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CAMA Working Paper 11/2024
February 2024

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myopic behaviour, DSGE, rational expectation, Bayesian estimation, US business cycle

JEL Classification

E17, E62, E63, E70

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ISSN 2206-0332

Myopic behaviour in macroeconomic models: Empirical evidence from the US*

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January 24, 2024

Abstract

We investigate the empirical implications of myopic behaviour within an estimated medium-scale macroeconomic DSGE model. Our analysis provides a comprehensive and agnostic examination of the macroeconomic outcomes when households' and firms' beliefs deviate from rational expectations, as proposed by Gabaix (2020). The estimation on US data proposes a strong preference towards cognitive discounting and suggests: (i) an improvement in overall model fit and forecasting performance, (ii) more stimulative fiscal policy, (iii) demand shocks resembling uncertainty shocks where consumption and investment co-move, and (iv) a diminished efficacy of monetary policy. Notably, our empirical results support the presence of rational price setters.

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*Disclaimer and acknowledgements: The views expressed in this paper are those of the authors only and should not be attributed to the European Commission. We thank Christian Bayer, Martin Eichenbaum, Sergio Rebelo, Mathias Trabandt and participants of the Aarhus BSS macro seminar and the macro seminar at the ifo Institute for helpful comments and discussions.

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1 Introduction

Traditional macroeconomic dynamic stochastic general equilibrium (DSGE) models are based on full-information rational expectations (RE). In other words, once a shock occurs, agents form their expectations fully rational and respond optimally in a full-information set-up. This assumption is crucial for the effectiveness of policies because it rests on the ability of policymakers to anchor expectations in the private sector. Especially large-scale DSGE models can be powerful macroeconomic tools for policy analysis, but potential misspecifications may lead to significant distortions in parameter estimates and implied model dynamics. Both the RE assumption and model misspecification may be particularly relevant for models aiming to provide quantitative insight into the dynamic effects of specific shocks, such as those used for fiscal and monetary policy analysis, counterfactual simulations, or forecasting exercises. These models have the underlying objective of fitting and replicating historical data and business cycle properties reasonably well. Against this backdrop, it is of particular interest to explore and assess empirical tools for macroeconomic models that deviate from the RE assumption.

The existing literature in recent years has explored various ways of departing from the RE assumption to improve the model's fit and reconcile its predictions with empirical evidence. One strand of literature introduces adaptive learning (Milani, 2007; Eusepi and Preston, 2018a), while the work of Bianchi et al. (2023) and L'Huillier et al. (2023) focuses on diagnostic expectations based on behavioural heuristics.[1] Other strands of literature propose alternative ways of introducing behavioural adjustments to macroeconomic models, such as the work on reflective equilibrium and level-k thinking (García-Schmidt and Woodford, 2019; Farhi and Werning, 2019), studies on incomplete information and higher-order uncertainty (Angeletos and Lian, 2018; Angeletos and Huo, 2021), or the introduction of finitely-lived agents (Eggertsson et al., 2019; Negro et al., 2012; Woodford, 2018). However, one common caveat for most studies on models with bounded rationality is the difficulty of their applicability to larger-scale DSGE models, as the derivation of equilibrium conditions is theoretically and algebraically highly complex and cumbersome.

An alternative and mathematically more tractable way of introducing behavioural elements in macroeconomic models is the proposal of cognitive discounting by Gabaix (2020). The latter introduces a behavioural element to a standard New Keynesian (NK) model that measures the degree of (in)attention to the future or myopia. Economically,

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[1] For an extensive review of various approaches of deviating from RE in macroeconomic models see Woodford (2013) and Angeletos and Lian (2023), and Eusepi and Preston (2018b) in the context of monetary policy.

it captures the idea that agents cannot fully understand events that will take place in the future and, hence, do not pay full attention to their future prospects when making decisions today. The advantage of the approach by Gabaix (2020) lies in its adaption and straightforward implementation into medium or large-scale DSGE models. This approach has become particularly popular in monetary policy models (e.g. Budianto et al., 2023; Erceg et al., 2021) as a solution to the forward-guidance (FG) puzzle.[2] Other studies, such as Hebden et al. (2020), analyse the robustness of make-up strategies in the context of the Fed's strategy review in a model with learning, while Briciu et al. (2023) investigate the ECB's 2021 monetary policy strategy review by allowing for deviations from RE à la Gabaix (2020).

This paper adapts the approach proposed by Gabaix (2020) to a medium-scale DSGE model and contributes to the literature along several dimensions: First, we develop and estimate a DSGE model for the US under RE and myopic behaviour. Second, and to the best of our knowledge, it is the first paper that provides a comprehensive analysis of the macroeconomic implications of myopic behaviour by focusing on (i) the ability of the models to fit the data, (ii) the dynamic responses to shocks, and (iii) the historical drivers of US GDP growth and inflation. Third, we contribute along the lines of Blanchard (2018), who motivates the introduction of 'empirical tools' for policy models, with the aim of improving the fit in the dynamic adjustment to shocks, despite their deviation from the ideal of maximum theoretical purity.[3] The introduction of myopia via cognitive discounting can be classified as such empirical or behavioural 'tool', and we take an agnostic perspective in evaluating this approach of bounded rationality in a macroeconomic model for the US.

There is a recent and growing literature on estimating the behavioural component in macroeconomic models. The studies closest to ours are Afsar et al. (2024), Meggiorini (2023) and Hirose et al. (2023). Afsar et al. (2024) estimate a standard three-equation NK model for the US with backward-looking components and a cognitive discount factor à la Gabaix (2020). They estimate the myopic parameter by matching the forecast under-revision coefficient in Coibion and Gorodnichenko (2015) and find evidence of strong bounded rationality with a cognitive discount factor between 0.2 and 0.4 for the period

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[2] The puzzle consists in the observation that standard New Keynesian RE models overestimate the impact of forward guidance on the economy: interest rate cuts become more powerful the further they occur in the future. In the behavioural model of Gabaix (2020), this impact is counterbalanced by agents' myopia that increases with the forecast horizon.

[3] Examples for such empirical tools include, for instance, financially-constrained households to allow for positive correlations between private and public consumption expenditures (Galí et al., 2007) or backward-looking ('adaptive') expectations in the Phillips curve to better fit empirical data (Galí and Gertler, 1999; Albonico et al., 2019).

1960 - 1997, depending on the model specification. Thus, matching the stylised facts from survey beliefs requires a high degree of myopia under the behavioural framework of Gabaix (2020). Using a similar three-equation NK model, Hirose et al. (2023) analyse the power of forward guidance under zero-lower bound regimes.[4] Imposing rather tight priors for the behavioural parameters, they estimate the degree of myopia of around 0.85, which significantly weakens the effects of forward guidance compared to the the RE counterpart and improves the fit of the model. In comparison, we remain agnostic to the degree of myopia and employ a rather uninformative prior, leading to estimates that are closer to the ones in Afsar et al. (2024). Meggiorini (2023) estimates a Smets and Wouters (2007) model for the US with a cognitive discount factor of around 0.6-0.7. In contrast to these studies, this paper stands out by (i) developing a structurally rich medium-scale DSGE model with several nominal and real frictions that is closer to a 'model for policy purposes' à la Blanchard (2018), (ii) employing a more efficient and robust estimation procedure with a rather loose prior for the cognitive discount parameter, and (iii) providing a thorough examination and evaluation between the RE assumption and bounded rationality in terms of model fit, shock transmissions, and business cycle drivers. Additionally, we discuss empirical evidence of behavioural heterogeneity among firms' decisions.

Our main results can be summarised as follows: (i) Data for US suggest a strong preference for myopic behaviour. (ii) The introduction of cognitive discounting improves the overall model fit. (iii) Fiscal policy is more effective due to less Ricardian behaviour (crowding-out) of private consumption and investment. (iv) With sufficiently large myopia, demand shocks (such as saving shocks and shocks to investment risk) behave like uncertainty shocks, leading to short-term co-movement of consumption and investment. (v) Monetary policy is less powerful in anchoring expectations, resulting in more sluggish and persistent adjustments when setting interest rates. (vi) However, we find empirical evidence of rational price-setting decisions, while firms' longer-term employment and investment decisions deviate from the RE assumption.

