of low-skill jobs. Panels (b) and (c) of Figure 8 report the same information but for workers with access to wages in middle and high-skilled jobs. Finally, panel (d) of Figure 8 makes the connection between the extremes, the top 10% of high wages compared to the bottom 10% of low wages. It also reports the consumption ratios between the bottom 10% of low earners and the median of the middle class, and between the Top 10% and the median of the middle class.

Our model forecasts the evolution of inequalities consistent with macroeconomic dynamics. Increases in the real interest rate and high salaries are factors in increasing inequalities, while strong GDP growth in terms of employment further favors the consumption of the poorest. When we assume that all transfers (the Bismarkian and the Beveridgian components of transfers) are reduced homogeneously, the model reveals that inequalities increase: in 2023, a well-off worker consumes 4.36 times more than a poor worker, while he would consume 4.85 times more in 2027. The drop in transfers penalizes households with the lowest incomes who are the main beneficiaries and who have no savings to compensate for these losses of income. In this scenario, strong growth, which nevertheless favors the consumption of the most disadvantaged, is not sufficient to contain the increase in inequalities. This could risk blocking the implementation of the decisions necessary for the realization of the Finance Act. We will now use our model to see if it is possible to implement a Finance Act causing a decrease of public debt without hindering economic growth or exacerbating inequalities.

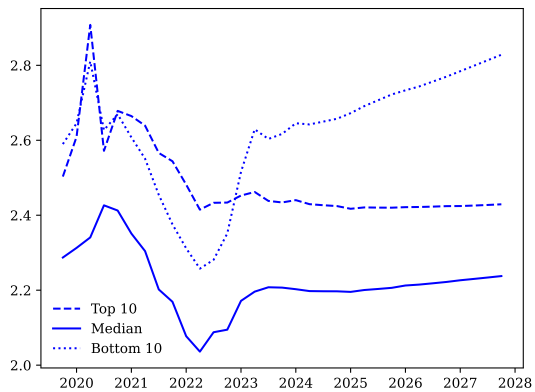
6.2 How to reduce debt without damaging growth or worsening inequality?

Thanks to our micro-founded decomposition of public spending between public consumption, Bismarckian (proportional to wage) and Beveridgian transfers (inversely proportional to wage) we can evaluate the consequences of different debt-reducing policies. Furthermore, with our method we take into account the general-equilibrium effects of those programs and the heterogeneous-agent structure of the model gives us a precise vision of inequality dynamics induced by those policies. This way our model allows us to go further into the analysis of those policies than previous studies.

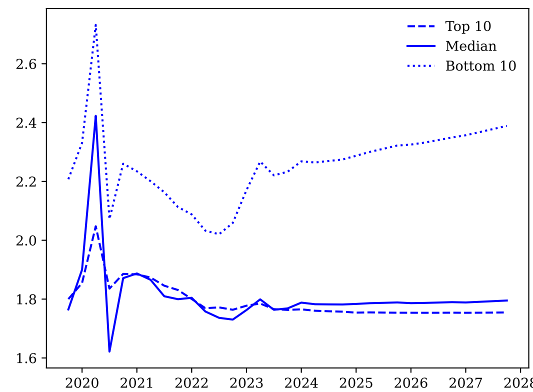
Using the structural shocks estimated for the forecast period, we look at the future trajectories of the French economy according to several fiscal and budgetary policies in the same economic context defined by these structural shocks and compare it to the forecasts of the Finance Act. We consider three different programs.

1. A two-fold reduction in public consumption expenditure.

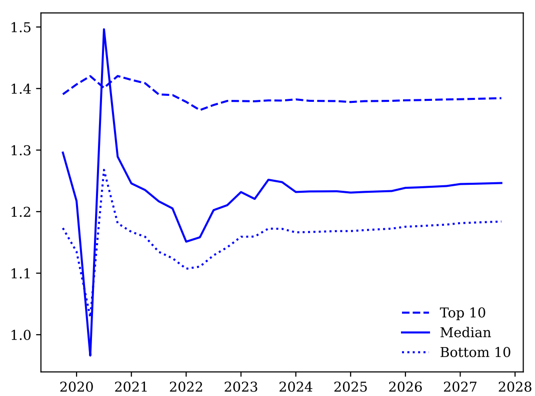
[27] The 1.5% lowest and highest remunerations are excluded respectively from the categories called Bottom 10% and Top 10%.



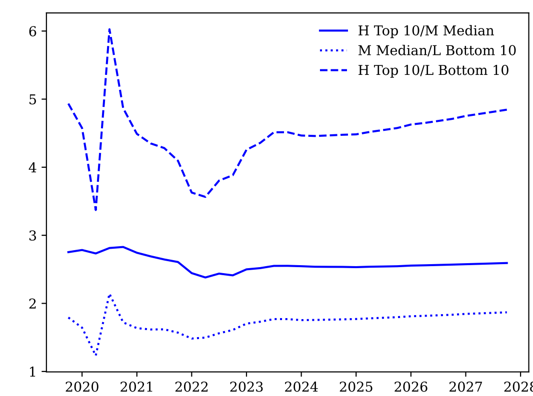
(a) High-skilled vs Low-skilled (B)



(b) High-skilled vs Medium-skilled (B)



(c) Medium-skilled vs Low-skilled (B)



(d) Skill and productivity differences (B)

Figure 7: Consumption ratios: comparison across two different workers' types. (B) after re-estimation.

2. A two-fold reduction in public transfers keeping unchanged the breakdown between Bismarkian and the Beveridgian components of transfers.

3. A two-fold reduction in public transfers made entirely by reducing Bismarkian transfers and leaving Beveridgian transfers unchanged.

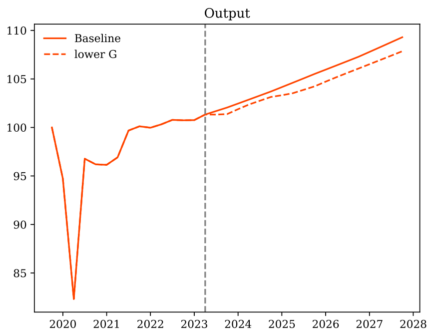
Figure 8 shows the consequences of the first program. Fiscal consolidation based solely on a reduction in public consumption will not be able to bring to the French economy a strong decrease of public debt with a sustained economic growth or a decrease of inequalities. The debt-to-GDP ratio falls (after an initial increase), but only 1pp more than in the Finance Act. The fall in public consumption causes a decrease in aggregate demand. As such, output growth is strongly damaged with an average annual growth of 1.37% (versus 1.64% in the Finance Act). This also leads to a reduction in employment for all workers, regardless of their qualifications (annual growth of 0.5% versus 0.71% in the Finance Act). As the most disadvantaged households are the most dependent on wage income, this would also lead to an increase in inequality. As such, a fiscal-consolidation program based on decreasing public consumption does not seem to be effective.

Figure 9 shows the consequences of the second program. Unlike the previous program, cuts in public transfers significantly reduce the debt-to-GDP ratio (it falls to 103.7% of GDP in 2027Q4) and it is not recessionary. Economic growth will be virtually identical to that projected in the Finance Act (slightly lower during the first quarters). On the other hand, this program leads to a sharp rise in inequalities. Our extreme consumption-inequality ratio rises to 5.62 in 2027 (versus 4.85 in the Finance Act). Low-skill households are strongly dependent on Beveridgian transfers that represent the majority of their income. Therefore, their fall has a very strong impact on those disadvantaged households. Despite increasing their supply of labor, it is not enough to compensate for the suffered income loss and their consumption falls more sharply than for other households. Thus, despite the strong decrease in public debt, the increase in inequality this program entails would be a considerable obstacle to its social acceptability.

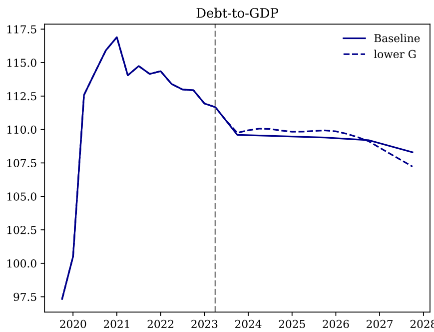
Figure 10 shows the consequences of the third program. As in the second program, it is based on a reduction in public transfers. The difference is that in this third program the reduction in transfers only concerns Bismarckian transfers. This means that Beveridgian transfers increase more in this program than in our baseline (which assumes no change in the distribution between the two types of transfers). With this program, a sharp reduction in the debt-to-GDP ratio occurs (104.6% of GDP in 2027Q4). Economic growth is higher than in the Finance Act (1.83% per year versus 1.64%). Indeed, as transfers decrease, households lose part of their income and decide to work more to compensate this loss. This change in labor supply occurs for all types of households as Bismarckian transfers, the ones proportional to wage, are the ones to fall. Finally, as Beveridgian transfers, favoring the more disadvantaged households remain stable, inequalities follow a similar path as in the Finance Act (4.81 versus 4.85 in 2027 for the extreme consumption-inequality measure). Thus, this program reconciles the three objectives: a sharp reduction in the debt-to-GDP ratio, no change in inequality compared to the benchmark situation, and a sustained economic growth. As such, it seems possible to reduce debt without worsening inequalities or damaging economic growth. What matters is the type of transfers to cut. The government must decrease transfers proportional to income as pensions or unemployment insurance.

6.3 General versus partial-equilibrium effects

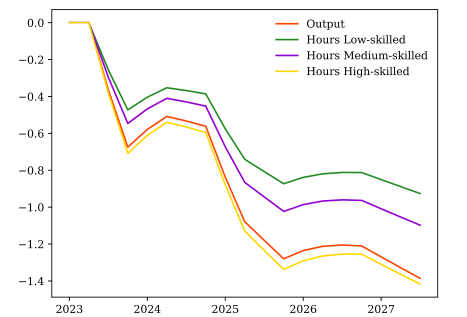
The advantage of our method is to give us the general-equilibrium effect of each of the government policies we studied. We can decompose this general-equilibrium effect between different partial-equilibrium effects. We show these effects for the dynamics of the debt for the two-fold decrease



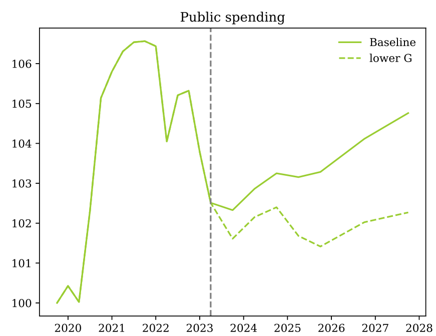
(a) GDP (B)



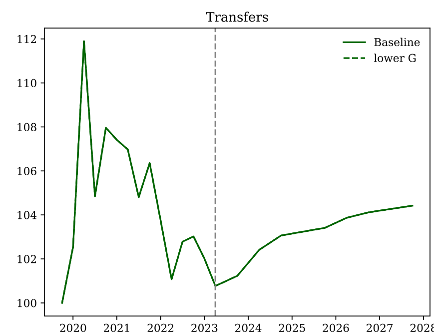
(b) Debt-to-GDP ratio (B)



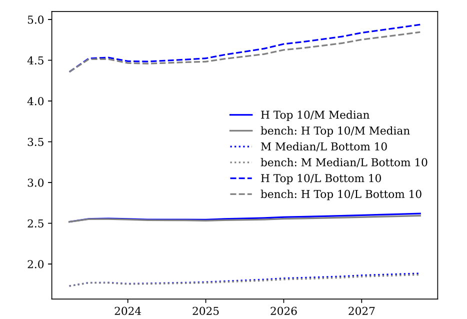
(c) Gaps in output and hours / 1Q-2023 (B)



(d) Government spending (B)



(e) Transfers (B)

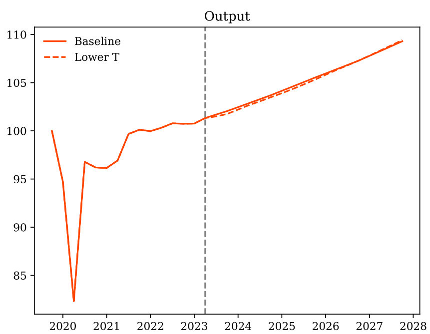


(f) Inequalities (B)

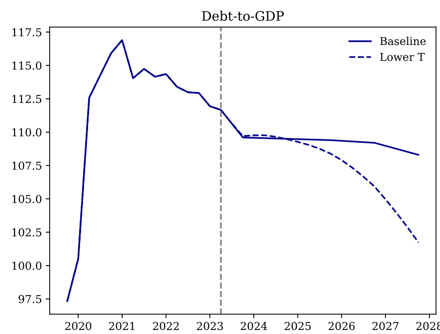
Figure 8: Counterfactual: two-fold reduction in government spending. (B) after re-estimation.

of government consumption, of transfers with and without a change in their composition in Figure 11. The results are expressed as percentage-point difference with respect to the forecasts of the Finance Act. First, we see the impact of only the decrease in government expenditures, that is the direct effect of the policy. Second, we add to this decrease the modification in revenue. Indeed, the decrease in government expenditures implies a decrease in public revenue. Third, we add the modifications in terms of output to the changes in public spending and revenue. In this case, the real interest rate is the only variable that remains as in the benchmark. Finally, we show again the general-equilibrium effect.

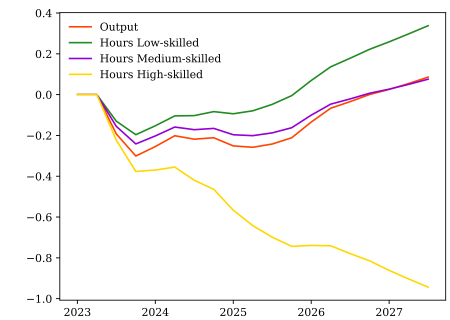
In all three cases, the direct effect of the policy (the sole impact of the decrease in public expenditures) is the largest. It implies a decrease of debt with respect to the benchmark of more than 14pp for both policies implying a diminution of transfers; and a decrease of more than five points in the case of the diminution of public consumption. For our preferred policy (a decrease of transfers only due to a diminution of its Bismarckian part), this 14pp difference means that this partial-equilibrium effect is about three times bigger than the general-equilibrium effect. When taking into account the implied change in revenue, the impact on debt diminishes. It falls from 5pp to 3.5pp for the policy diminishing public consumption and from 14pp to 10pp for the policy diminishing public transfers. For our preferred policy, this diminution of the impact is even bigger, it is divided by more than two, going from 14pp to 6pp. Indeed, the Bismarckian transfers that are reduced are the ones that are taxed and as such they bring additional revenues to the government. Adding the impact on output brings limited changes to the previous results. For the policy that



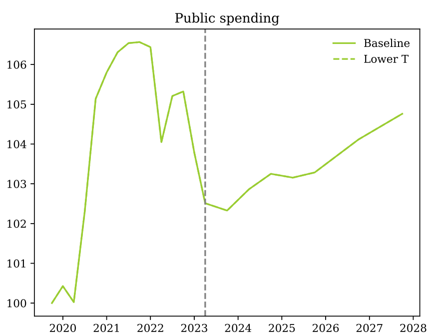
(a) GDP (B)



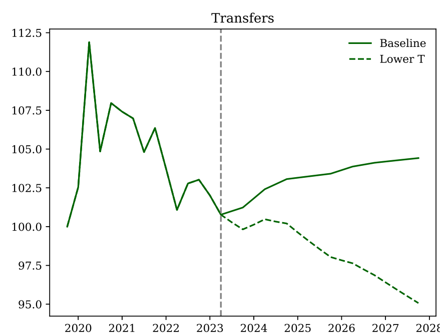
(b) Debt-to-GDP ratio (B)



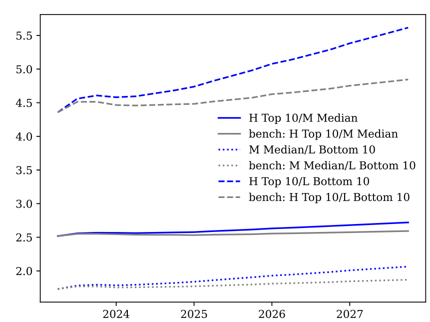
(c) Gaps in output and hours / 1Q-2023 (B)



(d) Government spending (B)

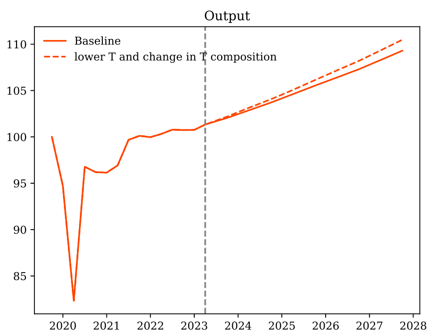


(e) Transfers (B)

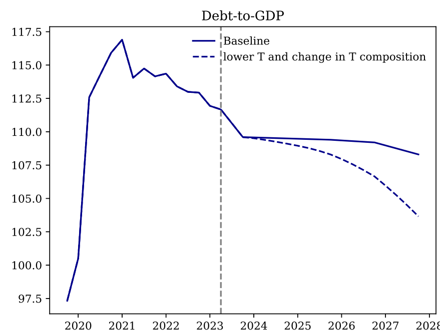


(f) Inequalities (B)

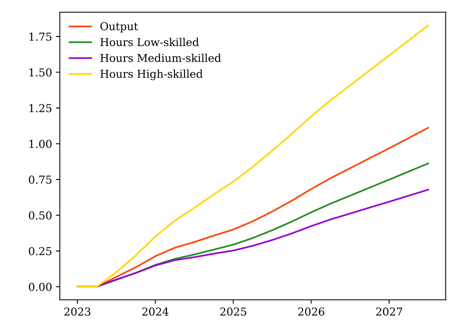
Figure 9: Counterfactual: two-fold reduction in Transfers. (B) after re-estimation.