The remainder of the paper proceeds as follows. Section 2 gives an overview of how myopic behaviour is introduced in our model. Section 3 outlines the structure of our model. Section 4 describes the model solution, estimation methodology, and posterior estimates. Section 5 analyses and discusses the economic implications of myopic behaviour

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[4] In contrast to Hirose et al. (2023), we do not account for the effective lower bound (ELB) in the US, as we find only a short period during the financial crisis where agents expect monetary policy to be binding in the future, but no indication for actual constrained monetary policy, after implementing a piecewise-linear approach as in Hohberger et al. (2019) or Croitorov et al. (2020).

and the RE model with respect to model fit, dynamic responses and historical decompositions. Section 6 provides robustness checks and evidence for rational price setters. Section 7 summarises the paper and concludes.

2 Myopic behaviour

The proposal by Gabaix (2020) introduces a behavioural component to a standard New Keynesian (NK) model through the incorporation of a cognitive discount parameter. This parameter gauges the degree of (in)attention to the future, commonly referred to as myopia. While agents maintain rationality regarding the long-run equilibrium considerations, they exhibit partial myopia concerning deviations from this equilibrium. To be specific, disturbances anticipated to occur in the future undergo an additional discounting by a factor m, where $m \in [0, 1]$ quantifies the intensity of myopia. In economic terms, this concept captures the notion that agents may not entirely grasp future events and tend to progressively diminish their significance towards the long-run steady state.

In technical terms and in a generalised form, assuming zero mean and log-linearisation, the evolution of the state vector of the economy, denoted as X_t, can be expressed by the following law of motion:

$$X_{t+1} = \Theta X_t + \epsilon_{t+1} \tag{1}$$

where Θ represents a matrix of coefficients and ϵ_{t+1} is a vector of innovations. In accordance with Gabaix (2020), behavioural agents instead perceive that the state vector evolves as:

$$X_{t+1} = m(\Theta X_t + \epsilon_{t+1}) \tag{2}$$

where $m \in [0, 1]$ is the cognitive discounting parameter indicating the degree of myopia. Note that the rational case is preserved when setting $m = 1$. Consequently, behavioural agents form expectations according to:

$$\mathbb{E}_t^B \left[X_{t+k}\right] = m\mathbb{E}_t \left[X_{t+k}\right] = m\Theta^k X_t \tag{3}$$

where $\mathbb{E}_t^B$ and $\mathbb{E}_t$ represent the behavioural and the rational expectation operator, respectively. The further into the future events are, the more obscurely the behavioural agent perceives them, with a dampened cognitive discount factor m.[5]

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[5] In case of a deterministic trend, as in our model, the behavioural agent would be rational with respect to the values around this trend path, but myopic for the deviations from it. Consequently, in case the mean of X_t is X^*, then the process perceived by the behavioural agent is: $X_{t+1} = (1-m)X^* + m(\Theta X_t + \epsilon_{t+1})$, which becomes, linearised, $\mathbb{E}_t^B \left[X_{t+k} - X^*\right] = m\mathbb{E}_t \left[X_{t+k} - X^*\right]$. For more detailed information, see the

Following the approach of Gabaix (2020), we introduce myopic behaviour by pre-multiplying the expected $t+1$ variables with an additional cognitive discount parameter $m^k \in [0,1]$, where $k \in h, f$ is the cognitive discount parameter in the First order conditions (FOCs) of the households (with respect to the risk free asset, the government bond, the shares, and the wage setting), and the FOCs of the firms (with respect to labour, capital, investment and prices), respectively. Consistent with Gabaix (2020), we linearise the model around the steady state of the fully rational model ($m^k = 1$). The behavioural feature does not alter the long-run steady state, but is significant for the dynamic adjustment to shocks.

3 Model economy

This section sets up a state-of-the-art structural macroeconomic model in the spirit of Smets and Wouters (2007). We consider a closed economy consisting of households, intermediate goods producers, a final goods firm, a fiscal authority and a central bank. Wages are set by trade unions, nominal rigidities link inflation and real activity, while real rigidities enhance the empirical plausibility of the model as commonly assumed in estimated DSGE models. Time is discrete and indexed by t.

3.1 Households

Ricardian households consume and provide labour to intermediate good producers, own domestic firms and participate in financial markets. They maximise their life-time utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_t \left\{ \frac{\left(C_{j,t} - hC_{t-1}\right)^{1-\theta}}{1-\theta} - \omega_t^N \frac{\left(N_{j,t}\right)^{1+\theta^N}}{1+\theta^N} - \overline{\lambda}_t \frac{\mathcal{U}_{t-1}^A}{P_t^C} \right\}, \tag{4}$$

subject to

$$\begin{aligned} P_t^C C_{j,t} + B_{j,t+1}^{rf} + B_{j,t+1}^{G} + B_{j,t+1}^{S} = \left(1-\tau_t^N\right) W_t N_{j,t} \\ + \left(1 + i_{t-1}^{rf}\right) B_{j,t+1}^{rf} + \left(1 + i_{t-1}^{G}\right) B_{j,t}^{G} + \left(1 + i_t^{S}\right) B_{j,t}^{S} + T_{j,t} - tax_t \end{aligned} \tag{5}$$

where, in eq. (4), $0 < \theta, \theta^N$. h governs the importance of external consumption habits. β_t and ω_t^N are the stochastic discount factor and a stochastic labour disutility term,

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online appendix of Gabaix (2020).

respectively.[6] τ_t^N, $T_{j,t}$ and tax_t denote the labour tax rate, transfers, and lump-sum taxes, respectively. The households' financial portfolio consists of risk-free domestic bonds (rf), government bonds (B_t^G) and corporate shares (B_t^S). Risk-free bonds (B_t^{rf}), are in zero net supply in equilibrium.

The term $\mathcal{U}_{t-1}^A$ explicitly introduces stochastic preferences for (real) asset holdings ('risk shocks') into the utility function.[7] We define the disutility of holding assets as

$$\mathcal{U}_{t-1}^A = \sum_{\mathcal{Q}=G,S} \left(\alpha^{\mathcal{Q}} + \varepsilon_{t-1}^{\mathcal{Q}}\right) B_t^{\mathcal{Q}}, \tag{6}$$

with asset-specific risk premium shocks $\varepsilon_{t-1}^{\mathcal{Q}}$. Asset-specific intercepts, $\alpha^{\mathcal{Q}}$, capture steady-state risk premia except for risk-free assets. Fisher (2015) interprets an increase in $\varepsilon_t^{\mathcal{Q}}$ as a wedge between the returns on corporate assets and government bonds, on the one hand, and risk-free assets on the other. These financial shocks also capture the precautionary saving behaviour of households in the absence of high-order risk. As in other estimated models (e.g. Christiano et al., 2015; Gust et al., 2017; Del Negro et al., 2017), risk premium shocks will be important drivers of demand fluctuations in our framework.

As Ricardian households own the firms, they receive nominal profits in form of dividends, Π_t^f, that are distributed by differentiated goods producers according to the number of shares held by the households. We define the gross nominal return on shares S_t as:

$$1 + i_t^S = \frac{P_t^S + P_t^Y \Pi_t^f}{P_{t-1}^S}. \tag{7}$$

The Ricardian households maximise the present value of the expected stream of future utility, subject to equation (5), by choosing the amount of consumption, C_t, and next period asset holdings, B_t^{rf}, B_t^G, B_t^S. The FOCs in a symmetric equilibrium are for $\mathcal{Q} \in \{rf, G, S\}$:

$$1 = \mathbb{E}_t \left[\beta_t \frac{m^h \lambda_{t+1} + (1-m^h)\overline{\lambda_{t+1}}}{\lambda_t} \frac{(1+i_t^{\mathcal{Q}}) - (\alpha^{\mathcal{Q}} + \varepsilon_t^{\mathcal{Q}})}{1+\pi_{t+1}^{C,vat}} \right], \tag{8}$$

where $\lambda_t = (C_t - hC_{t-1})^{-\theta}$. m^h denotes the cognitive discounting parameter à la Gabaix (2020). When $m^h = 1$, the rational agent's Euler equations are preserved. Note that

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[6] Formally, $\beta_t = \beta \frac{\Theta_{t+1}}{\Theta_t}$, where $\frac{\Theta_{t+1}}{\Theta_t} \equiv \exp\left(\varepsilon_t^C\right)$ introduces an exogenous saving shock. To ensure a balanced growth path, labour disutility features a multiplicative term $C_t^{1-\theta}$, such that $\omega_t^N = \omega^N \exp(\varepsilon_t^U) C_t^{1-\theta}$ where ε_t^U is exogenous. Following a similar strategy, an exogenous marginal utility scales asset-specific utility. Finally, note that, unless stated otherwise, all exogenous random variables follow autoregressive processes of order 1.