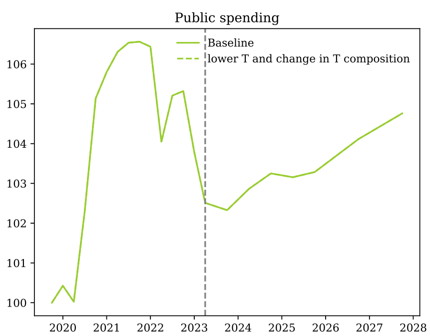
(a) GDP (B)



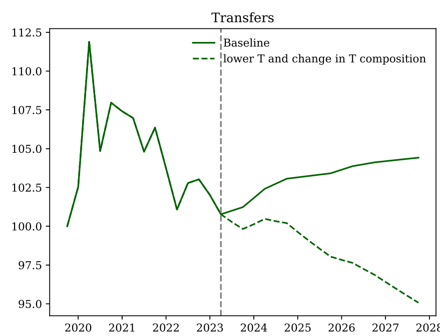
(b) Debt-to-GDP ratio (B)



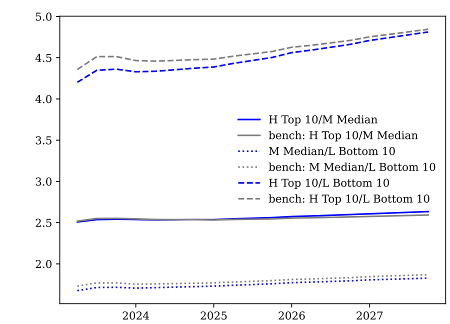
(c) Gaps in output and hours / 1Q-2023 (B)



(d) Government spending (B)

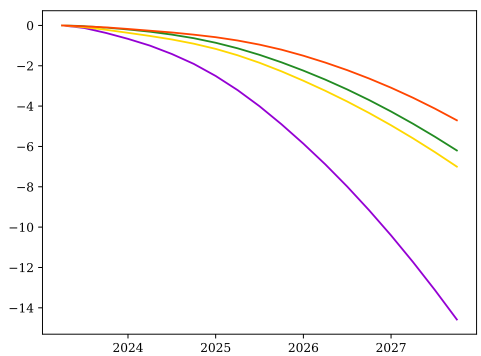


(e) Transfers (B)

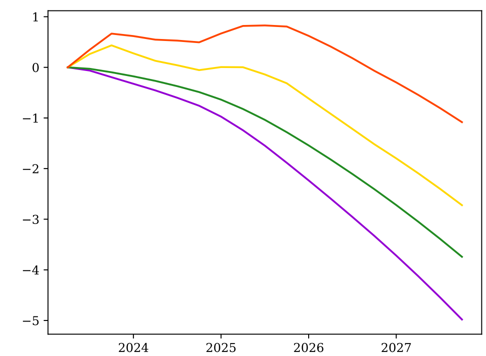


(f) Inequalities (B)

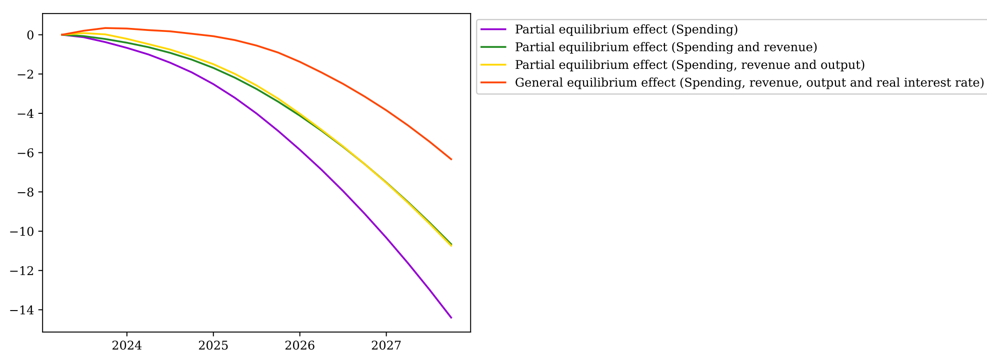
Figure 10: Counterfactual: two-fold reduction in Transfers only born by Bismarckian Transfers. (B) after re-estimation.



(a) Two-fold decrease of transfers only born by Bismarckian transfers (B)



(b) Two-fold decrease of public consumption (B)



(c) Two-fold decrease of transfers (B)

Figure 11: Partial versus general equilibrium effects of public policies on debt-to-GDP ratio (absolute difference with respect to the Finance Act forecasts). (B) after re-estimation.

reduces transfers homogeneously, the impact on debt is very similar as this policy has almost no effect on output (especially when looking at the end of the period). For the policy reducing public consumption, the decrease of debt is reduced a little more (from 3.5pp to 2.5pp) as output is lower. The opposite occurs for our favored policy. As output becomes higher in this counterfactual policy, taking it into account increases the impact on debt from 6pp to 7pp.

7 Debt-at-Risk

7.1 Methodology

This section introduces the debt-at-risk concept that we propose to use for stochastic debt-sustainability analysis (SDSA) in our setup. In the previous sections, we focused on the trend dynamics of macroeconomic fundamentals: the primary fiscal balance, economic growth, and interest and inflation rates. This analysis is useful for assessing the future trajectory of debt, but it does not provide an assessment of the risks weighing on public debt contrary to the SDSA as defined by Blanchard et al. (2021). For the authors: SDSA "would generate a distribution of paths of the debt ratio (sometimes called a 'fan chart'), based on forecasts for the drivers of the debt dynamics, which are themselves stochastic. (...) The forecasts would also take into account the policy intentions of the authorities, as well as the interactions between growth and fiscal policies. The result would be a distribution for the debt ratio n years out (...) conditional on expected policies (but allowing for uncertainty about these policies would affect the economy)."

Our application of conditional forecasting techniques to the HANK model allows us to generate the distribution of the debt-to-GDP ratio conditional on government forecasts, the economic policies pursued by the government, and the distribution of shocks that have hit the economy in the past. We denote the measure of as debt-at-risk b^{α}_{t+n}, which satisfies

$$F\left(b^{\alpha}_{t+n}|\mathcal{I}_t\right) = \alpha, \tag{4}$$

where $F\left(b_{t+n}|\mathcal{I}_t\right)$ is the conditional distribution of the debt ratio determined by the estimated HANK model and the set if information $\mathcal{I}_t$, which includes the estimated parameters of the model Θ and the policy $\mathcal{P}_t(x)$ announced as of time t for $t+n$ periods. The value of $b^{\alpha}_{t+n}\left(x\right)$ is the debt-to-GDP ratio that, according to our model, the economy will exceed with a probability $1-\alpha\%$ in n periods given the policy $\mathcal{P}_t(x)$.[28] The use of a structural model allows us to evaluate counterfactual scenarios for reducing the risk on public debt. We define

$$\Delta^{\alpha}_{t+n}\left(x,y\right) = b^{\alpha}_{t+n}\left(x\right) - b^{\alpha}_{t+n}\left(y\right) \tag{5}$$

as the changes of debt-at-risk, measured in percentage points, induced by a shift from policy $\mathcal{P}_t\left(x\right)$ to $\mathcal{P}_t\left(y\right)$. Applied to the fiscal consolidation programs we are studying, this measure makes it possible to assess the risk reduction they bring in relation to the policy announced by the government.

7.2 Results

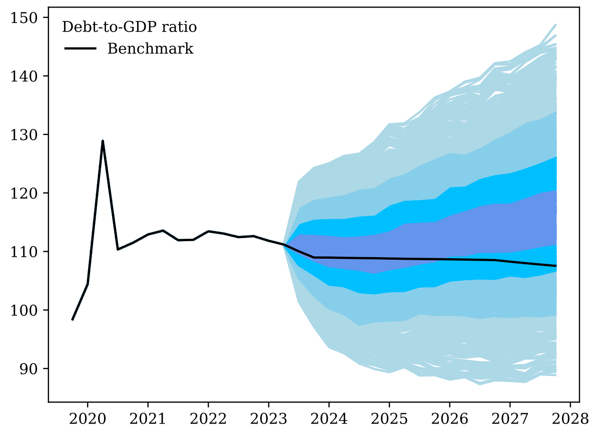
In this section, we present forecasts of the debt-to-GDP ratio conditional on the economic policy pursued (see Section G for the unconditional forecasts of all macroeconomic variables considered in the estimation). We make forecasts by drawing 1000 realizations from the estimated distributions of all shocks that do not concern the government policy decisions, namely shocks on preferences, markup, interest rates, and productivity. For policy shocks to government consumption, transfers and debt residual, we impose values based on the policy scenario $\mathcal{P}_t\left(x\right)$ under consideration. We then plot the forecast paths of the debt-to-GDP ratio and calculate the values of $b^{\alpha}_{t+n}\left(x,y\right)$ for $\alpha = \{2.5, 12.5, 25, 37.5, 50, 62.5, 75, 87.5, 97.5\}$ in percentage.

Policy x	Policy forecast	Distribution of forecasts for percentiles α								
		2.5%	12.5%	25%	37.5%	50%	62.5%	75%	87.5%	97.5%
(a) Benchmark (Finance Act)	108.3%	88.9%	99.3%	106.7%	111.3%	115.7%	120.7%	126.4%	134.2%	150.5%
(b) Larger $\Downarrow G$	107.2%	87.9%	98.3%	105.7%	110.3%	114.7%	119.7%	125.4%	133.2%	149.6%
(c) Large $\Downarrow T$	101.7%	82.3%	92.7%	100.1%	104.7%	109.1%	114.1%	119.8%	127.6%	144.0%
(d) Large $\Downarrow T$ and $\omega = 0$	103.7%	84.2%	94.6%	102.0%	106.6%	111.0%	116.0%	121.7%	129.4%	145.8%

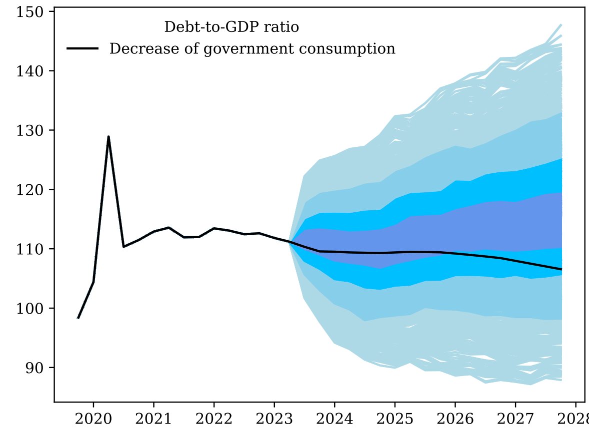
Table 8: Debt-at-risk $b^{\alpha}_{t+n}\left(x\right)$ conditional to the policy x with (a) the benchmark policy (Finance Act), (b) a two-fold decrease in public consumption G, (c) a two-fold decrease in transfers T, and (d) a two-fold decrease of transfers only born by Bismarckian transfers.
Debt-to-GDP values in 2027Q4

We start with policy $\mathcal{P}_t\left(a\right)$ associated with the Finance Act. Panel (a) of Figure 12 shows the distribution of debt-to-GDP ratio (in shapes of blue) as well as the trajectory planned by the

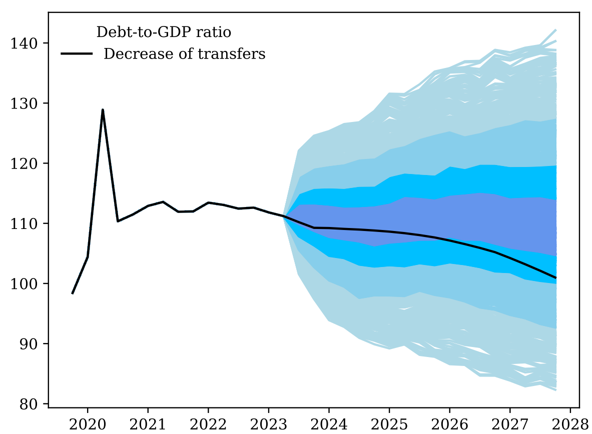
[28] The underlying definition of risk is similar to the one developed by Adrian et al. (2019) for growth at risk, the key difference being that our predictive distributions are based on the estimation of an estimated structural model rather than on quantile regressions.



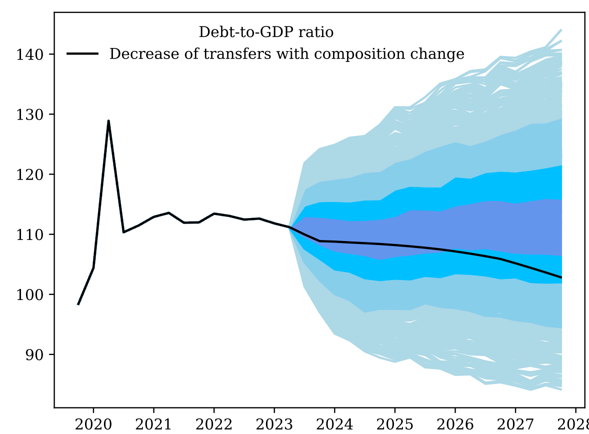
(a)



(b)



(c)



(d)

Figure 12: Distribution of debt-to-GDP forecasts conditionnal to the policy (in blue) and debt-to-GDP planned in the policy scenario (in black). Panel (a): Benchmark (Finance Act). Panel (b): Two-fold decrease in public consumption G. Panel (c): Two-fold decrease in transfers T. Panel (d): Two-fold decrease of transfers only born by Bismarckian transfers. Shaded colors correponds to the distribution percentiles $[2.5; 97.5]$, $[12.5; 87.5]$, $[25; 75]$, and $[37.5; 62.5]$ in percentage.

government (in the black line). As we can see, the path planned by the government is not in the middle of the distribution: the median of the forecast is 115.7% while the government forecasted 108.3%. This means that even if the non-government shocks compatible with the Finance Act are not unrealistic, in the sense that they belong to the distributions of these shocks estimated on the basis of past data (see Section 4), they are optimistic in the sense that the sum of their revealed values tend to lower this ratio more than a random draw of these values. The amount of debt at risk at the 25% threshold is $b^{0.75}_{t+n}(\mathcal{P}_t) = 126.4\%$. According to our model, there is a 25% chance that debt will exceed the value of 126.4%. This figure may seem high. However, we should keep in mind that the model is estimated over the recent period, when two major crises led to a sharp increase in the debt-to-GDP ratio of almost 15 points in a single year (during the Great Recession in 2009 and the COVID crisis in 2020). We are indeed living in a risky environment, with an unconditional probability of 10% (two years of crises in twenty years of observation) of experiencing a crisis with major consequences for the sustainability of public debt. The distribution of forecasts reflects this high risk to government debt. It is also worth noting that, as the model is linear, the risks are symmetrical on the upside and the downside. Thus, there is also a 25% chance that government debt will fall below 106.7% of GDP by 2027.

We now compare the policy $\mathcal{P}_t(a)$ associated with the Finance Act with alternative policies $\mathcal{P}_t(x)$ defined in Section 6. In all three cases, we maintain the shocks to the residual public debt that are revealed in the reference case, that of the Finance Act. The results are shown in Figure 12 and Table 8. These results make it possible to assess how fiscal-consolidation programs reduce the risk burden on debt. The fiscal-consolidation programs we study modify the trajectory either of public spending or of transfers, leaving non-government shocks unchanged in any case. Committing to a more intensive debt-reduction path reduces the risk to the debt, as these non-government shocks are superimposed on lower debt paths. For example, in scenario (b) with lower public consumption, the risk to debt is little changed, as the negative impact of this program on growth does not significantly alter the debt trajectory until 2027. The consolidation program (b) reduces debt-at-risk value (at the 25% level of risk) by only $\Delta^{0.75}_{t+20}(a,b) = 1$ point of percentage. By constrat, in scenario (c) with lower transfers, the risk to debt is sharply reduced $\Delta^{0.75}_{t+20}(a,c) = 6.6$ points of percentage. In our preferred scenario (d), which reduces public debt while maintaining growth and containing inequality, the reduction in debt risk is $\Delta^{0.75}_{t+20}(a,d) = 4.7$ points of percentage. In this case, it should be pointed out that the change in the transfer rule also changes the risk by modifying the sensitivity of the economy to all shocks, since the Jacobian is modified by the change in the share of Beveridgian transfers.

8 Conclusion

We develop a methodology that rigorously assesses the debt susbtainability implied by Finance Acts and evaluates the implications of alternative fiscal-consolidation programs. Using the conditional forecasts of a HANK model, we identify all future shocks consistent with the Finance Act proposed by the government. Then, we measure the contribution of fiscal decisions in the projections and compare it to the contributions of tailwinds and headwinds, thus revealing the optimism or pessimism of the forecast. The uncertainties about these macroeconomic projections may cast doubt on France's ability to reduce its public debt. We therefore compare alternative fiscal-consolidation programs to the one proposed in the government Finance Act. The results show that fiscal consolidation via a reduction in public consumption has the disadvantage of generating significant recessionary effects, unlike fiscal consolidation via a reduction in public transfers. The choice of which transfers are subject to cuts is of crucial importance in terms of consumption inequalities between households.

We show that it is possible to reduce debt and support growth without increasing inequality if the reduction concerns insurance transfers (of the Bismarckian type) without affecting assistance transfers (of the Beveridgian type). Our analysis also shows the importance of studying debt sustainability in the general equilibrium: fiscal policies should not be decided only looking at partial equilibrium effects. In all studied cases, the impact on debt in partial equilibriums exceeds largerly their impacts measured in general equilibrium.

References

Accardo, A., M. André, S. Billot, J.-M. Germain, and M. Sicsic (2021). Réduction des inégalités: la redistribution est deux fois plus ample en intégrant les services publics. *Insee Référence, INSEE*.

Achdou, Y., J. Han, J.-M. Lasry, P.-L. Lions, and B. Moll (2022, January). "Income and wealth distribution in macroeconomics: A continuous-time approach". *Review of Economic Studies 89*, 45–86.

Adolfson, M., S. Laseen, J. Linde, and M. Villani (2005). "Are Constant Interest Rate Forecasts Modest Policy Interventions? Evidence from a Dynamic Open-Economy Model". *International Finance 8*, 509–544.

Adrian, T., N. Boyarchenko, and D. Giannone (2019). Vulnerable growth. *American Economic Review 109*(4), 1263–1289.

Aiyagari, S. R. (1994). "Uninsured idiosyncratic risk and aggregate saving". *The Quarterly Journal of Economics 109*(3), 659–684.

Alesina, A., C. Favero, and F. Giavazzi (2015). The output effect of fiscal consolidation plans. *Journal of International Economics 96*, S19–S42.

Alesina, M. A., G. Ciminelli, D. Furceri, and G. Saponaro (2021). *Austerity and Elections*. International Monetary Fund.

André, M., J.-M. Germain, and M. Sicsic (2023). La redistribution élargie, incluant l'ensemble des transferts monétaires et les services publics, améliore le niveau de vie de 57% des personnes. *Insee Analyses 88, INSEE*.

Antolin-Diaz, J., I. Petrella, and J. F. Rubio-Ramirez (2021). "Structural scenario analysis with SVARs". *Journal of Monetary Economics 117*, 798–815.

Auclert, A., B. Bardóczy, and M. Rognlie (2023). Mpcs, mpes, and multipliers: A trilemma for new keynesian models. *Review of Economics and Statistics 105*(3), 700–712.

Auclert, A., B. Bardoczy, M. Rognlie, and L. Straub (2021). "Using the sequence-space Jacobian to solve and estimate heterogeneous-agent models". *Econometrica 89*(5), 2375–2408.

Auclert, A., H. Monnery, M. Rognlie, and L. Straub (2023). "Managing an Energy Shock: Fiscal and Monetary Policy". Mimeo, *Stanford*.

Auclert, A., M. Rognlie, M. Souchier, and L. Straub (2021). "Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel". Mimeo, *Stanford University*.

Auclert, A., M. Rognlie, and L. Straub (2018). "The intertemporal Keynesian cross". Working paper 25020, *National Bureau of Economic Research*.

Ball, L. M., D. Furceri, M. D. Leigh, and M. P. Loungani (2013). *The distributional effects of fiscal consolidation*. International Monetary Fund.

Barnard, G. and P. Ollivaud (2023). Inflation factors: how returns to capital and labour have contributed to domestic inflation pressures. *OECD Ecoscope July 27*.

Bayer, C., A. Kriwoluzky, G. Muller, and F. Seyrich (2023). "Hicks in HANK: Fiscal Responses to an Energy Shock". Discussion papers 18557, *CEPR*.

Bayer, C. and R. Luetticke (2020). "Solving discrete time heterogeneous agent models with aggregate risk and many idiosyncratic states by perturbation". *Quantitative Economics 11*(4), 1253–1288.

Blanchard, O. (2019). Public debt and low interest rates. *American Economic Review 109*(4), 1197–1229.

Blanchard, O., A. Leandro, and J. Zettelmeyer (2021). Redesigning eu fiscal rules: From rules to standards. *Economic Policy 36*(106), 195–236.

Blanchard, O. J. (2023). Reconciling the tension between green spending and debt sustainability. *PIIE*.

Blanchard, O. J. and J. Gali (2007). The macroeconomic effects of oil shocks: Why are the 2000s so different from the 1970s?

Blanchard, O. J. and D. Leigh (2013). Growth forecast errors and fiscal multipliers. *American Economic Review 103*(3), 117–120.

Blanchard, O. J. and D. Leigh (2014). Learning about fiscal multipliers from growth forecast errors. *IMF Economic Review 62*(2), 179–212.

Bohn, H. (1998). The behavior of us public debt and deficits. *the Quarterly Journal of economics 113*(3), 949–963.

Boivin, J. and M. Giannoni (2006). "DSGE Models in a Data-Rich Environment". Manuscript, *HEC Montreal and Columbia University*.

Bouabdallah, O., C. D. Checherita-Westphal, T. Warmedinger, R. De Stefani, F. Drudi, R. Setzer, and A. Westphal (2017). Debt sustainability analysis for euro area sovereigns: a methodological framework. *ECB Occasional Paper* (185).

Brender, A. and A. Drazen (2008). How do budget deficits and economic growth affect reelection prospects? evidence from a large panel of countries. *American Economic Review 98*(5), 2203–2220.

Brinca, P., M. H. Ferreira, F. Franco, H. A. Holter, and L. Malafry (2021). Fiscal consolidation programs and income inequality. *International Economic Review 62*(1), 405–460.

Carvalho, C., F. Nechio, and T. Tristao (2021). "Taylor Rule Estimation by OLS". *Journal of Monetary Economics 124*, 140–154.

Chetty, R., A. Guren, D. Manoli, and A. Weber (2012). "Does Indivisible Labor Explain the Difference between Micro and Macro Elasticities? A Meta-Analysis of Extensive Margin Elasticities". *NBER Macroeconomics Annual 27*, 1–56.

Del Negro, M. and F. Schorfheide (2013a). DSGE Model-Based Forecasting. In *Handbook of economic forecasting*, Volume 2, pp. 57–140. Elsevier.

Del Negro, M. and F. Schorfheide (2013b). "DSGE Model-Based Forecasting". In G. Elliott and A. Timmermann (Eds.), *Handbook of Computational Economics*, Volume 2 of *Handbook of Economic Forecasting*, pp. 57–140. Elsevier.

Gali, J. (2011). "Are central banks' projections meaningful ?". *Journal of Monetary Economics* (58), 537–550.

Gelfer, S. (2019). "Data-rich DSGE forecasts of the great recession and its recovery". *Review of Economic Dynamics* (31), 18–41.

IMF (2023). Chapter 3: Coming down to earth: How to tackle soaring public debt.

Kaplan, G., B. Moll, and G. L. Violante (2018). "Monetary policy according to HANK". *American Economic Review 108*(3), 697–743.

Kaplan, G. and G. L. Violante (2018). "Microeconomic heterogeneity and macroeconomic shocks". *Journal of Economic Perspectives 32*(3), 167–194.

Krusell, P. and A. Smith (1998). "Income and wealth heterogeneity in the macroeconomy". *Journal of Political Economy 106*(5), 867–896.

Langot, F., S. Malmberg, F. Tripier, and J.-O. Hairault (2023). "The Macroeconomic and Redistributive Effects of Shielding Consumers from Rising Energy Prices: the French Experiment". Working paper 2305, Cepremap.

Leeper, E. and T. Zha (2003). "Modest policy interventions". *Journal of Monetary Economics* (50), 1673–1700.

Lucas, R. (1976). "Econometric Policy Evaluation: A Critique". *Carnegie Rochester Conference Series on Public Policy 1*, 104–130.

Pieroni, V. (2023). "Energy shortages and aggregate demand: Output loss and unequal burden from HANK". *European Economic Review 154*, 104428.

Reiter, M. (2009). "Solving heterogeneous-agent models by projection and perturbation". *Journal of Economic Dynamics and Control 33*(3), 649–665.

Reiter, M. (2010, October). "Approximate and almost-exact aggregation in dynamic stochastic heterogeneous-agent models". Economics series 258, *Institute for Advanced Studies.*

Schorfheide, F., K. Sill, and M. Kryshko (2010). "DSGE model-based forecasting of nonmodeled variables". *International Journal of Forecasting* (26), 348–373.

Waggoner, D. F. and T. Zha (1999). "Conditional forecasts in dynamic multivariate models". *Review of Economics and Statistics 81*(4), 639–651.

Winberry, T. (2018). "A method for solving and estimating heterogeneous agent macro models". *Quantitative Economics 9*(3), 1123–1151.

Appendix

A Union and Phillips Curve

A union sets a unique nominal wage W_k^s by task k, $\forall s \in \{l, m, h\}$. The union's program is:

$$U_{k,t}^s(W_{k,t-1}^s) = \max_{W_{k,t}^s} \left\{ \begin{array}{c} \int_{e,a_-} u(c^s(e,a_-)) - v(n_k^s(e,a_-))d\Gamma^s(e,a_-) \\ -\frac{\Psi_W^s}{2}\left(\frac{W_{k,t}^s}{W_{k,t-1}^s} - 1\right)^2 + \beta U_{k,t+1}^s(W_{k,t}^s) \end{array} \right\}$$

$$\text{s.t.} \quad N_{k,t}^s = \left(\frac{W_{k,t}^s}{W_t^s}\right)^{-\varepsilon_s} N_t^s$$

$$\Leftrightarrow U_{k,t}^s(W_{k,t-1}^s) = \max_{W_{k,t}^s} \left\{ \begin{array}{c} \int_{e,a_-} u(c^s(e,a_-)) - v(n_k^s(e,a_-))d\Gamma^s(e,a_-) \\ -\frac{\Psi_W^s}{2}\left(\frac{W_{k,t}^s}{W_{k,t-1}^s} - 1\right)^2 \left(\frac{W_{k,t}^s}{W_t^s}\right)^{-\varepsilon_s} + \beta U_{k,t+1}^s(W_{k,t}^s) \end{array} \right\}$$

where $W_t^s = \left(\int_k (W_{k,t}^s)^{1-\varepsilon_s} dk\right)^{\frac{1}{1-\varepsilon_s}}$ and $N_t^s = \left(\int_k (N_{k,t}^s)^{\frac{\varepsilon_s - 1}{\varepsilon_s}} dk\right)^{\frac{\varepsilon_s}{\varepsilon_s - 1}}$. Furthermore, the union k imposes that every worker works the same amount of hours, so that: $n_k^s = N_k^s$. An agent of type s:

- Provides $n_{k,t}^s$ hours of work for the task k and a total number of hours $n^s = \int n_{k,t}^s dk$
- Gets income $z_t^s = \int_k (1 - \lambda_{inc})((1 - \tau_{ssc})W_{k,t}^s e_t n_{k,t}^s + A)^{1-\tau_{inc}} dk$
- Has before tax income $\widetilde{z}_t^s = \int_k ((1 - \tau_{ssc})W_{k,t}^s e_t n_{k,t}^s dk + A$
- Pays the progressive tax $\widetilde{z}_t^s - z_t^s$
- where $A = (1 - \tau_f)d(e) + \bar{T}(e)$

$$\begin{aligned} z_t^s &= \int_k (1 - \lambda_{inc}) \left((1 - \tau_{ssc})W_{k,t}^s e_t n_{k,t}^s + A\right)^{1-\tau_{inc}} dk \\ &= \int_k (1 - \lambda_{inc}) \left((1 - \tau_{ssc})W_{k,t}^s e_t \left(\frac{W_{k,t}^s}{W_t^s}\right)^{-\varepsilon_s} N_t^s + A\right)^{1-\tau_{inc}} dk \end{aligned}$$

FOC w.r.t W_k^s of the labor union's problem:

$$0 = \underbrace{\frac{\partial}{\partial W_k^s}\left(\int_{e,a_-} u(c^s(e,a_-)) - v(n_k^s(e,a_-))d\Gamma^s(e,a_-)\right)}_{\text{part 1}} - \Psi_W^s \frac{1}{W_{k,t-1}^s}\left(\frac{W_{k,t}^s}{W_{k,t-1}^s} - 1\right) + \beta \underbrace{\frac{\partial U_{k,t+1}^s}{\partial W_k^s}(W_k^s)}_{\text{part 2}}$$

Part 1.

$$\begin{aligned} \frac{\partial}{\partial W_k^s}\left(\int_{e,a_-} u(c^s(e,a_-)) - v(n_k^s(e,a_-))d\Gamma(e,a_-)\right) &= \int_{e,a_-} \left(\frac{\partial u}{\partial c^s}\frac{\partial c^s}{\partial W_k^s} - \frac{\partial v}{\partial n_k^s}\frac{\partial n_k^s}{\partial W_k^s}\right) d\Gamma^s(e,a_-) \\ &= \int_{e,a_-} \left(u'(c^s)\frac{\partial c^s}{\partial W_k^s} - v'(n_k^s)\frac{\partial n_k^s}{\partial W_k^s}\right) d\Gamma^s(e,a_-) \\ &= \int_{e,a_-} \left(u'(c^s)\frac{\partial c^s}{\partial W_k^s} + v'(n_k^s)\varepsilon_s \frac{n_k^s}{W_k^s}\right) d\Gamma^s(e,a_-) \end{aligned}$$

Indeed,

$$\frac{\partial n_k^s}{\partial W_k^s} = \frac{\partial}{\partial W_k^s}\left(\left(\frac{W_{k,t}^s}{W_t^s}\right)^{-\varepsilon_s} N_t^s\right) = -\varepsilon_s \frac{N^s}{W_k^s}\left(\frac{W_{kt}^s}{W_t^s}\right)^{-\varepsilon_s} = -\varepsilon_s \frac{N_k^s}{W_k^s}$$

and we have

$$\begin{aligned}
\frac{\partial c^s}{\partial W_k^s} &= \frac{1}{(1+\tau_c)P_t}\frac{\partial z^s}{\partial W_k^s} \\
&= \frac{1}{1+\tau_c}\frac{\partial}{\partial W_k^s}\int_k (1-\lambda_{inc})\left((1-\tau_{ssc})W_{k,t}^s e_t n_{k,t}^s + A\right)^{1-\tau_{inc}} dk \\
&= \frac{1}{(1+\tau_c)P_t}\int_k (1-\lambda_{inc})(1-\tau_{inc})(1-\tau_{ssc})\left(e_t n_{k,t}^s + W_{k,t}^s e_t \frac{\partial n_k^s}{\partial W_k^s}\right)((1-\tau_{ssc})W_{kt}^s e_t n_{kt}^s + A)^{-\tau_{inc}} dk \\
&= \frac{1}{(1+\tau_c)P_t}\int_k (1-\lambda_{inc})(1-\tau_{inc})(1-\tau_{ssc})\left(e_t n_{k,t}^s - \varepsilon_s W_{k,t}^s e_t \frac{N_k^s}{W_k^s}\right)\left((1-\tau_{ssc})W_{k,t}^s e_t n_{k,t}^s + A\right)^{-\tau_{inc}} dk \\
&= \frac{1}{(1+\tau_c)P_t}\int_k (1-\lambda_{inc})(1-\tau_{inc})(1-\tau_{ssc})(1-\varepsilon_s)e_t n_{k,t}^s \left((1-\tau_{ssc})W_{k,t}^s e_t n_{k,t}^s + A\right)^{-\tau_{inc}} dk
\end{aligned}$$

Part 2. Envelope theorem: $\frac{\partial U_{k,t+1}^s}{\partial W_k^s}(W_k^s) = \Psi_W^s\left(\frac{W_{k,t+1}^s}{W_{k,t}^s} - 1\right)\frac{W_{k,t+1}^s}{(W_{k,t}^s)^2} = \Psi_W^s \frac{1}{W_{k,t}^s}\left(\frac{W_{k,t+1}^s}{W_{k,t}^s} - 1\right)\frac{W_{k,t+1}^s}{W_{k,t}^s}$

At the symmetric equilibrium, we have $W_k^s = W_{k'}^s = W^s$ and $n_k^s = n_{k'}^s = N^s$ $\forall k, k'$

$$\frac{\partial c^s}{\partial W_k^s} = \frac{1}{(1+\tau_c)P_t}(1-\tau_{inc})(1-\tau_{ssc})(1-\varepsilon_s)e_t N_t^s \underbrace{(1-\lambda_{inc})\left((1-\tau_{ssc})W_t^s e_t N_t^s + A\right)^{-\tau_{inc}}}_{1-\text{average tax rate}=1-\overline{\mathcal{T}}_t^s}$$

Using $\pi_{W,t}^s = \frac{W_t^s}{W_{t-1}^s} - 1$, the FOC rewrites:

$$\begin{aligned}
0 &= \frac{1}{(1+\tau_c)P_t}(1-\tau_{inc})(1-\tau_{ssc})(1-\varepsilon_s)N_t^s \int_{e,a_-} u'(c^s)e_t(1-\overline{\mathcal{T}}_t^s)d\Gamma^s(e,a_-) \\
&\quad + v'(N^s)\frac{N^s}{W^s}\varepsilon_s - \Psi_W^s \frac{1}{W_{t-1}^s}\pi_{W,t}^s + \beta\Psi_W^s \pi_{W,t+1}^s(1+\pi_{W,t+1}^s)\frac{1}{W_t^s}
\end{aligned}$$

Notation. Assume that we can compute $\widetilde{u}_t'(c^s, \overline{\mathcal{T}}^s) \equiv \int_{e,a_-} u'(c^s)e_t(1-\overline{\mathcal{T}}_t^s)d\Gamma^s(e,a_-)$, therefore we deduce:

$$\begin{aligned}
0 &= \frac{1}{(1+\tau_c)P_t}(1-\tau_{inc})(1-\tau_{ssc})(1-\varepsilon_s)N_t^s \widetilde{u}_t'(c^s,\overline{\mathcal{T}}^s) + v'(N_t^s)\frac{N_t^s}{W_t^s}\varepsilon_s \\
&\quad -\Psi_W^s \frac{1}{W_{t-1}^s}\pi_{W,t}^s + \beta\Psi_W^s \frac{1}{W_t^s}\pi_{W,t+1}^s(1+\pi_{W,t+1}^s) \\
\Leftrightarrow 0 &= (1-\varepsilon_s)\frac{(1-\tau_{inc})(1-\tau_{ssc})}{(1+\tau_c)P_t}W_t^s N_t^s \widetilde{u}_t'(c^s,\overline{\mathcal{T}}^s) + v'(N_t^s)N_t^s\varepsilon_s \\
&\quad -\Psi_W^s(1+\pi_{W,t}^s)\pi_{W,t}^s + \beta\Psi_W^s \pi_{W,t+1}^s(1+\pi_{W,t+1}^s)
\end{aligned}$$

The resulting New-Keynesian Phillips curve for sector s is:

$$\begin{aligned}
\pi_{W,t}^s &= \frac{\varepsilon_s}{\Psi_W^s}\left[\frac{1-\varepsilon_s}{\varepsilon_s}\frac{(1-\tau_{inc})(1-\tau_{ssc})}{(1+\tau_c)P_t}W_t^s N_t^s \widetilde{u}_t'(c^s,\overline{\mathcal{T}}^s) + v'(N_t^s)N_t^s\right] + \beta\pi_{W,t+1}^s \\
&= \kappa_W^s\left(N_t^s v'(N_t^s) - \frac{1}{\mu_w^s}td_t^s\frac{W_t^s}{P_t}N_t^s\widetilde{u}_t'(c^s,\overline{\mathcal{T}}^s)\right) + \beta\pi_{W,t+1}^s
\end{aligned}$$

with tax distortion $td_t^s = \frac{(1-\tau_{inc})(1-\tau_{ssc})}{1+\tau_c}$, $\mu_w^s = \frac{\varepsilon_s}{\varepsilon_s - 1}$, $\kappa_W = \frac{\varepsilon_s}{\Psi_W^s}$, $\pi_W(1+\pi_W) \approx \pi_W$ and the average level of e is 1 leading to $W_t^s e_t N_t^s = W_t^s N_t^s$.

B Data, Steady State and Calibrations

B.1 Raw data

Data	Web access	Providers
Population	DBnomics code	Eurostat
GDP	DBnomics code	Eurostat
CPI	DBnomics code	INSEE
Energy price	DBnomics code	INSEE
Government consumption	DBnomics code	Eurostat
Government transfers	DBnomics code	Eurostat
Public debt	DBnomics code	Eurostat
Employment rate	DBnomics code	INSEE
Employment in Agriculture	DBnomics code	Eurostat
Employment in Wholesale and Retail Trade	DBnomics code	Eurostat
Employment in Construction	DBnomics code	Eurostat
Employment in Real estate	DBnomics code	Eurostat
Employment in Science and Administration	DBnomics code	Eurostat
Employment in Industry	DBnomics code	Eurostat
Employment in Finance	DBnomics code	Eurostat
Employment in Information and Communication	DBnomics code	Eurostat
Total Compensation in Agriculture	DBnomics code	Eurostat
Total Compensation in Wholesale and Retail Trade	DBnomics code	Eurostat
Total Compensation in Construction	DBnomics code	Eurostat
Total Compensation in Real estate	DBnomics code	Eurostat
Total Compensation in Science and Administration	DBnomics code	Eurostat
Total Compensation in Industry	DBnomics code	Eurostat
Total Compensation in Finance	DBnomics code	Eurostat
Total Compensation in Information and Communication	DBnomics code	Eurostat
Total hours in Agriculture	DBnomics code	Eurostat
Total hours in Wholesale and Retail Trade	DBnomics code	Eurostat
Total hours in Construction	DBnomics code	Eurostat
Tota hours in Real estate	DBnomics code	Eurostat
Total hours in Science and Administration	DBnomics code	Eurostat
Tota hours in Industry	DBnomics code	Eurostat
Total hours in Finance	DBnomics code	Eurostat
Total hours in Information and Communication	DBnomics code	Eurostat
Euribor	DBnomics code	BdF
Interest charges	DBnomics code	AMECO

Table 9: Data sources

All the raw series of Table 9 are quarterly and range from 2Q1995 to 4Q2021, except Euribor that starts in 1999 and the employment rate, available only from 2Q2003. For the population and interest charges, which are annual series, we build quarterly series by interpolation. Some series 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 quarterized using a moving average, from which we derive π. The energy price (P_{FE}) is the crude-oil price in Euro. Finally, the data of hours and wages by worker types are constructed using data described in Appendix B.3. All times series are plotted in Figure 13.

For the estimation, the time series of per-capita GDP , price index, Govt. consumption, Govt. transfers and wages are stationarized around a linear trend. The other times series are stationarized around their average over the sample.

B.2 Energy Market

Data for consumption gives us the distribution of consumption by type of goods. We consider that the categories "Housing, water, gas, electricity and other fuels" ("Logement, eau, gaz, electricité et autres combustibles") and "fuels and lubricants, antifreeze" ("Carburants et lubrifiants, antigel") belong to the energy part of consumption. Making the assumption that the demand for energy is equally shared between households and firms, we obtain that the shares of firm and household energy demand over GDP are each 1.59%.