[7] We follow Krishnamurthy and Vissing-Jorgensen (2012), which incorporate bonds in the utility function.

$\alpha^{rf} = 0$ and $\varepsilon^{rf} = 0$.

3.2 Wage setting

Households provide differentiated labour services $N_{j,t}$ in a monopolistically competitive market. A labour union bundles labour hours into a homogeneous labour service and resells it to intermediate good producing firms. The union maximises the discounted future stream of lifetime utility with respect to the wage and their budget constraints, $C_{j,t}$.

$$\max_{W_{j,t}} U_{j,t} = \sum_{t=0}^{\infty} (\beta_t) U(C_{j,t}, N_{j,t}, \cdot) \tag{9}$$

subject to:

$$\begin{aligned} P_t^C C_{j,t} + B^Q_{j,t+1} + \Gamma^W_{jt} &= \\ \left(1-\tau_t^N\right) W_{j,t} N_{j,t} + (1+i_t^Q) B^Q_{j,t} + D_t + T_{j,t} - tax_t & \end{aligned} \tag{10}$$

$$N_{j,t} = \left(\tfrac{W_{j,t}}{W_t}\right)^{-\sigma^n} N_t, \tag{11}$$

where $\Gamma^W_{j,t} = \frac{\gamma^w(\sigma^n-1)}{2} W_t N_t \left(\pi_t^w - \pi^w\right)^2$ is a quadratic wage adjustment cost that is born by the households. σ^n is the inverse of the steady state gross wage markup. We also allow for a slow adjustment of real wages as in Blanchard and Galí (2007). The resulting wage equation is:

$$\begin{aligned} \left(\frac{\mu^w U_t^N}{\lambda_t} \frac{P_t^{C,vat}}{P_t^Y}\right)^{1-\gamma^{wr}} \left(\frac{(1-\tau^N) W_{t-1}}{P_{t-1}^Y}\right)^{\gamma^{wr}} &= \\ \frac{W_t}{P_t^Y}\left[(1-\tau^N) + \gamma^w \left(\pi_t^w + 1\right)\left(\pi_t^w - \pi^w\right)\right] & \\ - \gamma^w \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t^{C,vat}}{P_{t+1}^{C,vat}} \frac{1}{P_t^Y} \beta_t m^h \left[W_{t+1} \frac{N_{t+1}}{N_t}\left(\pi_{t+1}^w + 1\right)\left(\pi_{t+1}^w - \pi^w\right)\right] & \end{aligned} \tag{12}$$

where $\mu^w = (\frac{\sigma^n}{1-\sigma^n})^{\gamma^{wr}-1}$ is the gross wage mark-up, γ^w and γ^{wr} represent the degree of nominal and real wage rigidity, respectively. The marginal utility of leisure is defined as $U_t^N = \omega^N \varepsilon_t^U (C_t)^{1-\theta} (N_t)^{-\theta^N}$, where ε_t^U captures a shock to the wage mark-up (labour supply shock). m^h captures the cognitive discount parameter à la Gabaix (2020).

3.3 Production

Each firm $i \in [0, 1]$ produces a variety of the domestic goods which is an imperfect substitute for varieties produced by other firms. Firms are monopolistically competitive and face a downward-sloping demand function for goods. Differentiated goods are produced using labour, $N_{i,t}$, and total capital, $K^{tot}_{i,t-1}$, which are combined in a Cobb-Douglas production function:

$$Y_{i,t} = \left(A^Y_t N_{i,t}\right)^{\alpha} \left(cu_{i,t} K^{tot}_{i,t-1}\right)^{1-\alpha}, \tag{13}$$

where α is the steady-state labour share, A^Y_t represents the labour-augmenting productivity common to all firms in the differentiated goods sector, $cu_{i,t}$ denotes firm-specific capital utilisation. Total capital is a sum of private installed capital, $K_{i,t}$, and public capital, $K^G_{i,t}$:

$$K^{tot}_{i,t} = K_{i,t} + K^G_{i,t}. \tag{14}$$

Monopolistically competitive firms maximise the real value of the firm $\frac{P^S_t}{P_t} S^{tot}_t$, that is the discounted stream of expected future profits, subject to the output demand $Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\sigma^y} Y_t$, the technology constraint (13) and a capital accumulation equation $K_{i,t} = I_{i,t} + (1-\delta)K_{i,t-1}$.[8] Their problem can be written as:

$$\max_{P_{i,t}, N_{i,t}, I_{i,t}, cu_{i,t}, K_{i,t}} \sum_{s=t}^{\infty} D^S \Pi^f_{i,t}, \tag{15}$$

where the stochastic discount factor, D^S, is:

$$D^S = \frac{1 + r^S_t}{\Pi^S_{r=t}(1 + r^S_r)} \tag{16}$$

with $1 + r^S_t = \frac{1+i^S_{t+1}}{1+\pi_{t+1}}$ being the real stock return.

$P_{i,t}$ is the price of intermediate inputs and the corresponding price index is:

$$P_t = \left(\int_0^1 (P_{i,t})^{1-\sigma^y} di\right)^{\frac{1}{1-\sigma^y}}. \tag{17}$$

The period t profit of an intermediate goods firm i is given by:

$$\Pi^f_{i,t} = (1-\tau^K)\Big(\frac{P_{i,t}}{P_t} Y_{i,t} - \frac{W_t}{P_t}(N_{i,t})\Big) + \tau^K \delta \frac{P^I_t}{P_t} K_{i,t-1} - \frac{P^I_t}{P_t} I_{i,t} - \Gamma_{i,t}, \tag{18}$$

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[8] We assume that the total number of shares $S^{tot}_t = 1$.

where $I_{i,t}$ is the physical investment at price $P^I_{i,t}$, τ^K is the corporate tax and δ the capital depreciation rate. Firms face quadratic factor adjustment costs, $\Gamma_{i,t}$, measured in terms of production input factors:

$$\Gamma_{i,t} = \Gamma^P_{i,t} + \Gamma^N_{i,t} + \Gamma^I_{i,t} + \Gamma^{cu}_{i,t} \tag{19}$$

Specifically, the adjustment costs are associated with the output price $P_{i,t}$, labour input $N_{i,t}$, investment $I_{i,t}$, as well as capacity utilisation variation $cu_{i,t}$:

$$\Gamma^P_{i,t} = \sigma^y \frac{\gamma^P}{2} Y_t \left[\frac{P_{i,t}}{P_{i,t-1}} - \exp(\bar{\pi}) \right]^2, \tag{20}$$

$$\Gamma^N_{i,t} = \frac{\gamma^N}{2} Y_t \left[\frac{N_{i,t}}{N_{i,t-1} + \varepsilon^{tN}_{t-1}} - \exp(g^{pop}) \right]^2, \tag{21}$$

$$\Gamma^I_{i,t} = \frac{P^I_t}{P_t} \left[\frac{\gamma^I}{2} \frac{(I_{i,t} - I_{i,t-1}\exp(g^Y + g^{PI}))^2}{K_{t-1}} \right], \tag{22}$$

$$\Gamma^{cu}_{i,t} = \frac{P^I_t}{P_t} K^{tot}_{i,t-1} \left[\gamma^{cu,1}(cu_{i,t} - 1) + \frac{\gamma^{cu,2}}{2}(cu_{i,t} - 1)^2 \right], \tag{23}$$

where γ-parameters capture the degree of adjustment costs. $\bar{\pi}$ denotes steady state inflation. g^{pop}, g^Y, and g^{PI} are trend factors of population, GDP and prices for investment goods, respectively. $\delta^K_t \neq \delta$ is a function of the depreciation rate adjusted for the capital trend in order to have zero adjustment costs on the trend-path.[9]