Assuming further that $\sigma_f = \eta_E$, $Z = 1$ and $s_H = s_F = 0$. Then, using $mc = 1/\mu$, we can set $mc_F = mc$ and $p_F = mc_F$. Hence, we deduce Hence, we deduce

$$\begin{aligned} Y_{FE} &= \alpha_E \left(\frac{p_{FE}}{p_F}\right)^{-\eta_E} Y & \Leftrightarrow \quad \frac{p_{FE} Y_{FE}}{Y} = \alpha_E \left(\frac{1}{p_F}\right)^{-\eta_E} p_{FE}^{1-\eta_E} \\ E &= \alpha_f (1-\alpha_E) \left(\frac{p_{FE}}{p_F}\right)^{-\eta_E} Y & \Leftrightarrow \quad \frac{p_{FE} E}{Y} = \alpha_f (1-\alpha_E) \left(\frac{1}{p_F}\right)^{-\eta_E} p_{FE}^{1-\eta_E} \end{aligned}$$

which gives us:

$$\begin{aligned} \alpha_f &= \frac{\alpha_E}{1-\alpha_E} \frac{p_{FE} E/Y}{p_{FE} Y_{FE}/Y} \\ p_{FE} &= \left(\frac{(p_{FE} Y_{FE}/Y) + P_{FE} E/Y}{\alpha_E + \alpha_f (1-\alpha_E)} mc^{-\eta_E} \right)^{\frac{1}{1-\eta_E}} \end{aligned}$$

B.3 Labor Market.

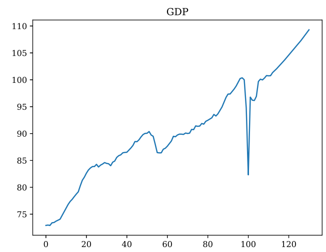
Figure 14 shows the employment shares and gross wage by sector of the French economy. For our model, we divide the labor market into three submarkets, $s = l, m, h$:

- the submarket of high wages ($s = h$): Information Communication + Finance
- the submarket of intermediate wages ($s = m$): Industry + Construction + Scientific and Administrative + Real Estate
- the submarket of low wages ($s = l$): Wholesale and Retail Trade + Agriculture

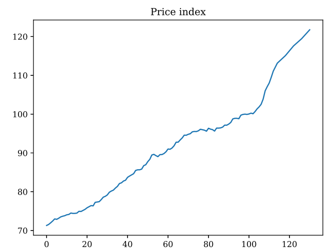
We obtain the distributions shown in Figure 15. Between 1Q2003 and 4Q2019, the employment rate were $\widetilde{N}_L = 25.5\%$, $\widetilde{N}_M = 32.5\%$ and $\widetilde{N}_H = 5\%$. Therefore, the aggregate employment rate is $\sum_s \widetilde{N}_s = \widetilde{N} = 63\%$. This allows to deduce the relative employment sizes s: $\widetilde{N}_s/\widetilde{N} \in \{40.5; 51.5; 8\}\%$.

To determine the employment rate by s, we need to use the participation rates and the employment rates for each s. We approximate these rates by assuming that low-wage workers have a diploma lower than the “baccalauréat”, those with an intermediate wage have a diploma between the “baccalauréat” and two years of higher education, and high-wage workers have a bachelor or more. Data for the participation rates, and data for unemployment lead to

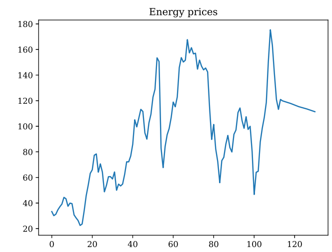
- Participation rates (1985-2016): $P_l = 71\%$, $P_m = 76.25\%$ and $P_h = 87.0\%$



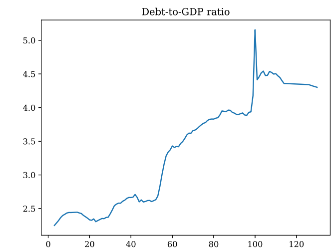
(a) GDP per capita



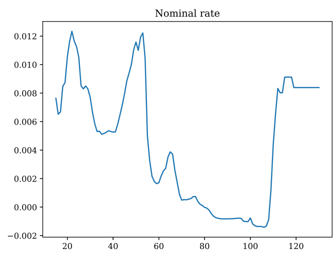
(b) Price index



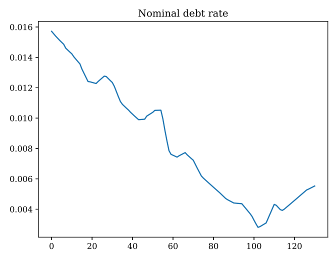
(c) Energy price



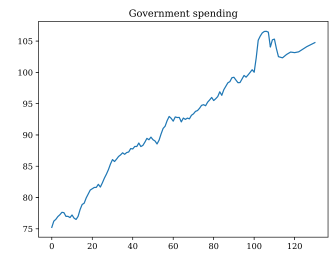
(d) Debt-to-GDP



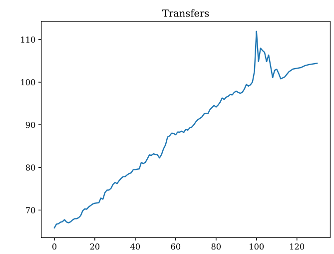
(e) Nominal interest rate



(f) Interest rate on public debt



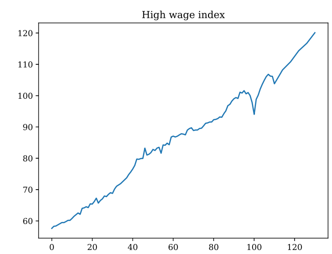
(g) Govt. consumption



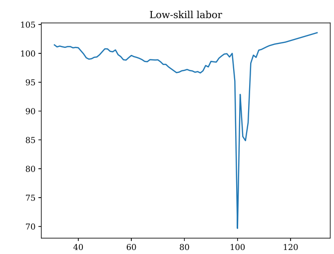
(h) Govt. transfers

(i) Low wages index

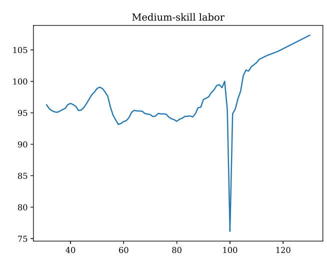
(j) Intermediate wages index



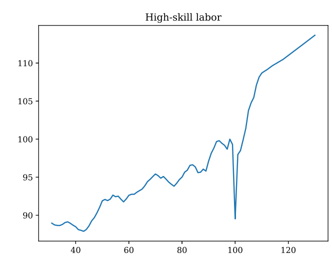
(k) High wages index



(l) Hours - Low wages

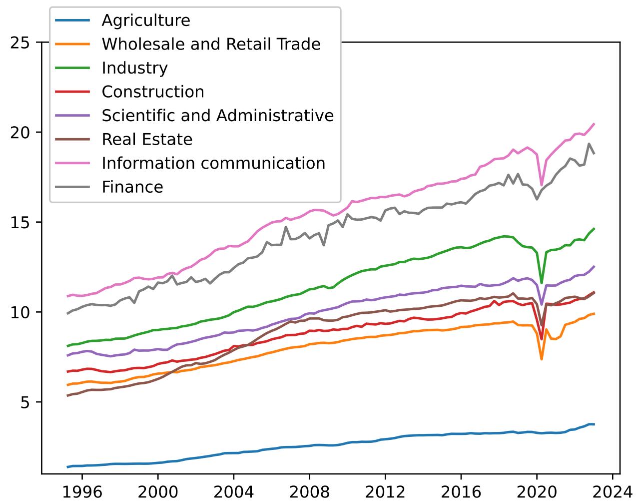


(m) Hours - Intermediate wages

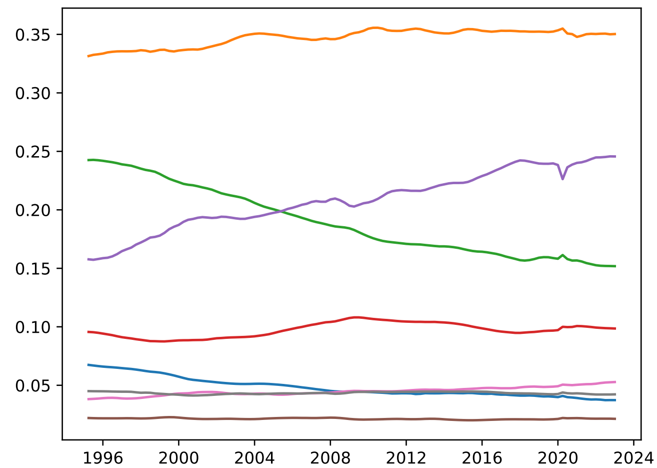


(n) Hours - High wages

Figure 13: Raw data (100 in 4Q2019)



(a) Gross wages by employee



(b) Employment Shares

Figure 14: Raw labor-market statistics

Sector s	L	M	H	Mean
Shares $(\widetilde{N}_s/\widetilde{N})$	45.2%	48.6%	6.2%	-
Wages	1	1.4	2	1.3
Employment rates	56%	66.25%	81%	63%
Hours worked	1	0.98	1.02	0.99
$\widehat{N}_s$ (employment rates×Share)	25.3	31.6	5.1	-

Table 10: Labor-market statistics

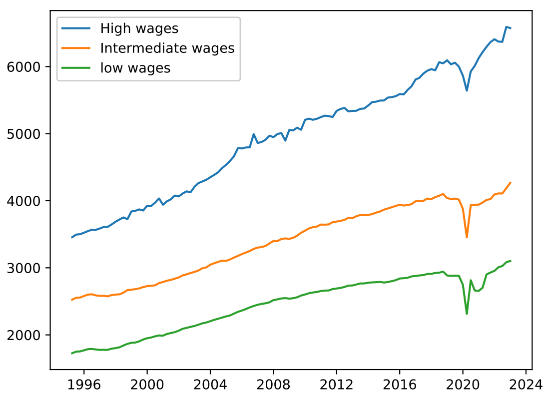
- Unemployment rates (2016): $U_l = 15\%$, $U_m = 10\%$ and $U_h = 6\%$.

This leads to employment rates equal to $N_l = 56\%$, $N_m = 66.25\%$ and $N_h = 81\%$, consistent with a total employment rate equals to 63% with the shares N_s/N.

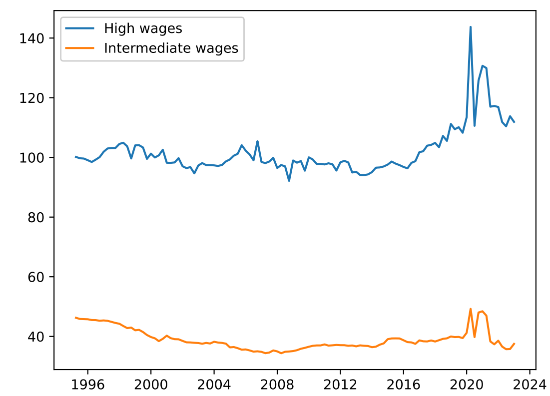
Beyond the employment rate (N), we also use the number of hours worked by workers (h) to build the aggregate hours $Nh = N \times h$.

- Information provided by the data
  - the values of $\{\omega^s, n^s\}$ $\forall s$. Given that efficient labor is $N^s = \sum_i \omega^s \pi_i^s e_i^s n_i^s$, where ω^s is the size of each population, $\sum_i \pi_i^s e_i^s = \varpi^s$ is the average productivity of each population and $n^s(i) = n^s(i') \equiv n^s$, $\forall i, i'$ is the homogenous aggregate hours worked $\forall s$ (restriction implied by unions) by each population, we deduce that $N^s = \varpi^s \omega^s n^s = \varpi^s \widehat{n}^s$.
  - the relative wages $\{1, l^m, l^h\}$

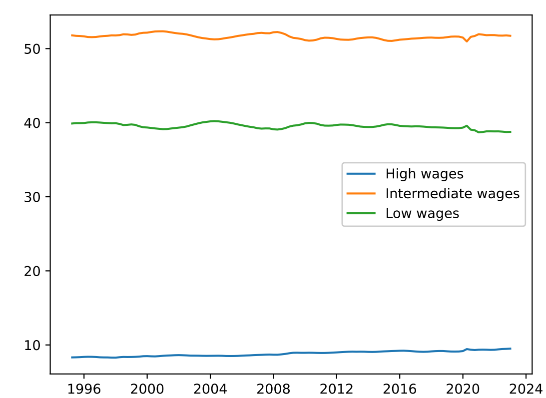
- Unknown parameters determined by steady-state restrictions: $\{\alpha_s, \varpi_s\}_{s=l,m,h}$



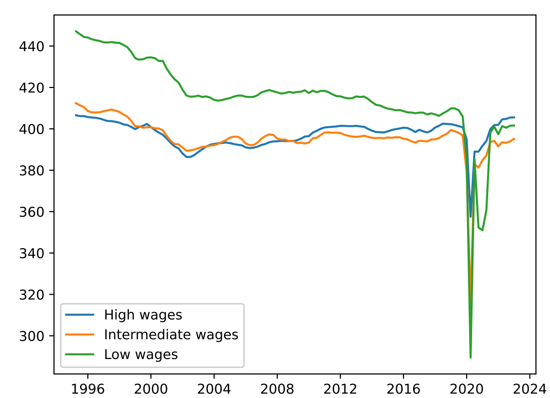
(a) Gross wages by employee



(b) Wage gaps



(c) Employment shares



(d) Hours worked by employee

Figure 15: Labor-market statistics

The production function is

$$
\begin{aligned}
Y_N &= \left(\alpha_l^{\frac{1}{\varepsilon_N}}\left(\varpi^l\omega^l n^l\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}+\alpha_m^{\frac{1}{\varepsilon_N}}\left(\varpi^m\omega^m n^m\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}+\alpha_h^{\frac{1}{\varepsilon_N}}\left(\varpi^h\omega^h n^h\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}\right)^{\frac{\varepsilon_N}{\varepsilon_N-1}} \\
&= \left(\alpha_l^{\frac{1}{\varepsilon_N}}\left(\varpi^l\widehat{n}^l\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}+\alpha_m^{\frac{1}{\varepsilon_N}}\left(\varpi^m\widehat{n}^m\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}+\alpha_h^{\frac{1}{\varepsilon_N}}\left(\varpi^h\widehat{n}^h\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}\right)^{\frac{\varepsilon_N}{\varepsilon_N-1}}
\end{aligned}
$$

where it is assumed that there are no TFP shocks at the steady state: $A^s = 1\ \forall s$. The entrepreneur controls the aggregate hours by skill $\widehat{n}^s$. The firm's FOC are, $\forall s \in \{l,m,h\}$:

$$
\begin{aligned}
\frac{\partial Y_N}{\partial \widehat{n}^s} &= \alpha_s^{\frac{1}{\varepsilon_N}}\varpi^s\left(\varpi^s\widehat{n}^s\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}-1}\left(\alpha_l^{\frac{1}{\varepsilon_N}}\left(\varpi^l\widehat{n}^l\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}+\alpha_m^{\frac{1}{\varepsilon_N}}\left(\varpi^m\widehat{n}^m\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}+\alpha_h^{\frac{1}{\varepsilon_N}}\left(\varpi^h\widehat{n}^h\right)^{\frac{\varepsilon_N-1}{\varepsilon_N}}\right)^{\frac{\varepsilon_N}{\varepsilon_N-1}-1} = \frac{W^s}{W} \\
\Rightarrow\quad \widehat{n}^s &= \alpha_s(\varpi^s)^{\varepsilon_N-1}\left(\frac{W^s}{W}\right)^{-\varepsilon_N}Y_N
\end{aligned}
$$

where W is the total marginal cost:

$$
\begin{aligned}
W = MC_N &= \left(\sum_s \alpha_s\left(\frac{W^s}{\varpi^s}\right)^{1-\varepsilon_N}\right)^{\frac{1}{1-\varepsilon_N}} \\
&= W_l\left(\alpha_l\left(\frac{1}{\varpi^l}\right)^{1-\varepsilon_N}+\alpha_m\left(\frac{l^m}{\varpi^m}\right)^{1-\varepsilon_N}+\alpha_h\left(\frac{l^h}{\varpi^h}\right)^{1-\varepsilon_N}\right)^{\frac{1}{1-\varepsilon_N}} \\
&\equiv W_l\Gamma(\alpha_l,\alpha_m,\alpha_h,\varpi^l,\varpi^m,\varpi^h)
\end{aligned}
$$

This leads to

$$
\begin{aligned}
\widehat{n}^s &= \alpha_s(\varpi^s)^{\varepsilon_N-1}\left(\frac{W^s}{W_l\Gamma(\alpha_l,\alpha_m,\alpha_h,\varpi^l,\varpi^m,\varpi^h)}\right)^{-\varepsilon_N}Y_N \\
&= \alpha_s(\varpi^s)^{\varepsilon_N-1}\Gamma(\alpha_l,\alpha_m,\alpha_h,\varpi^l,\varpi^m,\varpi^h)^{\varepsilon_N}\left(\frac{W^s}{W_l}\right)^{-\varepsilon_N}Y_N
\end{aligned}
$$

Therefore, we deduce

$$
\widehat{n}^l = \alpha_l(\varpi^l)^{\varepsilon_N-1}\Gamma(\alpha_l,\alpha_m,\alpha_h,\varpi^l,\varpi^m,\varpi^h)^{-\varepsilon_N}Y_N \tag{6}
$$

$$
\widehat{n}^m = \alpha_m(\varpi^m)^{\varepsilon_N-1}(l^m)^{-\varepsilon_N}\Gamma(\alpha_l,\alpha_m,\alpha_h,\varpi^l,\varpi^m,\varpi^h)^{-\varepsilon_N}Y_N \tag{7}
$$

$$
\widehat{n}^h = \alpha_h(\varpi^h)^{\varepsilon_N-1}(l^h)^{-\varepsilon_N}\Gamma(\alpha_l,\alpha_m,\alpha_h,\varpi^l,\varpi^m,\varpi^h)^{-\varepsilon_N}Y_N \tag{8}
$$

where $\{\varpi^l,\varpi^m,\varpi^h,\alpha_l,\alpha_m,\alpha_h\}$ are the 6 unknowns. Remark that the homogeneity of the production function implies that

$$
\sum_s W_s n^s = WY_N \quad\Rightarrow\quad Y_N = \frac{1}{\Gamma}(n^l + l^m n^m + l^h n^h)
$$

this equation being a linear combination of equations (6), (7) and (8). **Thus, we have 6 unknowns for only 3 independent equations (6), (7) and (8).**

Additional restrictions

1. $\sum_s \alpha_s = 1 \Rightarrow \alpha_h = 1 - \alpha_l - \alpha_m$
2. $\varpi_m = 1$ because we only observe 2 relative wages, $\{W_m/W_l, W_h/W_l\}$
3. $\sum_s \omega^s \varpi^s = 1 \Rightarrow \varpi^l = \frac{1-\omega^m\varpi^m - \omega^h\varpi^h}{\omega^l}$. With 2. this leads to $\varpi^h = \frac{1-\omega^l\varpi^l-\omega^m}{\omega^h}$

$\Rightarrow$ **The remaining 3 unknowns are** $\{\varpi^l, \alpha_l, \alpha_m\}$**.**

Using the definition of the function Γ, we deduce

$$\begin{aligned}\Gamma(\alpha_l,\alpha_m,\alpha_h,\varpi^l,\varpi^m,\varpi^h) &= \left(\alpha_l\left(\frac{1}{\varpi^l}\right)^{1-\varepsilon_N} + \alpha_m\left(\frac{l^m}{\varpi^m}\right)^{1-\varepsilon_N} + \alpha_h\left(\frac{l^h}{\varpi^h}\right)^{1-\varepsilon_N}\right)^{\frac{1}{1-\varepsilon_N}} \\ \Leftrightarrow \quad \widetilde{\Gamma}(\alpha_l,\alpha_m,\varpi^l) &= \left(\alpha_l\left(\frac{1}{\varpi^l}\right)^{1-\varepsilon_N} + \alpha_m\left(l^m\right)^{1-\varepsilon_N} + (1-\alpha_l-\alpha_m)\left(\frac{\omega^h l^h}{1-\omega^l\varpi^l-\omega^m}\right)^{1-\varepsilon_N}\right)^{\frac{1}{1-\varepsilon_N}}\end{aligned}$$

Solution can be obtained using:

$$\widehat{n}^l = \alpha_l(\varpi^l)^{\varepsilon_N-1}\widetilde{\Gamma}(\alpha_l,\alpha_m,\varpi^l)^{(\varepsilon_N-1)}(\widehat{n}^l + \widehat{l}^m\widehat{n}^m + \widehat{l}^h\widehat{n}^h) \quad (9)$$

$$\widehat{n}^m = \alpha_m(\widehat{l}^m)^{-\varepsilon_N}\widetilde{\Gamma}(\alpha_l,\alpha_m,\varpi^l)^{(\varepsilon_N-1)}(\widehat{n}^l + \widehat{l}^m\widehat{n}^m + \widehat{l}^h\widehat{n}^h) \quad (10)$$

$$\widehat{n}^h = \alpha_h(\varpi^h)^{\varepsilon_N-1}(\widehat{l}^h)^{-\varepsilon_N}\widetilde{\Gamma}(\alpha_l,\alpha_m,\varpi^l)^{(\varepsilon_N-1)}(\widehat{n}^l + \widehat{l}^m\widehat{n}^m + \widehat{l}^h\widehat{n}^h) \quad (11)$$

where the variables with a "hat" are the observable data. Solutions must satisfy $\varpi^l > 0$, $0 < \alpha_l < 1$, $0 < \alpha_m < 1$ with $\alpha^l + \alpha^m < 1$. Moreover, the solution would be such that $\varpi^l < \varpi^m < \varpi^h$. Results (parameters and wage distributions) are reported in Figure 16.