Given the Lagrange multiplier associated with the technology constraint, μ^y, the FOCs with respect to labour, capital, investments and capital utilisation are given by:

$$(1 - \tau^K)\frac{W_t}{P_t} = \alpha \left(\mu^y_t - \varepsilon^{ND}_t \right) \frac{Y_t}{N_t} - \frac{\partial \Gamma^N_t}{\partial N_t} + m^f E_t \Big[\frac{1 + \pi_{t+1}}{1 + i^s_{t+1}} \frac{\partial \Gamma^N_{t+1}}{\partial N_t} \Big], \tag{24}$$

$$\begin{gathered} Q_t - (1 - m^f)\overline{Q_{t+1}} = \\ m^f E_t \left[\tfrac{1+\pi_{t+1}}{1+i^s_{t+1}} \tfrac{P^I_{t+1}}{P_{t+1}} \tfrac{P_t}{P^I_t} \left(\tau^K \delta^K - \tfrac{\partial \Gamma^{cu}_{t+1}}{\partial K_t} + Q_{t+1}(1 - \delta) + (1 - \alpha)\mu^Y_{t+1} \tfrac{P_{t+1}}{P^I_{t+1}} \tfrac{Y_{kt+1}}{K^{tot}_t} \right) \right], \end{gathered} \tag{25}$$

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[9] We specify $\delta^K_t = exp(g^Y + g^{PI}) - (1 - \delta)$ so that $\frac{I}{K} - \delta^k \neq 0$ along the trend path.

$$\begin{aligned} Q_t = {} & E_t\left[1 + \gamma^{I,2}\frac{(I_t - I_{t-1}\exp(g^Y + g^{P^I}))}{K_{t-1}}\right] \\ & -m^f E_t\left[\frac{1+\pi_{t+1}}{1+i^s_{t+1}}\frac{P^I_{t+1}}{P_{t+1}}\frac{P_t}{P^I_t}\exp(g^Y + g^{P^I})\gamma^{I,2}\frac{(I_{t+1} - I_t\exp(g^Y + g^{P^I}))}{K_t}\right], \end{aligned} \tag{26}$$

$$\mu^y_t(1-\alpha)\frac{Y_t}{cu_t}\frac{P_t}{P^I_t} = K^{tot}_{t-1}\Big[\gamma^{u,1} + \gamma^{u,2}(cu_t - 1)\Big], \tag{27}$$

where $Q_t = \mu^y_t / \frac{P^I_t}{P_t}$.

In a symmetric equilibrium ($P_{i,t} = P_t$), the FOC with respect to $P_{i,t}$ yields the New Keynesian Phillips curve:

$$\begin{aligned} \mu^y_t\sigma^y = {} & (1-\tau^K)(\sigma^y - 1) + \sigma^y\gamma^P\frac{P_t}{P_{t-1}}\Big(\pi_t - \bar{\pi}\Big) \\ & - \sigma^y\gamma^P m^f\left[\frac{1+\pi_{t+1}}{1+i^s_{t+1}}\frac{P_{t+1}}{P_t}\frac{Y_{t+1}}{Y_t}\Big(\pi_{t+1} - \bar{\pi}\Big)\right] + \sigma^y\varepsilon^\mu_t, \end{aligned} \tag{28}$$

where ε^μ_t is a white noise markup shock. The firm-specific cognitive discount factor, m^f, enters the FOCs with respect to labour (24), capital (25), investment (26) and output price (Phillips curve) (28).

3.4 Fiscal policy

The fiscal authority raises constant linear taxes on consumption (τ^C) and corporate profits (τ^K), lump-sum taxes (tax_t) and wage income tax (τ^N_t). It finances consumptive purchases (G_t), investments (IG_t) and transfers (T_t). Nominal debt evolves as

$$B^{G,n}_t = (1 + i^G_t)B^G_{t-1} - R^G_t + P_tG_t + P_tIG_t + P_tT_t, \tag{29}$$

where R^G_t are the nominal government revenues:

$$R^G_t = \tau^C C_t P_t + \tau^K\Big(P_tY_t - W_tN_t - \delta P_tK_{t-1}\Big) + \tau^N_t N_t W_t + tax_t. \tag{30}$$

To close the government budget constraint, lump-sum taxes, $tax_{k,t}$, adjust residually as follows:

$$\begin{aligned} tax_t = \rho_\tau tax_{t-1} + \eta^{deft} \left(\frac{\Delta B^G_{t-1}}{Y_{t-1} P^Y_{t-1}} - DEFTAR \right) \\ + \eta^{BT} \left(\frac{B^G_{t-1}}{Y_{t-1} P^Y_{t-1}} - BTAR \right) + \varepsilon^{tax}_t, \end{aligned} \tag{31}$$

where $DEFTAR$ and $BTAR$ are the targets on government deficit and government debt, respectively, and ε^{tax}_t captures a shock. Hence, the government uses lump-sum taxes as budget closure and increases (decreases) taxes when the level of government debt and the government deficit is above (below) the debt and deficit target. On the spending side, government consumption, G_t, investment, I^G_t, and transfers, T_t follow autoregressive processes and are subject to idiosyncratic shocks (ε^G, ε^{IG} and ε^T).

3.5 Monetary policy

Monetary policy follows a Taylor-type rule (Taylor, 1993). The interest rate i_t responds sluggishly to deviations of annualised inflation and the output gap (Y^{gap}_t) from their respective target levels:

$$i_t - \bar{i} = \rho^i (i_{t-1} - \bar{i}) + (1 - \rho^i) \left[\frac{\eta^{i\pi}}{4} \left(\pi^{C,QA}_t - \bar{\pi}^{C,QA} \right) + \frac{\eta^{iy}}{4} Y^{gap}_t \right] + \varepsilon^i_t, \tag{32}$$

where $\bar{i} = 0.02$ in annual terms. $\pi^{C,QA}_t$ denotes quarterly annualised inflation and $\bar{\pi}^{C,QA}$ its steady state value.[10] Variable i_t is the actual or effective short-term interest rate. ρ^i, $\eta^{i\pi}$, η^{iy} govern interest rate inertia and the response to annualised inflation and output gap, respectively. The latter equals the (log) difference between actual and potential output, i.e. $Y^{gap}_t = \log \left(\frac{Y_t}{Y^{pot}_t} \right)$.[11] ε^i_t is a white noise monetary policy shock.

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[10] Quarterly annualised inflation is defined as $\pi^{C,QA}_t = \log \left(\sum_{r=0}^{3} P^{C,vat}_{t-r} \right) - \log \left(\sum_{r=4}^{7} P^{C,vat}_{t-r} \right)$.

[11] Potential output at date t is the output level that would prevail if labour input equalled hours worked in the absence of nominal wage rigidity as in Galí (2011) (we denote this $\bar{N}_t$), the capital stock was utilised at full capacity, and TFP equalled its trend component A_t. Thus, $Y^{pot}_t = \left(A_t \bar{N}_t \right)^a \left(K^{tot}_t \right)^{1-a}$.

3.6 Aggregation

The resource constraint is given by

$$Y_t = C_t + I_t + IG_t + G_t + D_t, \tag{33}$$

where D_t is the residual demand aggregate for matching the closed-economy version, i.e. the empirical proxy for the trade balance-to-GDP ratio.

4 Econometric approach

We estimate two versions of the model: the Rational Expectations (RE) model and the Myopic model. In the latter, households and firms exhibit myopic behaviour, discounting future events with a common factor. To ensure a meaningful comparison, we use ex-ante identical models, utilising the same equations, the same prior parameter distributions, and the same set of shocks. This set-up provides a robust framework for model comparison, where the direct effect of heterogeneity can be attributed directly to the introduction of myopic behaviour. This section presents ex-ante information on the prior distributions of potential estimates, summarises the dataset, the estimation procedure, and the key posterior estimates of both the RE and the Myopic models. Additional details can be found in Appendix A.

4.1 Ex ante sensitivity on prior distributions

We employ global sensitivity analysis techniques, as outlined by Ratto (2008), to offer ex-ante insights into how myopic behaviour might influence potential estimated outcomes. Specifically, our focus centres on the prior distributions of the impact of a temporary positive government expenditure shock on GDP, consumption, and investment.[12]

Figure 1 illustrates the prior distributions for both the RE model and the Myopic model before taking the data to the model. The sole distinction between the two models lies in one parameter - the cognitive discount factor. The visualisation demonstrates that the introduction of myopia shifts all prior distributions to the right, allowing the model to estimate crowding-in effects on consumption and investment. Importantly, these potential areas of crowding-in emerge without explicitly modelling financially-constrained

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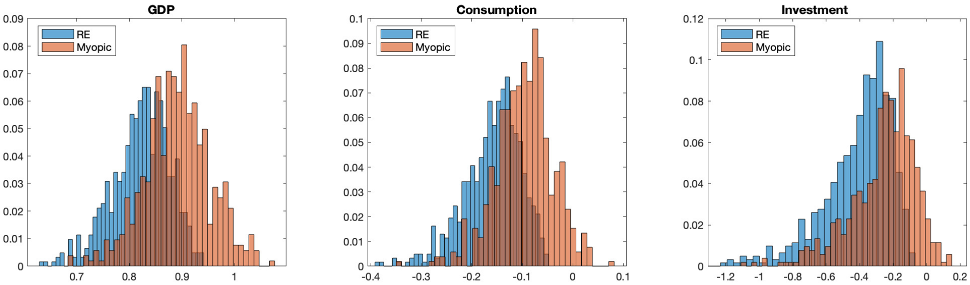
[12] The simulations are based on 2048 Monte Carlo samples from the prior distribution of all estimated parameters. For further details on global sensitivity analysis techniques, refer to Ratto (2008).



Note: The height of each bar shows the relative number of observations. The sum of all bar heights is equal to 1. 1 on the x-axis corresponds to 1 percent.

Figure 1: Prior distributions of the fiscal impact on GDP, consumption and investment

households or firms because myopia may capture similar dynamic effects. Thus, the incorporation of cognitive discounting (or myopia) mitigates model-imposed restrictions, rendering the model more agnostic in identifying ‘theory-free’ business cycle dynamics.

4.2 Data

The model estimation uses time series information for 15 endogenous variables, with an additional observation of the first quarter of the capital stock to initialise the starting point. The observed time series are listed in Table A.1 in Appendix A. Apart from standard macroeconomic aggregates, fiscal data also include information on government expenditure items (government consumption, investment, and transfers), as well as interest payments on government debt and the debt-to-GDP ratio. The analysis incorporates quarterly data for the period 1999:Q1 to 2019:Q4, sourced from the Bureau of Economic Analysis (BEA) and the Federal Reserve. We apply logarithmic transformations to all observables, except for the nominal interest rate. The GDP deflator is calculated as the ratio of the current-price value to the chain-indexed volume series.

4.3 Econometric procedure

We employ a two-step procedure to capture key features of the data. First, we calibrate a subset of parameters to align with long-run data properties, such as the steady-state consumption, investment, and government expenditure shares. The calibrated parameters are reported in Table A.2 in Appendix A. Real variables grow at the average growth rate of US GDP (2.1%), and the price level trend growth corresponds to the targeted inflation rate of 2% per year. The Cobb-Douglas labour share, α, is set to 0.65. In a second step, the remaining parameters are estimated using Bayesian methods. The posterior Kernel is then numerically simulated using a computationally efficient parallelised slice sampling algorithm, as proposed by Planas et al. (2015).[13] The estimated model incorporates 15 exogenous shocks, and we utilise the DYNARE software (Adjemian et al., 2011) for solving and estimating the model.

We apply standard priors for the estimated parameters consistent with existing studies (e.g. Cardani et al., 2023; Hohberger et al., 2023). For the cognitive discount parameter, m, we use a normal distribution with mean 0.9 and a relatively wide standard deviation of 0.15, truncated at 1. This specification reflects an ex-ante belief that the RE assumption might be the 'correct' one, as most of the prior mass is centred around rationality. However, we allow the estimation to pick a high degree of myopia if favoured by the data.[14] Table 1 lists the remaining prior distributions.

4.4 Posterior estimates

Table 1 compares the posterior estimates of the model parameters for the two model versions.[15] In the RE model, household consumption habits are relatively high, suggesting a smooth consumption response to changes in income. The estimated risk aversion and the inverse labour supply elasticity align with the literature (e.g. Kollmann et al., 2016). Our posterior RE estimates imply sticky prices and wages, as well as pronounced real wage rigidities. The estimated capital and investment adjustment costs indicate a sluggish response to changes in profitability. The estimated Taylor rule suggests a sluggish interest rate response to inflation and the output gap. The estimated debt stabilisation responds to the deficit and, to a lesser extent, to deviations from the debt target.

Table 1 reports a substantial degree of inattention (0.39) for the estimated Myopic model, akin to the findings of Afsar et al. (2024). The accompanying key differences in the posterior estimates compared to the RE model include lower estimated consumption habits, lower price, capital, and investment adjustment costs, and a stronger response of monetary policy to inflation. The estimates suggest that a high degree of cognitive discounting corresponds one-to-one with lower estimated adjustment costs. Specifically,

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[13] The slice sampler algorithm, introduced by Neal (2003) and reconsidered by Planas et al. (2015) for its implementation in DYNARE, reconsiders slices along the major axis of the ellipse to better fit the posterior distribution than any Euclidean slices. The slice sampler has been shown to be more efficient than the Metropolis-Hastings sampler and offers appealing properties for the usage of lager-scale DSGE models (Calés et al., 2017). Similar Bayesian techniques are used by Hohberger et al. (2019) or Croitorov et al. (2020).

[14] We opt for this specification to be less restrictive and more agnostic. We have also tested a uniform prior with very similar estimation results.

[15] Table A.3 in Appendix A provides a comparison of the estimated shock processes.

		Prior distribution		Posterior distribution	
		Distr	Mean St.Dev	RE	Myopia
Behavioural discounting					
Cognitive discounting	m	N	0.90	-	0.39
			0.15		(0.29, 0.72)
Preferences					
Consumption habit persistence	h	B	0.50	0.79	0.68
			0.10	(0.73, 0.85)	(0.49, 0.81)
Risk aversion	θ	G	1.50	1.64	1.53
			0.20	(1.38, 2.13)	(1.32, 2.00)
Inverse Frisch elasticity of labour supply	θ^N	G	2.50	2.08	2.21
			0.50	(1.58, 2.67)	(1.82, 3.12)
Nominal and real frictions					
Price adjustment cost	γ^P	G	20	39.32	25.97
			12	(33.81, 54.50)	(21.28, 36.69)
Nominal wage adjustment cost	γ^w	G	5.00	3.14	3.44
			2.00	(2.75, 5.32)	(3.01, 6.32)
Real wage rigidity	γ^{wr}	B	0.50	0.96	0.90
			0.20	(0.94, 0.98)	(0.81, 0.95)
Employment adjustment cost	γ^N	G	20	4.99	4.15
			12	(3.76, 7.25)	(3.25, 5.44)
Capacity utilisation adjustment cost	$\gamma^{CU,2}$	G	0.03	0.004	0.013
			0.012	(0.002, 0.007)	(0.007, 0.023)
Capital stock adjustment cost	$\gamma^{I,1}$	G	30	68.33	5.69
			20	(39.22, 103.97)	(1.95, 18.91)
Investment adjustment cost	$\gamma^{I,2}$	G	30	43.56	11.06
			20	(19.38, 70.80)	(4.71, 32.14)
Monetary Policy					
Interest rate persistence	ρ^i	B	0.85	0.83	0.89
			0.06	(0.77, 0.89)	(0.83, 0.94)
Response to inflation	$\eta^{i,\phi}$	B	2.00	1.41	2.01
			0.20	(1.31, 1.76)	(1.69, 2.25)
Response to GDP	$\eta^{i,y}$	B	0.10	0.10	0.04
			0.04	(0.07, 0.13)	(0.02, 0.05)
Fiscal Policy					
Lump-sum taxes persistence	ρ^τ	B	0.85	0.93	0.94
			0.06	(0.89, 0.97)	(0.90, 0.97)
Tax response to deficit	η^{def}	B	0.03	0.02	0.03
			0.008	(0.01, 0.04)	(0.01, 0.04)
Tax response to debt	η^b	B	0.02	0.002	0.002
			0.01	(0.001, 0.004)	(0.001, 0.004)

Note: Cols. (1)-(2) list model parameters. Cols. (3)-(4) indicate the prior distribution function (N: Normal; B: Beta; G: Gamma). Identical priors are assumed across model versions. Cols. (5)-(6) show the mode and the 90% HPD intervals of the posterior distributions for the two model versions.

Table 1: Posterior estimates of key model parameters.

price (25.97), employment (4.15), capital (5.69), and investment adjustment costs (11.06) are substantially lower compared to the RE model. Fiscal policy parameters remain within the magnitude of the RE model.