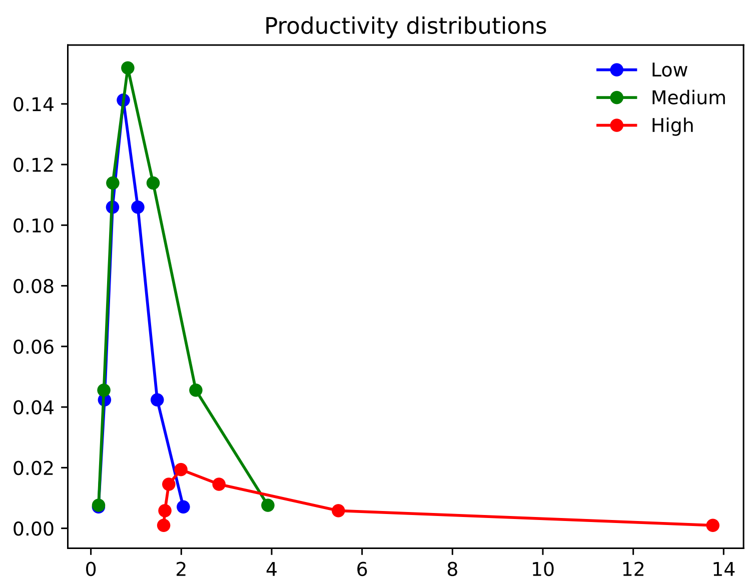


Figure 16: Productivity Distribution by Workers' Type s

s	l	m	h
	CES parameters of Y_N		
α_s	0.3133	0.5230	0.1636
ϖ_l	0.7808	1	2.5978
	Income Risks		
ρ_s	0.97	0.965	0.94
σ_s	0.36	0.64	1.4
	Disutility of working		
φ_s	0.3634	0.3278	0.1482

Table 11: Specific Parameters by Workers' Types s

Given the solutions for $\{\varpi^l, \varpi^m, \varpi^h\}$, where $\sum_s \omega^s \varpi^s = 1$, we define $\varpi^s = \Delta^s + \sum_i e_i^s \pi_i^s$, with $\sum_i e_i^s \pi_i^s = 1$, $\forall s$. Using the parameters $\{\rho^s, \sigma^s\}$, the grids of the idiosyncratic productivity shocks $[e_1^s, ..., e_N^s]$ and the Markov matrix $[\widetilde{\pi}_{ii'}^s]$ are constructed, and satisfy $\sum_i e_i^s \pi_i^s = 1$ where π_i^s is the eigenvector associated to the eigenvalue 1 of the matrix $[\widetilde{\pi}_{ii'}^s]$.

Finally, equilibria on labor markets allow us to deduce the values of the disutility of working φ_s, $\forall s = l, m, h$ (see the Table 11)).

B.4 Calibration of taxation and transfers

We use several moments of the decile distribution to calibrate notably transfer and income tax parameters. Those moments are computed from the data in Accardo et al. (2021) for 2018. We consider that Bismarckian transfers encompass pension and unemployment insurance transfers ("retraite" et "chômage et revenus de remplacement"). Beveridgian transfers include the other monetary transfers as well as health and social action and housing transfers in kind ("santé" et "action sociale et logement"). This way, we obtain the share of transfers over GDP (17.9% for Bismarckian and 14.2% for Beveridgian) and their distribution by decile. For gross income, we consider primary income ("revenu primaire élargi") to which we remove social contributions ("cotisations sociales") and add Bismarckian transfers. For net income, we use disposable income ("revenu disponible") plus health and social action and housing transfers in kind. Data for consumption gives us the distribution of consumption by decile. Finally, we obtain data for the distribution of dividends from André et al. (2023), using the dividend and mixed revenue category ("dividendes et revenus mixtes").

B.5 From government forecasts to quarterly data

The transfers (T) are the sum of "Social benefits in cash" + "Social benefits in kind". The energy price is first divided by the EUR/USD exchange rate and by the inflation level. For GDP, IPC, energy price and wage of the year τ, we compute the quarterly growth rates g_τ^z using the annual growth rates $g_{a,\tau}^z$ (forecasts of the GDP, IPC, energy price and wage growth rates reported in the Table 12)[29], solving

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

where Z = GDP, IPC, energy price and wage. We built the quarterly data for GDP, IPC and energy price over the periods 1Q2022 to 4Q2027 (see panels (a), (b) & (c) of Figure 17). We get quarterly

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

	2022	2023	2024	2025	2026	2027
Population (15-64)	41427249	41402466	41381174	41360167	41338765	41311515
GDP growth	2.6%	1.0%	1.6%	1.7%	1.7%	1.8%
GDP share of G	23.7%	23.2%	22.8%	22.5%	22.3%	22.1%
GDP share of T	25.7%	24.9%	25.0%	24.8%	24.6%	24.3%
Debt-to-GDP	111.6%	109.6%	109.5%	109.4%	109.2%	108.3%
Energy price	$101	$83	$83	$83	$83	$83
IPC (inflation rate)	5.2%	4.9%	2.6%	2.0%	1.8%	1.8%
Employment	2.4%	0.8%	0.6%	0.8%	0.8%	0.8%
Wage	5.0%	4.8%	3.0%	2.8%	2.4	2.5%
Short-term interest rate	0.3%	3.1%	3.7%	3.4%	3.4%	3.4%
GDP share of interest charges	1.9%	1.7%	1.9%	2.1%	2.3%	2.4%
Exchange rate EUR/USD	1.05	1.07	1.07	1.07	1.07	1.07

Table 12: Government forecasts. Source: Finance Act

series by interpolating the GDP share of G (government consumption) 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 (a) & (b) of the Figure 18). Concerning the debt-to-GDP ratio, the GDP share of interest charges and employment, we simply perform quarterly interpolation to construct quarterly data over the periods 1Q2022 to 4Q2027 (see panel (c) of the Figure 18), considering that the Finance Act gives the end-of-year value. For the short-term interest rate, we use the annual value for each quarter of the corresponding year.

Projected data for the labor markets. On the labor market, the government forecasts give aggregate projections for the employment rate (N) and the real wage (w). In order to construct hours worked (employment rate multiplied by number of hours worked per employee, $H = N \times h$) and real wages by salary level over the period 1Q2023 to 4Q2027, we use the government forecasts for N and w and the projections of the trends of N_s, h_s and w_s observed over the period 2Q-2003 to 4Q2022. To do this, we assume that:

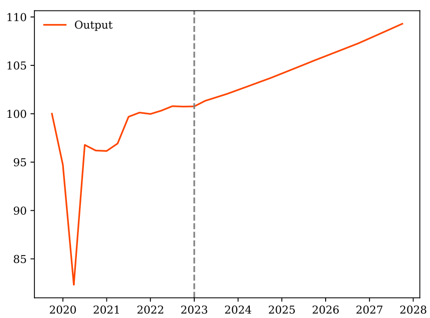
(i) the distribution of jobs remains stable, ie. $N_{s,t} = \omega_s N_t$, for $t = [1Q2023; 4Q2027]$. Hence, using the values of ω_s, we build $N_{s,t}$, consistent with N_t provided by the government forecasts.

(ii) the ratio between the salary of a job of type l and the aggregate salary continues to evolve as it did between 2Q2003 to 4Q2022, $w_{l,t} = \mu_t w_t$ with μ_t observed between 2Q2003 and 4Q2022 then projected linearly between 1Q2023 to 4Q2027. This provides the data for $w_{l,t}$, given the government forecasts for w_t.

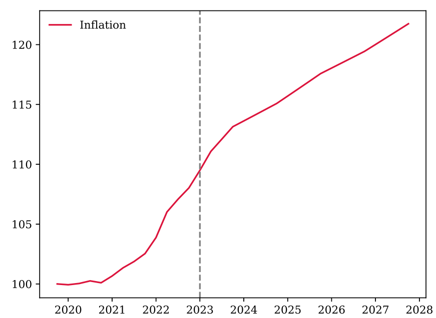
(iii) the wage gaps between m, h and l remain stable, i.e. $w_{s,t} = \gamma_s w_{l,t}$, for $s = m, h$.

(iv) the number of hours worked by type of employee $s = l, m, h$ evolves in the future (3Q2023 to 4Q2027) continuing the linear trend observed since 2Q2003.

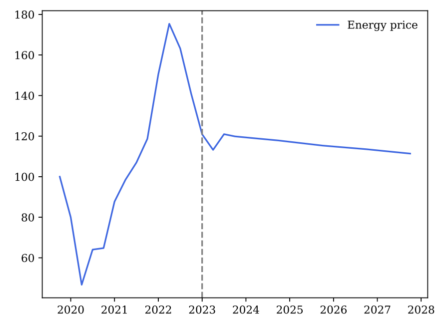
Using this set of restrictions, we built total hours worked H_s and real wage w_s for each labor market $s = l, m, h$ for the sample 1Q2023 to 4Q2027. Data for the labor market are in the Figure 19.



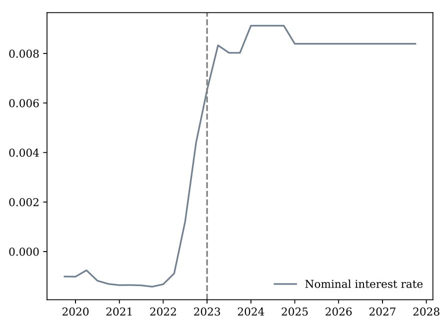
(a) GDP



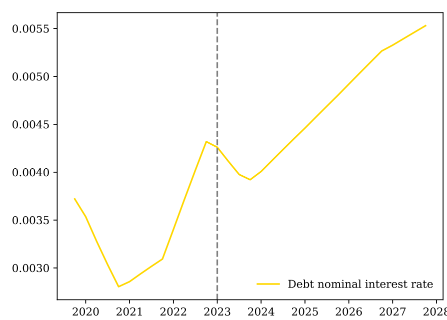
(b) Inflation



(c) Energy price

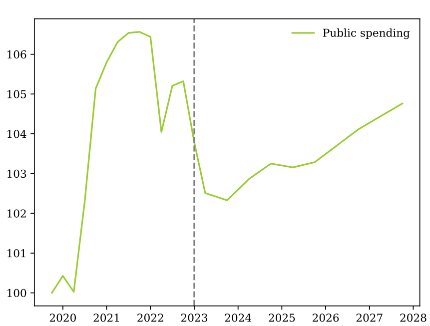


(d) Nominal interest rate

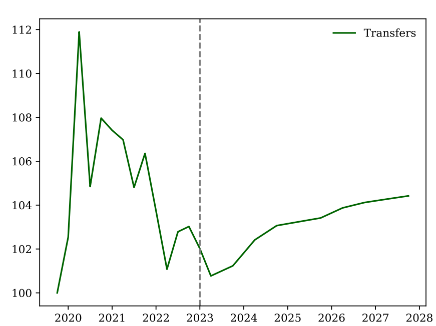


(e) Rate on public debt

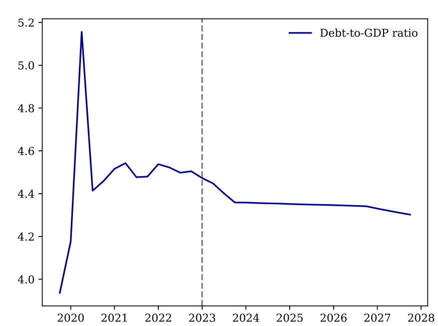
Figure 17: Data and Govt. Forecasts — Goods Market, Financial Market



(a) Govt. consumption

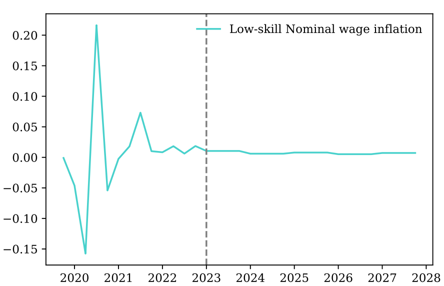


(b) Govt. transfers

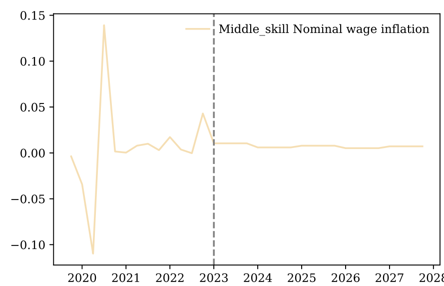


(c) Debt-to-GDP

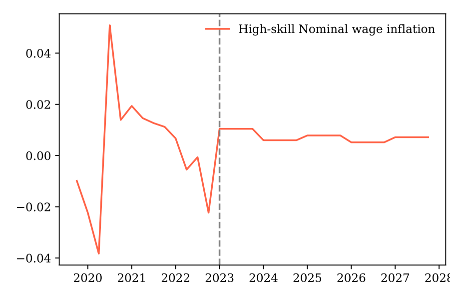
Figure 18: Data and Govt. Forecasts — Government Accounts



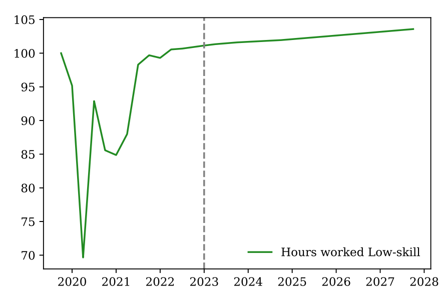
(a) Wage inflation l



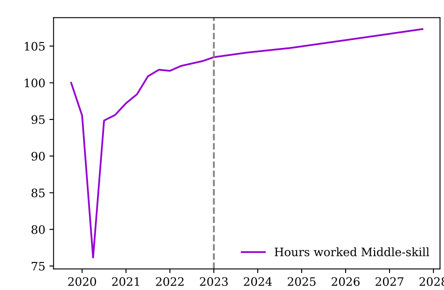
(b) Wage inflation m



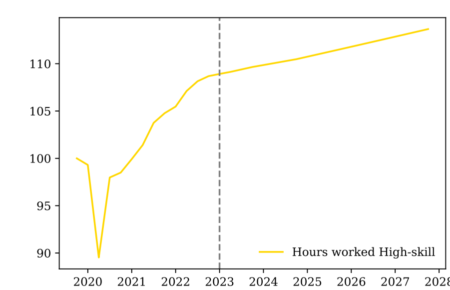
(c) Wage inflation h



(d) Hours worked l



(e) Hours worked m



(f) Hours worked h

Figure 19: Data and Govt. Forecasts — Labor Markets

C 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 13. 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 $\{\beta, \mu, \varepsilon, \vartheta, \{\varphi_s\}_{s=l,m,h},, \{A_s\}_{s=l,m,h}, e_\tau\}$ are assumed to follow beta distributions for the persistence and inverse-gamma distributions for the standard deviation, as usual in the literature. The results of the estimation are in the Table 13 and in the Figure 20.

Shock			**Prior**	**Mode**	**Mean**	**Std**	**95% CI**
Preference	β	ρ	$\beta(0.8, 0.05)$	0.779433	0.778482	0.025231	$[0.735657, 0.818507]$
		σ	$inv\Gamma(0.05, 1.0)$	0.008922	0.009143	0.001438	$[0.006991, 0.011675]$
Price markup	μ	ρ	$\beta(0.8, 0.05)$	0.797303	0.789200	0.027489	$[0.784003, 0.866901]$
		σ	$inv\Gamma(0.05, 1.0)$	0.022775	0.023420	0.002331	$[0.019887, 0.027508]$
Energy price	p_{FE}	ρ	$\mathcal{N}(0.89, 0.054)$	0.793492	0.794674	0.022682	$[0.755927, 0.830306]$
		σ	$\mathcal{N}(0.13, 0.067)$	0.113373	0.116112	0.009058	$[0.102126, 0.131723]$
Monetary policy	ε	ρ	$\beta(0.8, 0.05)$	0.578370	0.575467	0.040994	$[0.506296, 0.641365]$
		σ	$inv\Gamma(0.05, 1.0)$	0.006279	0.006381	0.000498	$[0.005615, 0.007241]$
Spread	ϑ	ρ	$\beta(0.8, 0.05)$	0.835287	0.832970	0.034203	$[0.773230, 0.884632]$
		σ	$inv\Gamma(0.05, 1.0)$	0.001158	0.001172	0.000126	$[0.000981, 0.001391]$
Disutility l	φ_l	ρ	$\beta(0.8, 0.05)$	0.772068	0.771044	0.048294	$[0.688632, 0.847175]$
		σ	$inv\Gamma(0.05, 1.0)$	0.019574	0.020303	0.002861	$[0.015940, 0.025250]$
Disutility m	φ_m	ρ	$\beta(0.8, 0.05)$	0.778410	0.772314	0.046330	$[0.692780, 0.844720]$
		σ	$inv\Gamma(0.05, 1.0)$	0.017942	0.018561	0.002492	$[0.014766, 0.022911]$
Disutility h	φ_h	ρ	$\beta(0.8, 0.05)$	0.703815	0.692028	0.058132	$[0.594230, 0.785392]$
		σ	$inv\Gamma(0.05, 1.0)$	0.031485	0.032577	0.003967	$[0.026451, 0.039417]$
Productivity l	A^l	ρ	$\beta(0.8, 0.05)$	0.819040	0.815107	0.029585	$[0.764506, 0.861222]$
		σ	$inv\Gamma(0.05, 1.0)$	0.024080	0.024635	0.002089	$[0.021438, 0.028305]$
Productivity m	A^m	ρ	$\beta(0.8, 0.05)$	0.804328	0.795198	0.029001	$[0.745639, 0.840641]$
		σ	$inv\Gamma(0.05, 1.0)$	0.021964	0.022278	0.001954	$[0.019318, 0.025698]$
Productivity h	A^h	ρ	$\beta(0.8, 0.05)$	0.844523	0.839992	0.032298	$[0.784530, 0.890326]$
		σ	$inv\Gamma(0.05, 1.0)$	0.024729	0.025028	0.002205	$[0.021721, 0.028933]$
Government spending	G	ρ	$\mathcal{N}(0.726, 0.085)$	0.705917	0.714310	0.056981	$[0.619684, 0.807090]$
		σ	$\mathcal{N}(0.0041, 0.0029)$	0.004198	0.004220	0.000379	$[0.003650, 0.004887]$
Transfers	T	ρ	$\mathcal{N}(0.815, 0.073)$	0.812377	0.797681	0.044078	$[0.722558, 0.867606]$
		σ	$\mathcal{N}(0.0052, 0.0059)$	0.005212	0.005315	0.000465	$[0.004602, 0.006132]$
Measurement error	e_τ	ρ	$\beta(0.8, 0.05)$	0.779472	0.773476	0.047124	$[0.691685, 0.846046]$
		σ	$inv\Gamma(0.05, 1.0)$	0.014396	0.015915	0.004046	$[0.010032, 0.023161]$

Table 13: 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. (2021), 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 estimate 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.