Our posterior estimates align with the economic narrative of Gabaix (2020): As myopic agents do not fully understand the world, shocks occurring in the future have a diminished impact on agents' expectations, influenced by the estimated cognitive discounting factor m, compared to the rational response. From an empirical point of view, this dampened effect of exogenous shocks on impact captures partly similar effects as adjustment costs; hence, (stronger) myopia and (lower) adjustment costs are (positively) correlated. Nonetheless, both empirical 'frictions' capture different economic adjustment dynamics in the medium term and are empirically well identified in the estimation process.

5 RE vs. myopic behaviour

In this section, we evaluate and analyse the macroeconomic implications of incoporating cognitive discounting as a behavioural element into our model. Our assessment focuses on three dimensions: (i) the model's capability to accurately capture historical data patterns, (ii) the dynamic responses to shocks, and (iii) the historical drivers of US GDP growth and inflation.

5.1 Moments and model fit

We conduct a more systematic comparison of the two model versions by assessing their ability to fit historical data patterns. Table 2 compares sample and model-implied moments for a subset of key statistics. Specifically, we examine the volatility and persistence of real GDP, consumption, investment, employment, and the GDP deflator, as well as the cross-correlation of GDP with its main components.

Both models tend to slightly overestimate the volatility of real variables in the US; however, the behavioural model more accurately reproduces the volatility of inflation. First-order auto-correlation coefficients in the myopic model align well with the data, particularly for consumption, investment and hours worked, while the RE model performs better in capturing the persistence of GDP. Notably, for the correlation between macroeconomic aggregates and output growth, the behavioural model with myopic behaviour closely matches the data.

The last two columns in Table 2 present the r^2 values for the 1-year ahead and 2-year ahead forecasts.[16] The r^2 for the 1-year ahead forecast is positive for all selected variables

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[16] We define the r^2 as the ratio of the k-step-ahead forecast error obtained from the Kalman filter recursions over the time series, with deviations from the model-implied steady-state. As we subtract this ratio from 1, the r^2 has an upper bound at 1 and is unbounded from below. In the perfect case where the model generates no forecast error, the r^2 is one. Hence, r^2 declines monotonically as the forecast error increases. Since the volatility of the forecast error can exceed the volatility of the time series, r^2 can also become negative.

Variable	Std		AR(1)		Corr (x, GY)		r2	
	Data	Model	Data	Model	Data	Model	1-y ahead	2-y ahead
RE model (Data density: 4842.48)								
GDP growth	0.58	0.66	0.30	0.30	1.00	1.00	0.71	-0.14
Consumption growth	0.45	0.58	0.50	0.65	0.63	0.49	0.69	-0.27
Investment growth	2.94	2.93	0.45	0.24	0.78	0.68	0.62	0.18
Hours growth	0.54	0.53	0.81	0.56	0.59	0.71	0.79	0.11
GDP deflator	0.23	0.42	0.46	0.73	0.19	0.03	0.64	-0.78
Myopic model (Data density: 4863.03)								
GDP growth	0.58	0.71	0.30	0.41	1.00	1.00	0.81	0.19
Consumption growth	0.45	0.50	0.50	0.59	0.63	0.52	0.75	0.27
Investment growth	2.94	3.05	0.45	0.48	0.78	0.76	0.71	0.22
Hours growth	0.54	0.58	0.81	0.70	0.59	0.71	0.89	0.30
GDP deflator	0.23	0.27	0.46	0.28	0.19	0.23	0.48	0.05

Note: We use quarter-on-quarter growth rates for all variables. Consumption and investment growth relates to the private sector only. The data density is reported in log points using a Laplace approximation.

Table 2: Simulated moments and model fit.

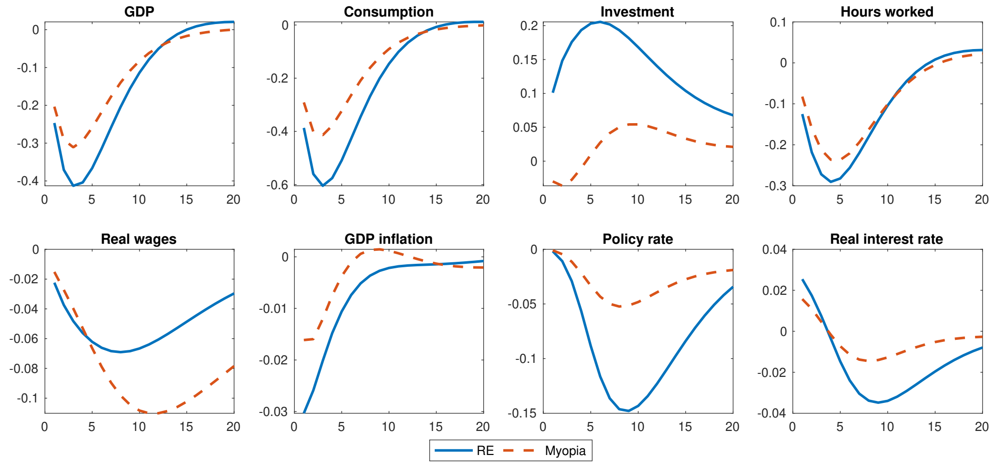
in both models. However, Table 2 indicates that, except for the 1-year ahead prediction of inflation, the myopic model reduces the forecast error for all variables, especially for the 2-year ahead predictions.

From an empirical standpoint, data density serves as a valuable global criterion for model evaluation in the Bayesian context. It assesses the model fit, favouring simplicity by penalising models with more parameters, assuming an equal fit. The data density in the Myopic model (4863.03) is 20 log points higher than in the RE model (4842.48), indicating that the estimation favours the inclusion of cognitive discounting.

5.2 Dynamic transmission

To gain a deeper understanding of how cognitive discounting affects the dynamic response to shocks, we compare the impulse responses functions (IRF) of selected macroeconomic variables to various shocks, including domestic demand shocks (private saving and government spending), monetary policy shocks, and domestic supply (mark-up) shocks between the two model estimates. Figures 2 and 3 depict the responses of the following endogenous variables: real GDP, private consumption, private investment, hours worked, real wages, GDP deflator, the policy rate, and real interest rates. The demand shocks are standardised with the same persistence for comparability, while the monetary policy and

(a) Positive private saving shock



(b) Positive government expenditure shock

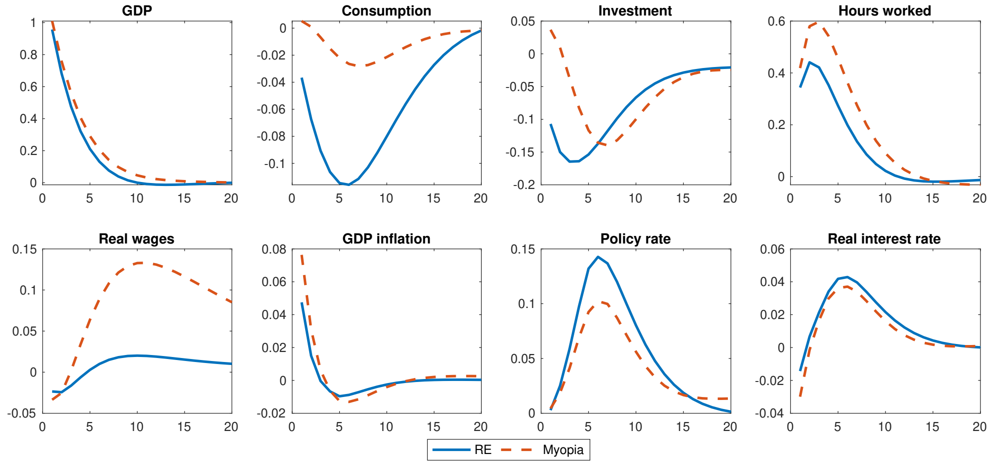


Figure 2: Dynamic transmission of shocks I.

Note: Real variables are presented as percentage deviation from steady state, GDP inflation and the policy rate are expressed as percentage-point and annualised percentage-point deviations from steady state.

mark-up shocks are assumed to be identically and independently distributed (iid). Real variables are presented in percent deviations from their respective steady states, whereas GDP inflation and the policy rate are expressed in percentage-point deviations from the steady state.[17]

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[17] Figures B.2 and B.3 in Appendix B illustrate the posterior IRFs with confidence bands around the posterior mode. Note that the posterior IRFs are based on the estimated shock processes, resulting in different persistence compared to the ones presented in Section 5.2.