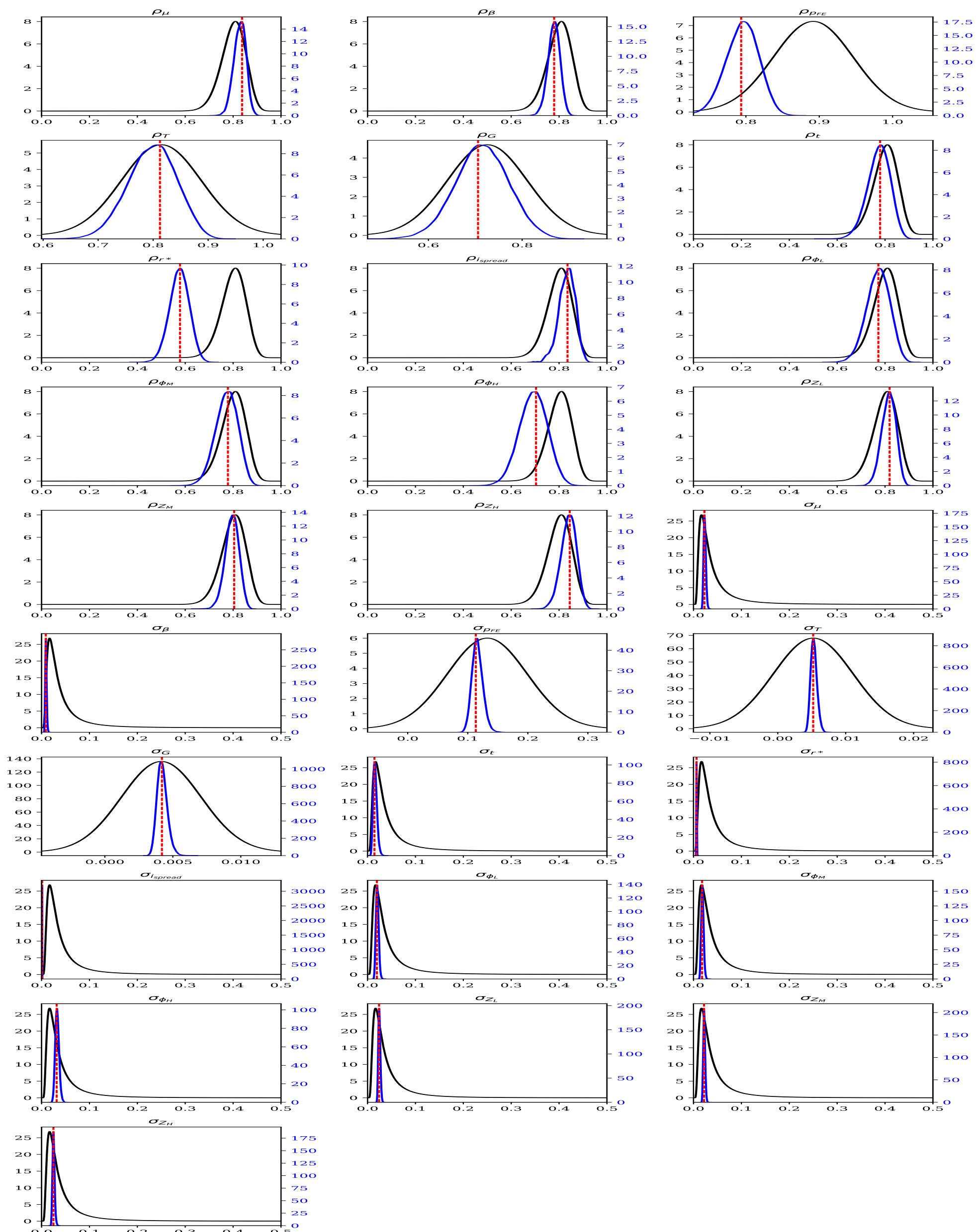
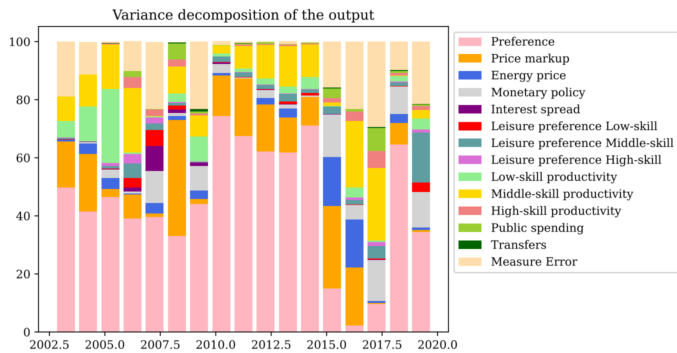
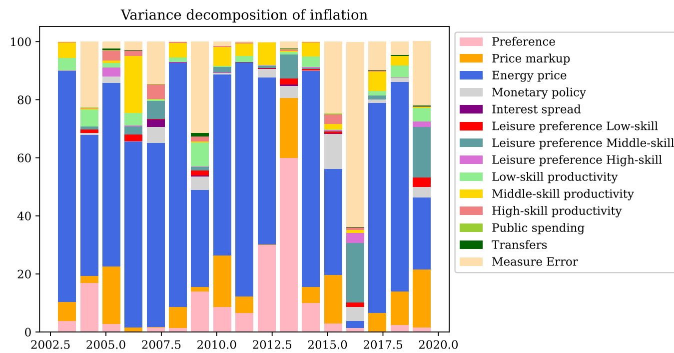


Figure 20: Prior and Posterior Distributions of the Estimated Parameters

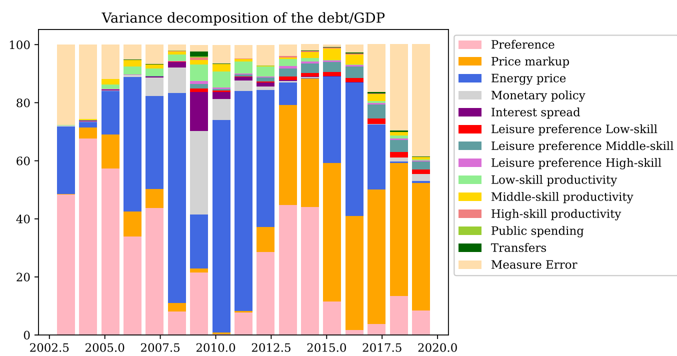
D Variance decomposition



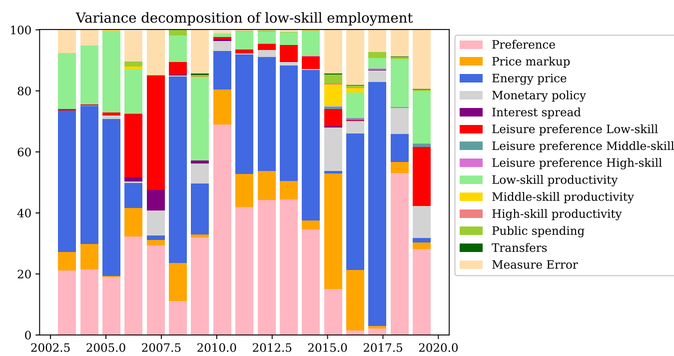
(a) Output



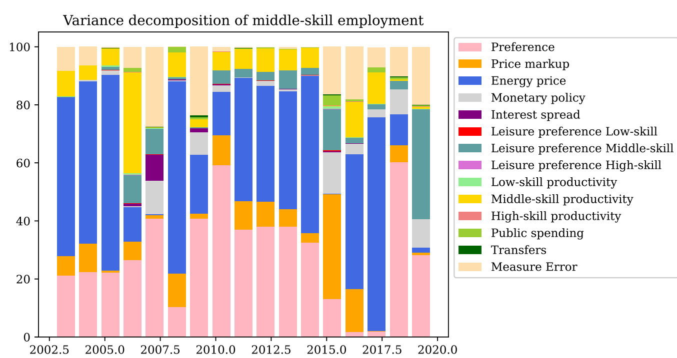
(b) Inflation



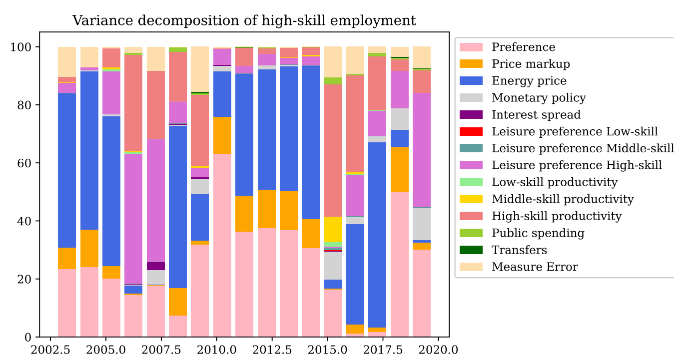
(c) Debt-to-GDP



(d) Hours worked l



(e) Hours worked m



(f) Hours worked h

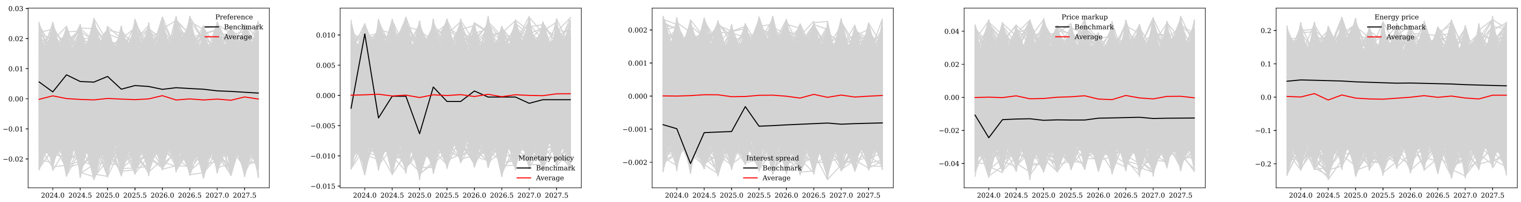
		2023				2024	2025	2026	2027
		1Q	2Q	3Q	4Q	2Q	2Q	2Q	2Q
	β	32.8%	26.0%	49.4%	50.5%	55.0%	51.6%	35.3%	19.7%
	μ	28.4%	12.5%	10.6%	12.1%	23.6%	23.9%	26.8%	25.9%
	P_{FE}	21.4%	8.7%	0.4%	0.1%	0.0%	0.0%	0.0%	0.1%
	ε	0.5%	0.9%	3.9%	3.4%	0.1%	0.0%	0.2%	0.1%
	ϑ	2.3%	8.6%	9.9%	7.2%	7.0%	2.1%	1.8%	1.5%
	φ_l	2.3%	2.3%	1.3%	1.3%	0.5%	0.1%	0.0%	0.0%
	φ_m	1.3%	0.4%	0.0%	0.0%	0.8%	3.8%	8.0%	11.5%
y	φ_h	0.2%	0.6%	0.5%	0.5%	0.7%	1.1%	2.0%	2.7%
	A^l	0.1%	1.8%	1.3%	1.3%	0.5%	0.5%	0.7%	0.9%
	A^m	0.0%	4.7%	3.9%	4.7%	2.6%	3.5%	7.1%	11.0%
	A^h	0.0%	0.4%	0.3%	0.3%	0.2%	0.3%	0.5%	0.8%
	G	0.1%	5.0%	7.4%	7.4%	3.1%	4.8%	6.6%	8.4%
	T	0.9%	2.7%	0.5%	0.1%	0.2%	0.2%	0.4%	0.4%
	s_H	9.4%	12.7%	10.4%	10.7%	0.5%	0.1%	0.0%	0.0%
	e_τ	0.3%	12.9%	0.1%	0.5%	5.2%	8.0%	10.5%	17.0%
	β	0.7%	0.0%	0.8%	1.0%	1.1%	1.3%	0.1%	0.1%
	μ	16.5%	20.7%	10.6%	9.2%	18.1%	11.6%	9.3%	9.2%
	P_{FE}	58.7%	48.6%	63.4%	59.9%	53.3%	48.7%	40.4%	30.4%
	ε	0.1%	0.1%	1.6%	1.6%	0.1%	0.0%	0.1%	0.1%
	ϑ	0.1%	0.7%	3.1%	2.8%	2.1%	0.7%	0.3%	0.2%
	φ_l	0.0%	0.1%	0.2%	0.3%	0.0%	0.0%	0.0%	0.0%
	φ_m	0.1%	1.7%	0.6%	0.8%	4.0%	2.7%	4.5%	2.9%
π	φ_h	0.1%	0.3%	0.2%	0.2%	0.6%	0.6%	0.9%	0.7%
	A^l	3.6%	3.9%	0.1%	0.2%	0.1%	0.0%	0.1%	0.1%
	A^m	19.1%	18.2%	2.4%	3.4%	0.4%	2.4%	3.1%	3.5%
	A^h	0.5%	0.8%	0.1%	0.3%	0.1%	0.3%	0.3%	0.3%
	G	0.0%	0.1%	3.0%	3.8%	1.5%	2.6%	2.9%	3.1%
	T	0.6%	2.4%	13.6%	15.8%	10.3%	16.3%	22.1%	29.1%
	s_H	0.1%	0.1%	0.1%	0.1%	2.4%	0.0%	0.0%	0.0%
	e_τ	0.0%	2.4%	0.2%	0.6%	5.9%	12.8%	15.8%	20.4%
	β	69.0%	64.0%	60.5%	57.8%	56.4%	49.2%	38.7%	28.6%
	μ	0.1%	0.5%	0.8%	1.2%	2.1%	4.9%	7.8%	9.7%
	P_{FE}	0.4%	0.3%	0.1%	0.5%	1.9%	5.9%	10.3%	13.3%
	ε	27.1%	30.8%	31.8%	33.5%	32.0%	29.8%	25.7%	20.6%
	ϑ	0.0%	0.0%	0.3%	0.6%	1.9%	4.0%	5.7%	6.6%
	φ_l	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	φ_m	0.2%	0.2%	0.5%	0.5%	0.4%	0.5%	0.6%	0.8%
$\frac{b}{y}$	φ_h	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%
	A^l	0.8%	1.0%	0.9%	0.8%	0.7%	0.5%	0.4%	0.2%
	A^m	0.1%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%
	A^h	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
	G	0.5%	1.2%	2.8%	3.2%	3.2%	2.7%	1.7%	0.8%
	T	1.5%	1.7%	2.0%	1.6%	0.8%	0.0%	0.5%	2.3%
	s_H	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	e_τ	0.0%	0.1%	0.0%	0.0%	0.1%	1.9%	7.9%	16.3%

Table 14: Variance decomposition. After re-estimation (B). Share of the deviation from the steady state explained by each shock

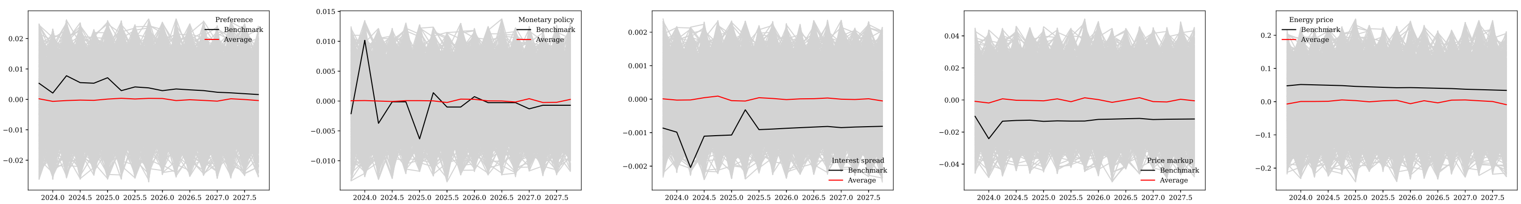
		2023				2024	2025	2026	2027
		1Q	2Q	3Q	4Q	2Q	2Q	2Q	2Q
	β	31.3%	20.0%	23.5%	24.4%	26.1%	26.2%	16.4%	8.6%
	μ	23.2%	8.0%	4.3%	5.0%	9.8%	10.3%	10.6%	9.8%
	P_{FE}	14.4%	19.9%	54.2%	53.3%	52.2%	53.6%	60.2%	63.2%
	ε	0.2%	0.2%	1.1%	0.9%	0.4%	0.2%	1.0%	1.0%
	ϑ	2.0%	6.1%	4.7%	3.5%	3.4%	1.0%	0.7%	0.4%
	φ_l	17.8%	15.9%	5.7%	5.9%	2.9%	0.7%	0.1%	0.0%
	φ_m	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
N_l	φ_h	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	A^l	7.6%	14.7%	2.0%	2.5%	0.7%	0.8%	1.2%	1.4%
	A^m	0.8%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%
	A^h	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	G	0.1%	3.2%	3.5%	3.5%	1.4%	2.3%	2.9%	3.8%
	T	0.7%	1.6%	0.1%	0.0%	0.4%	0.7%	1.3%	1.7%
	s_H	1.5%	1.3%	0.6%	0.6%	0.3%	0.1%	0.0%	0.0%
	e_τ	0.3%	8.8%	0.0%	0.2%	2.5%	4.2%	5.6%	10.0%
	β	31.2%	18.7%	22.6%	24.2%	26.5%	25.5%	16.0%	8.9%
	μ	26.5%	7.9%	3.9%	4.8%	9.7%	9.7%	9.6%	8.7%
	P_{FE}	19.7%	25.8%	60.0%	58.0%	52.9%	47.6%	47.4%	43.9%
	ε	0.5%	0.7%	1.9%	1.8%	0.0%	0.0%	0.0%	0.0%
	ϑ	2.6%	7.6%	4.9%	3.6%	3.4%	1.0%	0.8%	0.7%
	φ_l	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	φ_m	3.2%	0.6%	0.0%	0.0%	1.5%	6.2%	12.3%	17.5%
N_m	φ_h	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	A^l	0.0%	0.2%	0.2%	0.2%	0.1%	0.0%	0.0%	0.0%
	A^m	12.9%	18.2%	1.7%	2.6%	1.2%	2.6%	4.6%	6.8%
	A^h	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	G	0.1%	4.6%	3.7%	3.8%	1.5%	2.6%	3.2%	4.0%
	T	1.0%	2.4%	0.3%	0.1%	0.1%	0.1%	0.2%	0.2%
	s_H	2.0%	1.7%	0.7%	0.7%	0.3%	0.0%	0.0%	0.0%
	e_τ	0.3%	11.5%	0.0%	0.2%	2.8%	4.6%	5.8%	9.2%
	β	35.7%	22.8%	23.0%	23.7%	24.1%	21.6%	13.3%	7.5%
	μ	25.6%	10.0%	5.6%	6.7%	11.9%	13.4%	14.7%	14.9%
	P_{FE}	20.9%	24.4%	49.4%	47.4%	42.7%	36.0%	32.5%	27.7%
	ε	2.0%	2.4%	3.2%	3.2%	0.2%	0.7%	0.3%	0.4%
	ϑ	1.6%	4.5%	3.4%	2.7%	2.7%	1.1%	1.0%	1.0%
	φ_l	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	φ_m	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
N_h	φ_h	8.6%	16.0%	10.1%	10.6%	14.5%	21.9%	31.9%	40.5%
	A^l	0.1%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%
	A^m	0.5%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%
	A^h	2.4%	6.8%	1.0%	1.6%	0.8%	1.6%	2.7%	3.6%
	G	0.1%	2.7%	2.7%	2.8%	1.3%	1.9%	2.1%	2.4%
	T	0.8%	2.1%	0.6%	0.5%	0.1%	0.3%	0.5%	0.9%
	s_H	1.4%	1.1%	0.5%	0.5%	0.2%	0.0%	0.0%	0.0%
	e_τ	0.3%	7.0%	0.0%	0.2%	1.4%	1.5%	1.0%	1.0%