Positive private saving shock

A positive shock to the saving rate, modelled as a persistent increase in the subjective rate of time preference of households, leads to a decrease in consumption, causing a simultaneous decline in output and prices (Figure 2a). Under the standard RE assumption, the shock triggers an expansionary monetary policy response, reflected in a decrease in interest rates and an increase in investment. Figure 2a shows that with myopic agents (red dashed line) dynamic responses are dampened on impact. Notably, a significant difference emerges in the case of investment, where the response on impact is negative, mimicking the dynamics of an uncertainty or risk shock, as studied, for example, by Christiano et al. (2014), that dampens consumption and investment simultaneously.[18] This co-movement is a result of the relatively strong myopic behaviour of firms. The future drop in (real) interest rates has less impact on investment decisions today, leading to a one-to-one pass-through of higher real rates on impact.

Positive government expenditure shock

Under RE, an increase in government expenditure raises domestic output but crowds-out consumption and investment (Figure 2b). The upward pressure on prices triggers a tightening of monetary policy and a subsequent increase in interest rates in the medium term. The fiscal multiplier is slightly below one on impact. For the Myopic model (red dashed lines), Figure 2b reveals a crowding-in effect of private consumption and investment on impact. Given the high degree of myopia, Ricardian households spend more of their increased income and raise their consumption since they fail to perfectly anticipate future tax increases. Complementary, the future real interest hikes have less traction for the decisions of myopic firms today. Thus, the decrease in real rates on impact due to higher prices counterbalances the by m-dampened negative effects of higher future interest rates, leading to a marginal increase in investment on impact. Both effects enhance the effectiveness of fiscal policy in stimulating the economy. Although the fiscal multiplier for real GDP is slightly dampened by higher inflation in the short term, it remains above one. These findings complement studies that introduce heterogeneous agents or hand-to-mouth consumers to model non-Ricardian behaviour (e.g. Galí et al., 2007; Albonico et al., 2019; Croitorov et al., 2020).

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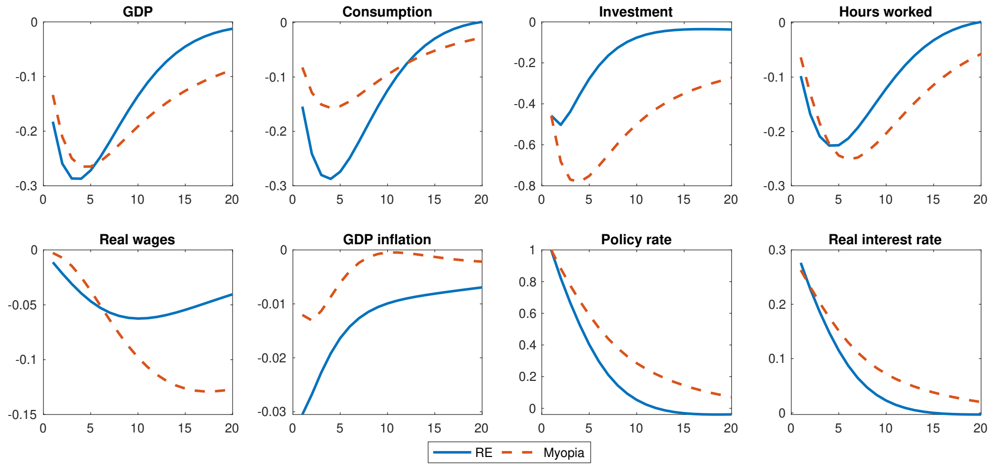
[18] A flight-to-quality or flight-to-safety shock is another alternative to obtain positive correlations between consumption and investment, which has been discussed, e.g. by Albonico et al. (2019) or Cardani et al. (2022).

(a) Positive shock to the policy rate



(b) Positive cost-push shock

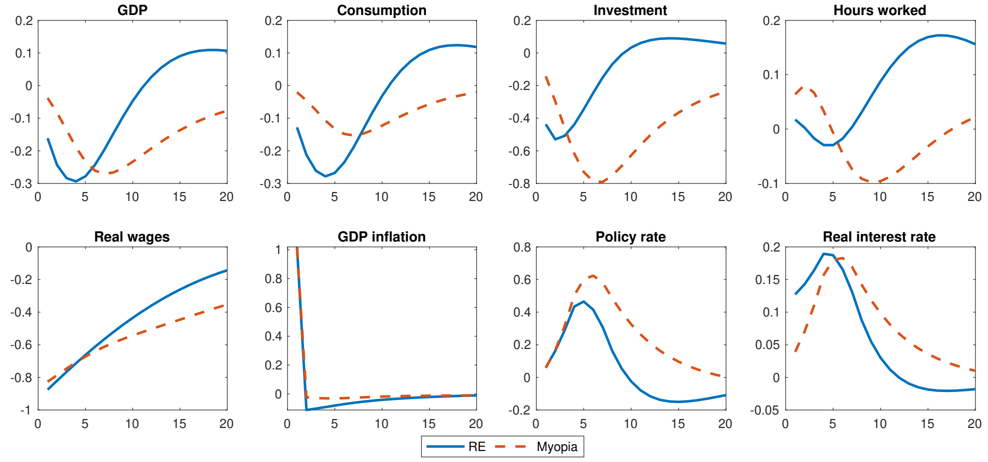


Figure 3: Dynamic transmission of shocks II.

Note: Real variables are presented as percentage deviation from steady state, GDP inflation and the policy rate are expressed as percentage-point and annualised percentage-point deviations from steady state.

Positive monetary policy shock

In the RE model, a monetary policy tightening (increase in the annualised interest rate by 1pp) implies a decrease in aggregate demand components (Figure 3a). Investment experiences a substantial decline due to higher nominal and real interest rates. The lower demand prompts firms to decrease labour demand, resulting in a decline in employment. Figure 3a shows that the dynamic effects of an increase in the policy rate are dampened on impact but are amplified and more persistent over the medium term when agents are myopic towards future events. The effectiveness of monetary policy rests on the ability to anchor private expectations. With fully rational agents, consumers and firms respect their Euler equations, meaning that a change in the interest rate in the future has a strong impact today.[19] However, deviations from RE weaken the power of the expectations channel of monetary policy. Consequently, the impact today of (future) interest rate changes is muted, and the adjustments are more sluggish over the medium term, leading to more persistent and higher interest rates (high-for-longer).[20]

Positive cost-push shock

A positive cost-push shock, modelled as a disturbance to the Phillips curve and a persistent increase in the price level, implies a drop in GDP and aggregate demand components, exemplifying the typical supply-side trade-off between prices and economic activity. Figure 3b shows that, similar to a shock to the policy rate, high cognitive discounting dampens the dynamics of an increase in prices on impact but amplifies the sluggish adjustment process over the medium term. The central bank needs to respond more aggressively over the medium-term because future monetary policy decisions are less effective in the absence of RE, resulting in a higher persistence of the increased price level (higher negative GDP inflation rates under RE in periods 2-10). Despite the lower estimated adjustment costs in the Myopic model, it is crucial to note the more sluggish adjustment over the medium-term.

5.3 Historical decomposition

To comprehensively assess the impact of the behavioural element introduced by cognitive discounting, we quantitatively analyse the estimated contribution of various (groups of) shocks to historical US real GDP growth and inflation data for the period 2000q1-2019q4. In each subplot, the continuous black line represents the historical GDP (inflation) data, with the steady-state growth or inflation (2.10% and 2%, respectively, in annual terms) subtracted. The vertical dark grey bars (for the RE model) and red bars (for the Myopic model) depict the contribution of the respective (group of) exogenous shocks to the data. Bars above the horizontal axis (steady state) represent positive shock contributions, while bars below the horizontal axis show negative contributions. The sum of all contributions equals the historical data. We classify shocks into the following groups: (1) shocks to

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[19] This relates to the 'Forward guidance puzzle' which has been discussed by Negro et al. (2012) and McKay et al. (2016). However, Gabaix (2020) shows that forward guidance is less powerful under myopic behaviour and, hence, solves this 'puzzle'.

[20] This finding is primarily driven by investment decisions by firms as they react more sensibly to changes in real rates.

productivity; (2) shocks to goods and labour market adjustments (supply); (3) shocks to the savings rate; (4) shocks to investment risk; (5) monetary policy shocks; (6) fiscal policy shocks.