Table 15: Variance decomposition. After re-estimation (B). Share of the deviation from the steady state explained by each shock

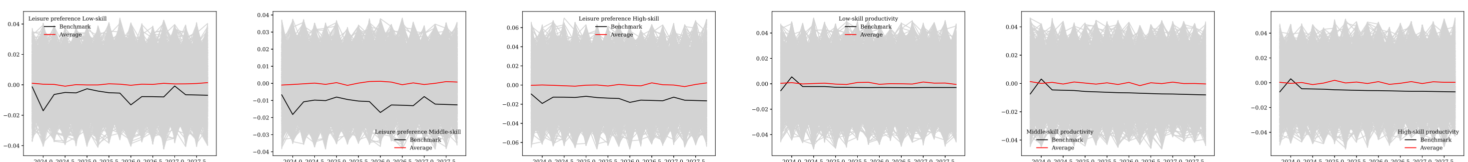
E Innovations Before and After Estimation



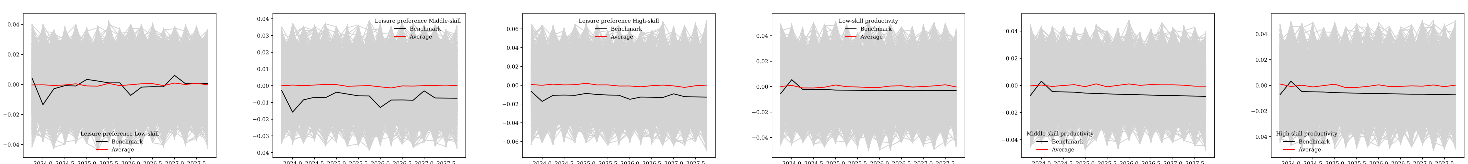
(a) Discount rate (A) (b) Nominal interest rate (A) (c) Spread (A) (d) Markup (A) (e) Energy price (A)



(f) Discount rate (B) (g) Nominal interest rate (B) (h) Spread (B) (i) Markup (B) (j) Energy price (B)



(k) Preferences l (A) (l) Preferences m (A) (m) Preferences h (A) (n) Productivity l (A) (o) Productivity m (A) (p) Productivity h (A)



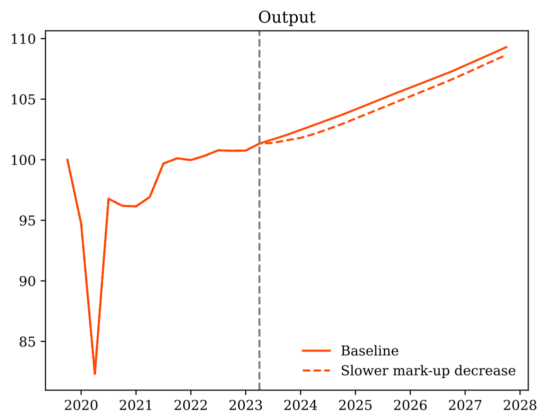
(q) Preferences l (B) (r) Preferences m (B) (s) Preferences h (B) (t) Productivity l (B) (u) Productivity m (B) (v) Productivity h (B)

Figure 21: Innovations of households and firms shocks. (A) before and (B) after re-estimation.

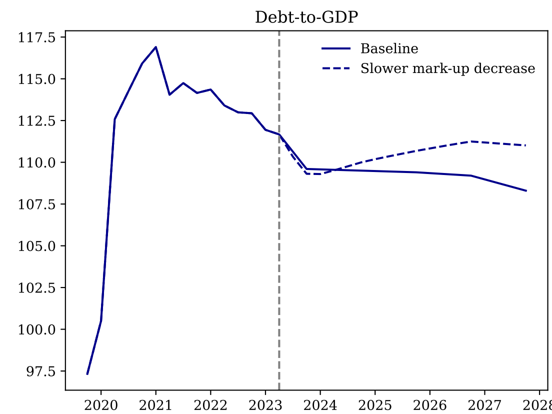
F Evaluating the Uncertainty Around a Finance Act

F.1 Smaller Decreases in Firms' Markups

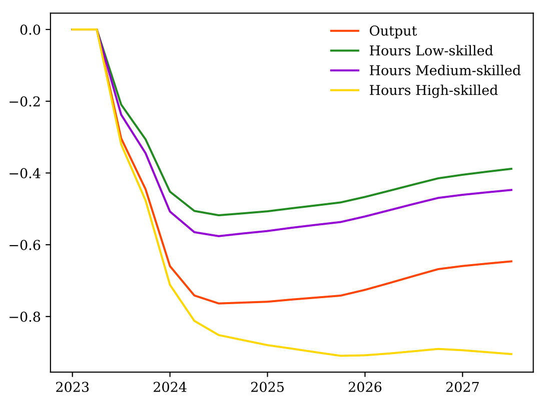
The first "favorable wind" concerns the fall in firms' markups. These markup reductions contribute to 26% of the 2027 GDP forecast (see figure 5). These contractions in markups are essential



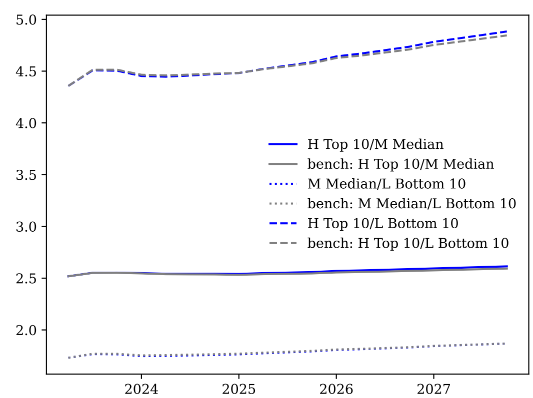
(a) Output (B)



(b) Debt-to-GDP ratio (B)



(c) Gaps in Output and Hours / 1Q-2023 (B)



(d) Consumption Inequalities (B)

Figure 22: Counterfactual: Smaller Decreases in Firms' Markups. (B) after re-estimation.

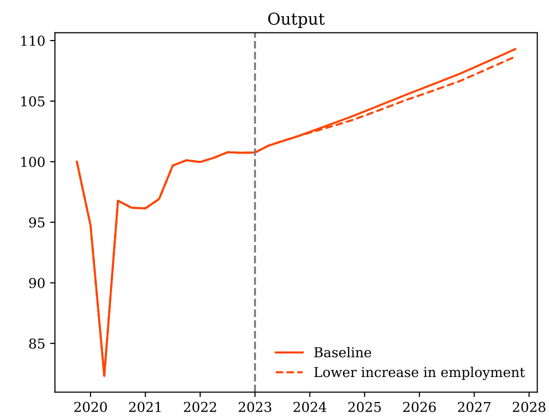
to the overall coherence of the Finance Act which indicates a rapid exit, from 2024, from the current period of high inflation and a return to moderate inflation occurring in a context of strong employment growth. To reconcile the dynamism of the labor market with the slowdown in inflation, our estimation indicates that the firms markups should fall by 9 percentage points. Contractions in the markups of French firms, favorable to growth, were observed during the inflationary episode that began in 2021 (see Barnard and Ollivaud (2023)). But French companies were the only ones within the OECD to have reacted in this way, which makes the hypothesis of reproduction of this behavior fragile, especially with this magnitude. These contractions in markups may be partly induced by the announced reductions in taxes on business added value: their decrease from 1.50% to 0.75%

reduces the markup by almost 1pp, and their disappearance would reduce it by 1.5pp, leaving the remaining 7.5pp burning to the firms.

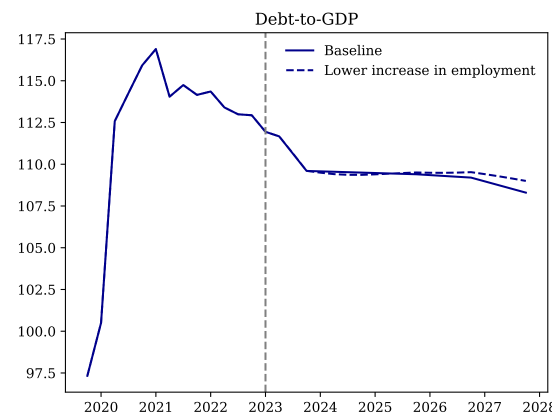
Finance Act forecasts predict a rapid exit, from 2024, from the current period of high inflation thanks in part to a reduction in corporate margin rates. If we reduce these expected declines in firms' markups by 25%, then, greater inflationary pressures (the inflation rate would be on average 3.05% per year compared to 2.42% in the Finance Act) would lead to an increase in interest rates and a fall in real wages, reducing growth (1.53% per year compared to 1.64% in the Finance Act). The debt would then amount to 111.0% of GDP in 2027. The employment growth rate would be at 0.62% per year, compared to 0.64% in the Finance Act.

F.2 Less Favorable Labor-Market Adjustments

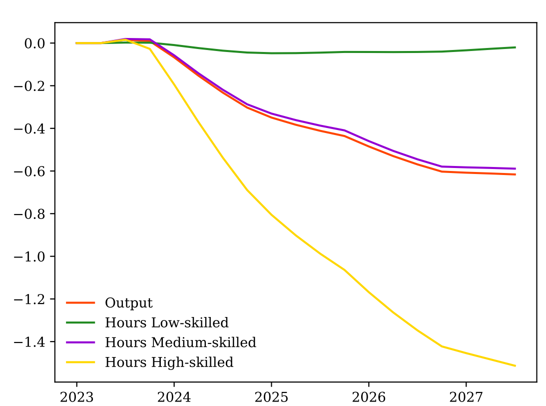
The second "favorable wind" concerns the evolution of the labor market. Indeed, the Finance Act projections require strong employment growth which cannot occur, according to our model, without changes in labor-supply behavior. Our estimates indicate that these changes in labor



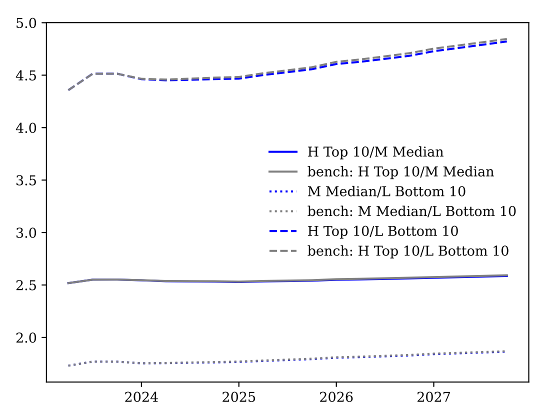
(a) Output (B)



(b) Debt-to-GDP ratio (B)



(c) Gaps in Output and Hours / 1Q-2023 (B)



(d) Consumption Inequalities (B)

Figure 23: Counterfactual: Smaller Decline in the Disutility of Working. (B) after re-estimation.

supply contribute to 14% of the 2027 GDP forecast. They also indicate that the adjustments are different from one labor market to another: the drop in transfers, provided for in the Finance Act, encourages low-wage employees to compensate for these reductions in income by increasing their hours worked. As the hours forecasted for this type of employee will increase as much as what this mechanism generates, the model then identifies that their disutility of work remains stable. On the contrary, the expected number of hours worked by middle and high-wage employees increases, while they are only little affected by the drop in transfers: an exogenous increase in the labor supply is then necessary (the disutility of work falls) to generate the expected increase in their hours worked. Thus, beyond the repercussions of reductions in transfers on hours worked, it does not seem unrealistic to envisage that pension and unemployment-insurance reforms will result in variations in the employed population and hours worked which are different depending on remuneration. Indeed, social measures accompany these structural reforms via modulations in favor of the more modest workers (for example, the "early retirement for long career" procedure of the latest pension reform). Exogenous and differentiated variations in labor supply can therefore be interpreted as the impact of these modulations.

Thus, our model suggests that middle and high-wage workers are willing to work more for unchanged wage levels. Our estimate reveals that the success of these policies is necessary for the Finance Act forecasts to be realized. If the magnitude of these changes in the labor supply of middle and high earners were reduced by 25%, growth would be lower (1.53% per year on average, a loss of 0.11pp compared to the Finance Act) and the increase in employment of high earners would be slowed down, going from 0.9% per year to 0.62%. When the labor supply is less stimulated, inflation is higher (2.79% per year on average between 2023 and 2027 compared to 2.42% in the Finance Act), which partly cushions the increase in the debt ratio which would represent 109.0% of GDP at the end of 2027 (an increase of 0.7 points compared to the Finance Act).

F.3 A Less Favorable Interest Rate Spread Dynamics

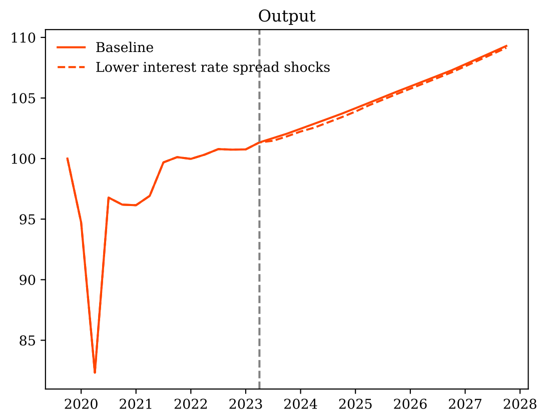
The third "favorable wind" concerns the evolution of the interest rate. Finance Act projections require low-interest rates, with a slow transmission of the ECB-rate increases, that occurred in 2022 and 2023, to the apparent debt rate. Given the fairly long maturity of the French debt (8.5 years in August 2023), the government is not directly exposed to the rise in short-term rates. However, in the event of tension in the sovereign-debt market, the gap between the ECB and debt rates could narrow more quickly and weaken the projections.

By being less optimistic than the government about the evolution of the interest rate on the public debt, the annual growth rate would be lower by only 0.02pp over the period 2023-2027 (the economy would be mainly impacted in 2024) but the debt-to-GDP ratio would increase by 2.8pp, rising to 111.1% at the end of 2027.

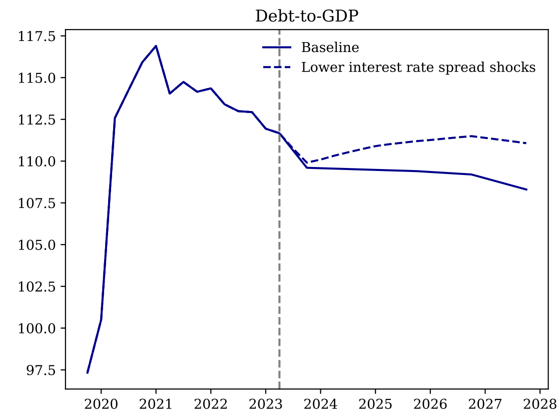
F.4 More Moderate Productivity Declines

Our assessment of the Finance Act also reveals that "unfavorable winds" must be taken into account to see Finance Act forecasts occurring. The first is a slowdown in labor productivity which would contribute to 13% of the realization of GDP in 2027. This strong slowdown in productivity in France is also underlined in the OECD forecasts. Our model also indicates that this drop in productivity growth is observed for all wage levels.

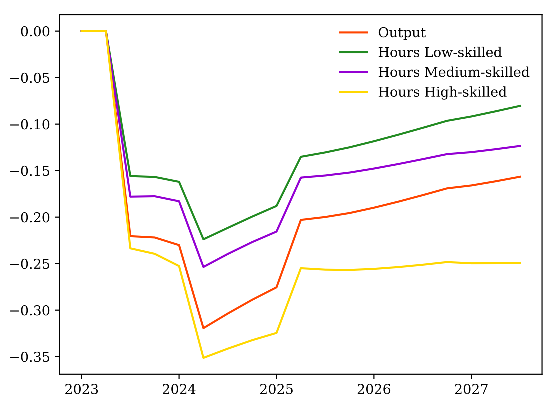
Finance Act forecasts assume very strong employment growth. As a result, labor-productivity growth would decline: the new-filled jobs, for each salary level, would be less productive than current jobs. If these productivity losses were lower, then growth could be 1.76% per year (compared to



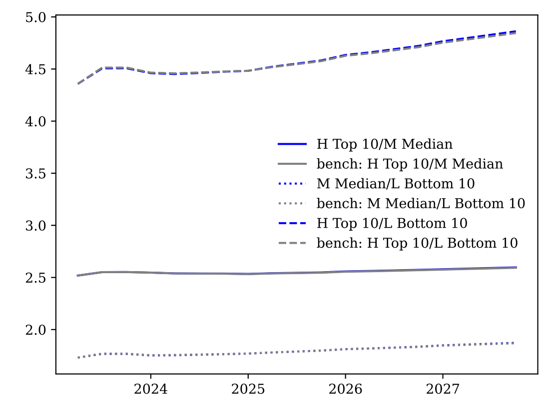
(a) Output (B)



(b) Debt-to-GDP ratio (B)

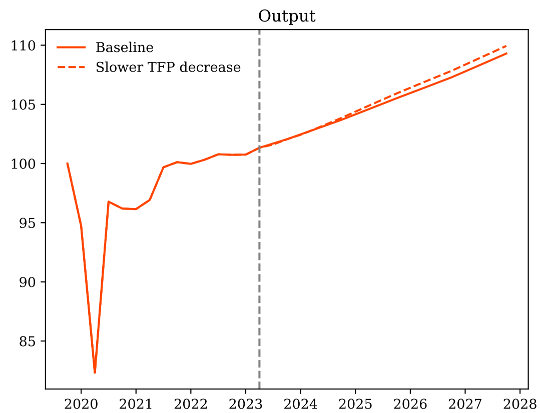


(c) Gaps in Output and Hours / 1Q-2023 (B)

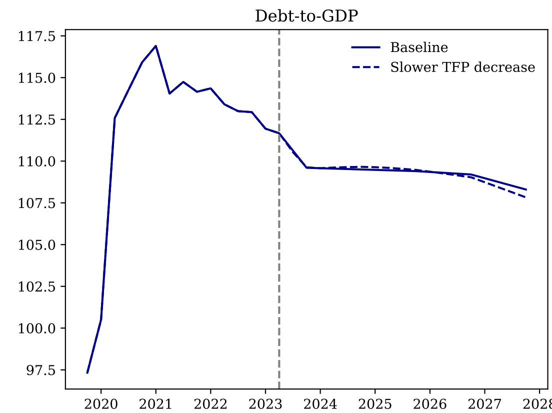


(d) Consumption Inequalities (B)

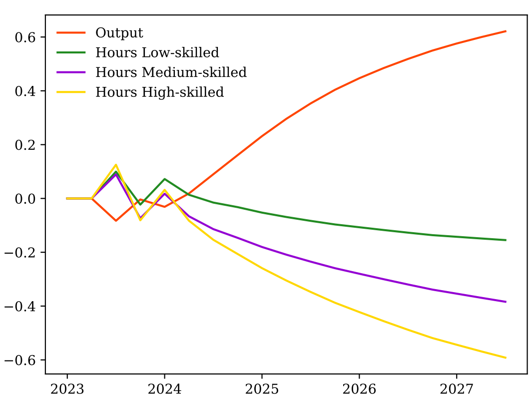
Figure 24: Counterfactual: Higher Interest Rate on Public Debt. (B) after re-estimation.



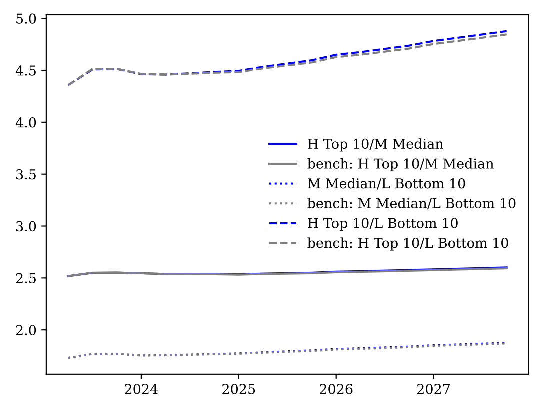
(a) Output (B)



(b) Debt-to-GDP ratio (B)



(c) Gaps in Output and Hours / 1Q-2023 (B)



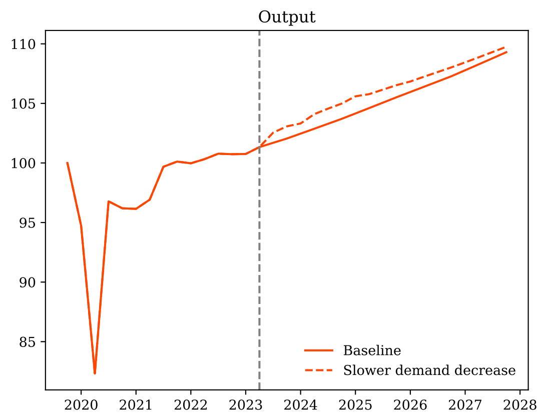
(d) Consumption Inequalities (B)

Figure 25: Counterfactual: Smaller Declines in TFP. (B) after re-estimation.

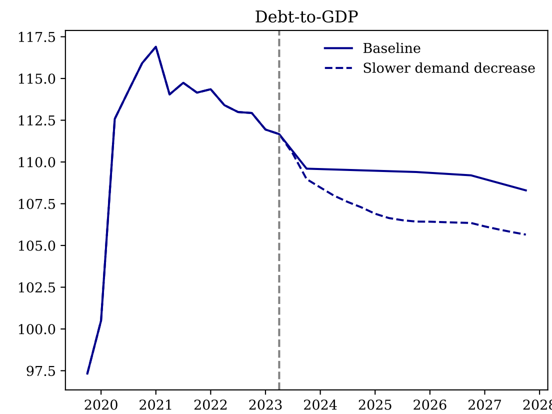
1.64%), in a context of very low inflation (2.08% per year compared to 2.42%). The debt would then slightly decrease to 107.8% of GDP in 2027. But these better results regarding GDP, inflation and debt would come at the cost of a lower job creation. With a more favorable productivity trajectory, fewer jobs would be needed to produce: the employment growth rate would only be 0.65% per year.

F.5 More Moderate Demand Decreases

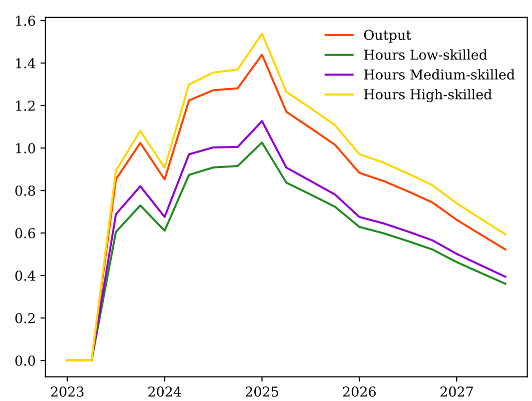
The second "unfavorable wind" is a low level of household demand, which contributes to 20% of the achievement of GDP in 2027. According to the French Institute of Statistics (INSEE), the savings rate of French households was 16% on average between 1950 and 2022, reaching a record level of 27% in 2Q2021. It fell until 2Q2022 when it was 16.6% but has since risen to 18.8% in 1Q2023. In accordance with these data, our model identifies a preference shock that shifts household decisions in favor of savings which remains sustainably above its average in the next two years.



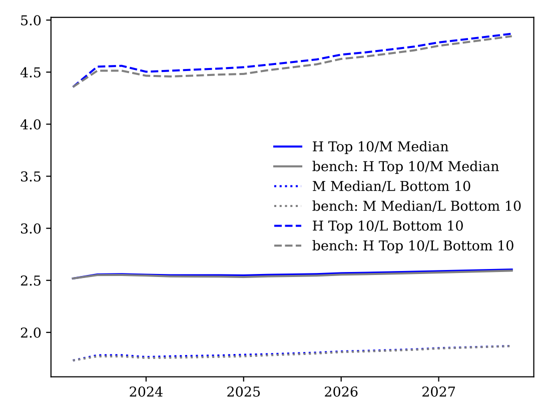
(a) Output (B)



(b) Debt-to-GDP ratio (B)



(c) Gaps in Output and Hours / 1Q-2023 (B)

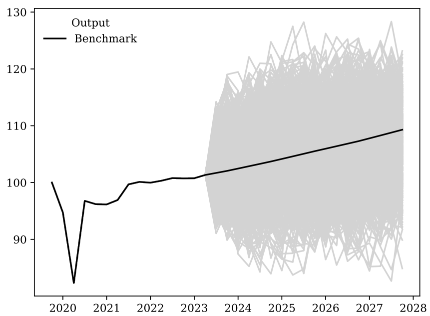


(d) Consumption Inequalities (B)

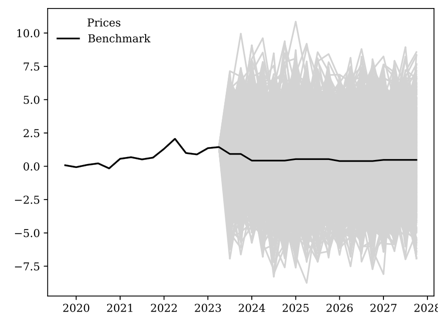
Figure 26: Counterfactual: Smaller Rise in Discount Factor (smaller contraction in Demand). (B) after re-estimation.

Our results indicate that households would, between 2024 and 2025, have a strong propensity to save while moderating their consumption, despite the growth in their income. With a diminution of these variations in demand, there would be an increase in consumption in 2024-2025 and therefore also in economic activity and state resources. Thus, if we moderate this contraction in household demand, the average GDP growth rate between 2023 and 2027 would be 1.73% per year, with inflation at 2.81% (compared to 2.42%) and a debt-to-GDP ratio of 105.7% in 2027. Employment would also grow stronger (0.78% per year vs 0.71% in the Finance Act).

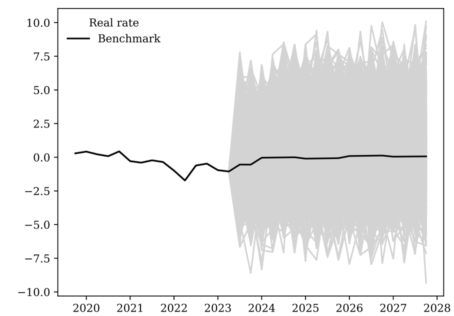
G Forecasts



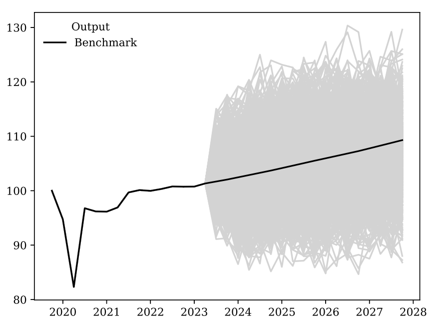
(a) Output (A)



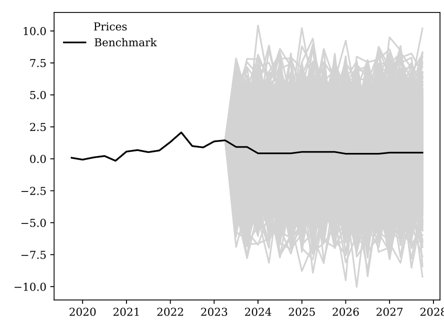
(b) Inflation (A)



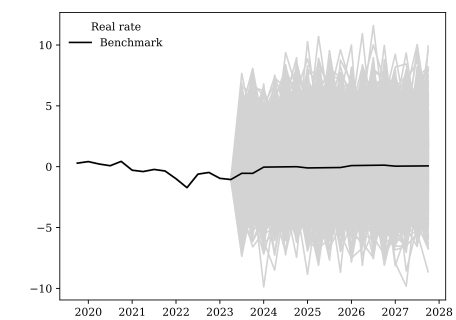
(c) Real interest rate (A)



(d) Output (B)

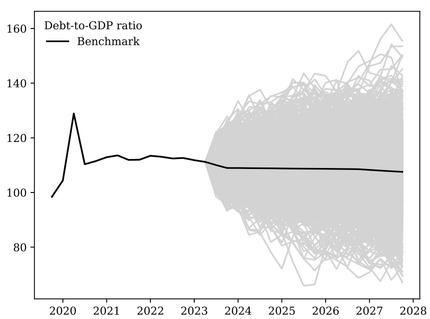


(e) Inflation (B)

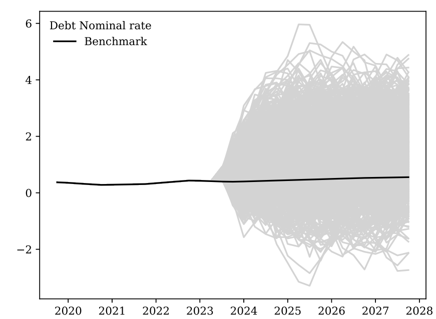


(f) Real interest rate (B)

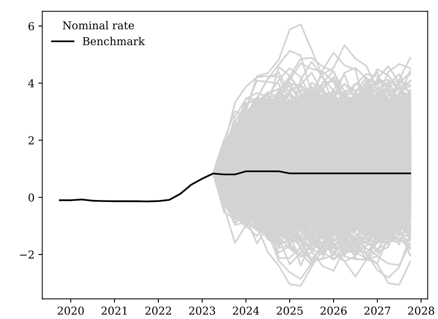
Figure 27: Predicted endogenous variables. (A) before and (B) after re-estimation.



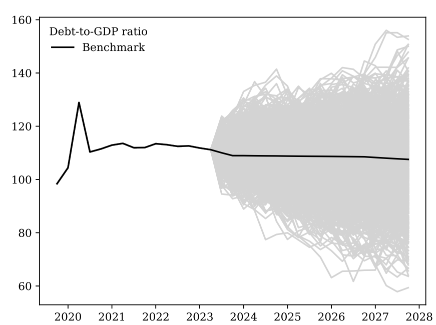
(a) Debt-to-GDP ratio (A)



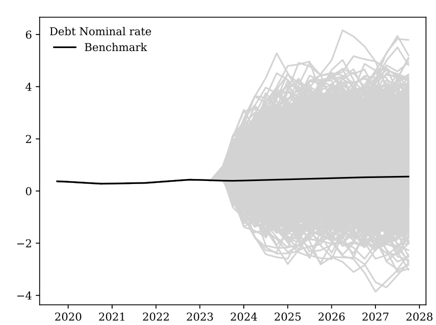
(b) Nominal rate on debt (A)



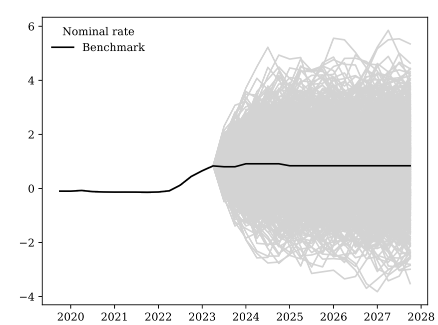
(c) Nominal rate (A)



(d) Debt-to-GDP ratio (B)

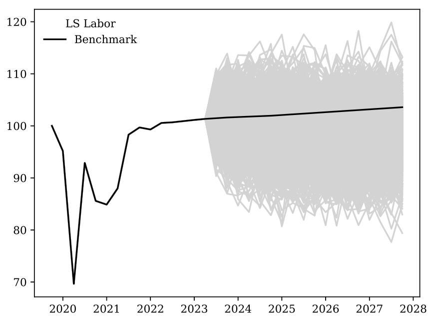


(e) Nominal rate on debt (B)

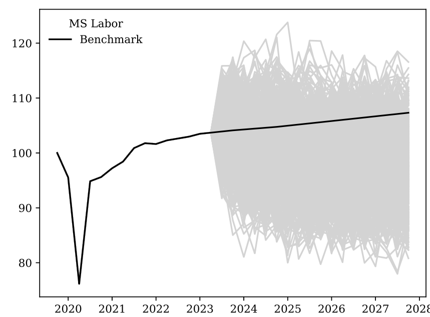


(f) Nominal rate (B)

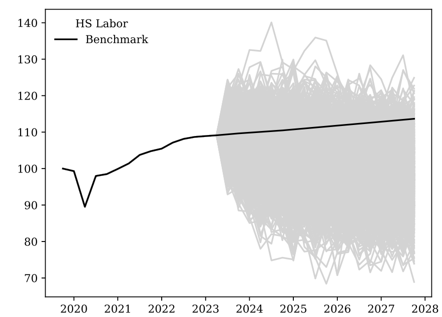
Figure 28: Predicted endogenous variables. (A) before and (B) after re-estimation.



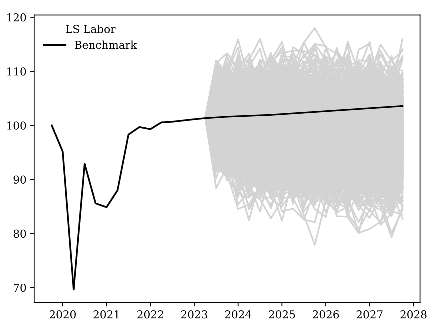
(a) Hours worked - low wage workers (A)



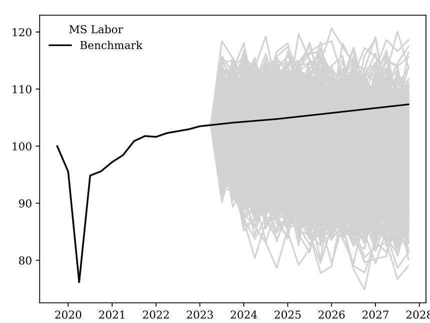
(b) Hours worked - medium wage workers (A)



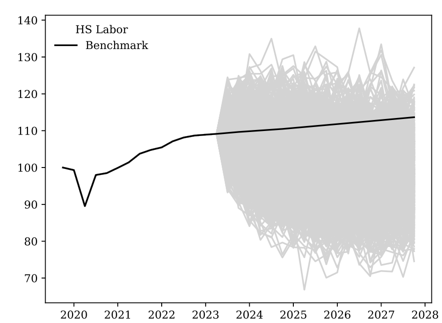
(c) Hours worked - high wage workers (A)



(d) Hours worked - low wage workers (B)

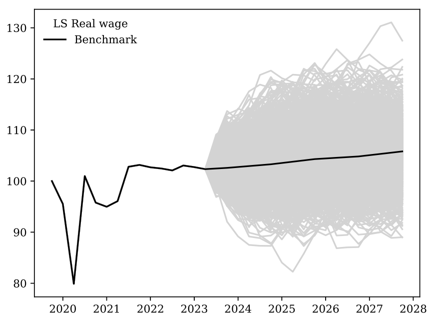


(e) Hours worked - medium wage workers (B)

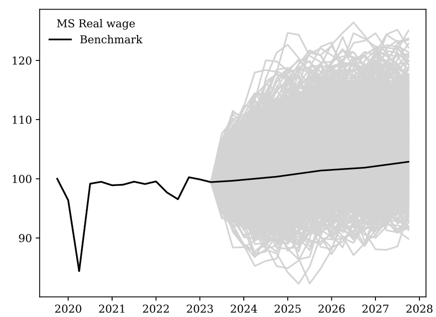


(f) Hours worked - high wage workers (B)

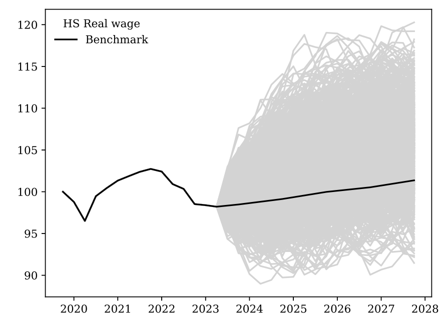
Figure 29: Predicted endogenous variables. (A) before and (B) after re-estimation.



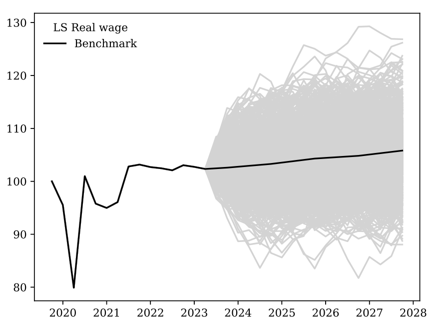
(a) Real wage - low wage workers (A)



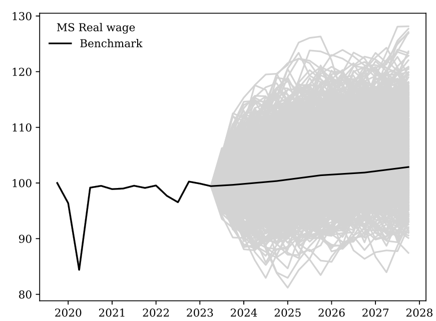
(b) Real wage - medium wage workers (A)



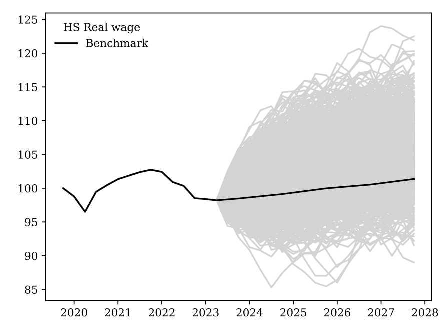
(c) Real wage - high wage workers (A)



(d) Real wage - low wage workers (B)



(e) Real wage - medium wage workers (B)



(f) Real wage - high wage workers (B)

Figure 30: Predicted endogenous variables. (A) before and (B) after re-estimation.