Figure 4 indicates that fluctuations in US real GDP growth are primarily attributed to domestic demand shocks, specifically shocks related to household saving shocks and changes in investment risk. Compared to the impact of productivity and supply shocks, the influence of these demand disturbances is considerably more significant.[21] Although myopic behaviour introduces some quantitative differences in the shock transmission, as discussed in Section 5.2, the most notable variation lies in the contribution of productivity and supply shocks. In the Myopic model, productivity shocks play a less pivotal role, while supply shocks contribute marginally positively, particularly in the aftermath of the financial crisis (Figure 4). This empirical result suggests that the model-implied TFP trend aligns more closely with observed data under myopic behaviour. Demand and monetary policy shocks, however, remain qualitatively and quantitatively similar across both model versions, with fiscal shocks contributing more negatively during the post-crisis period of 2011-2014.

Analysing the key drivers of historical US inflation in Figure 5, it becomes evident that the two model versions exhibit both qualitative and quantitative differences. Notably, the Myopic model (red) requires lower shock variances to account for the observed pattern in US inflation. This suggests that the model-implied inflation dynamics of the behavioural model is closer to the observed data pattern compared to the RE model, supporting the superior fitting of US inflation by the Myopic model, as discussed in Section 5.1. Figure 5 depicts two striking differences, particularly concerning the supply-side drivers. Firstly, the negative contributions of productivity shocks diminish over time but do not turn into positive territory during the most recent years. Secondly, a substantial portion of the inflation drop during the financial crisis is attributed to supply shocks, in particular negative price markup shocks.[22] This observation can be attributed to the high degree of myopia on the firms' side, particularly for price setters (Phillips curve), who do not fully anticipate the negative shocks and dynamics of the financial crisis. As a consequence, they do not decrease their prices as much as rational firms would, as empirically captured

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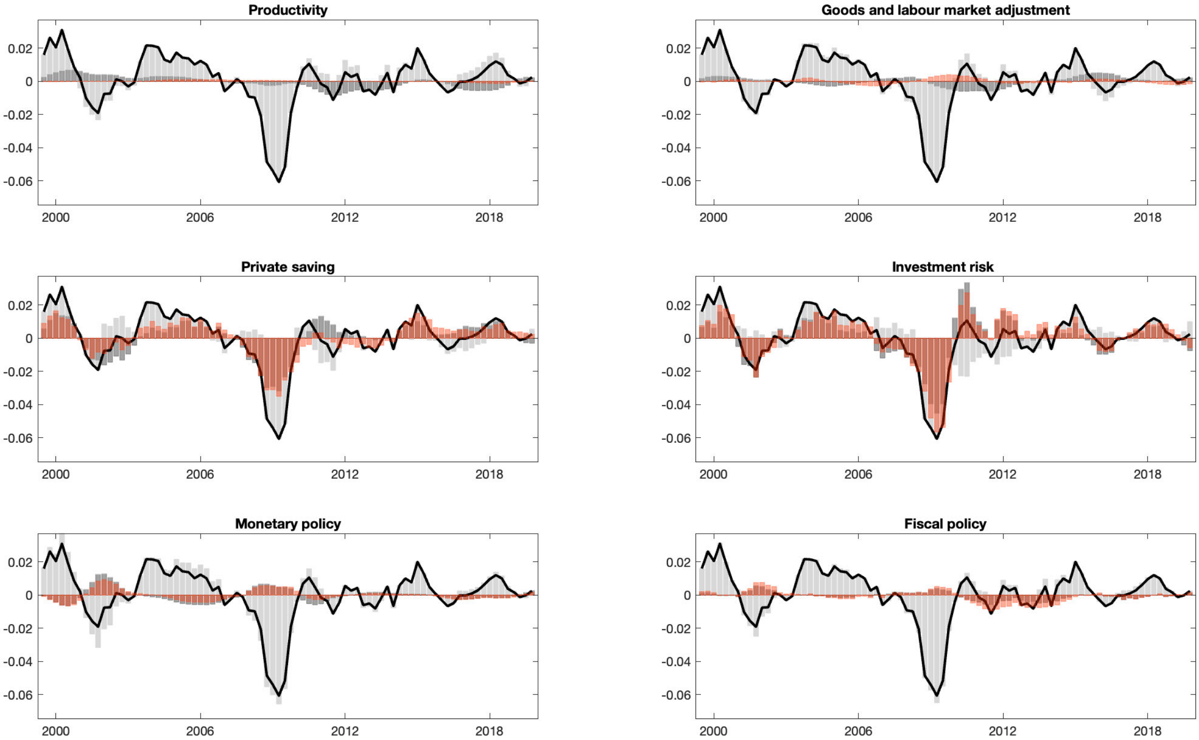
[21] The dominant role of demand shocks in the decomposition of real GDP growth aligns with findings from other estimated DSGE models, as observed in studies such as Smets and Wouters (2007) and Croitorov et al. (2020).

[22] The group of supply shocks shows the aggregate effect of the labour supply, labour demand, and the price markup shock. While labour market shocks still contribute positively during the financial crisis, albeit less strongly than under RE, the price markup shock contributes more negatively to the inflation drop compared to the RE model. This results in an overall negative aggregate effect under myopic behaviour.

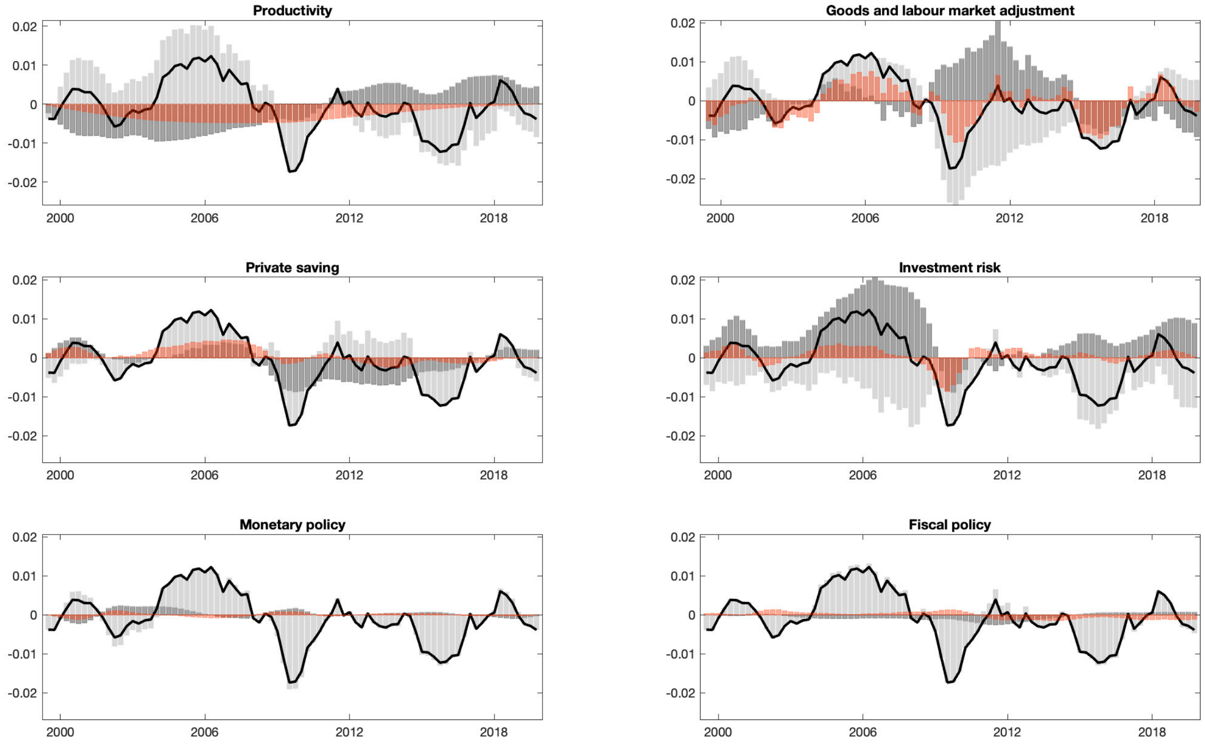


Note: Annual real GDP growth is shown in percentage-point deviations from steady state (2.1%). Dark grey bars depict the decomposition of the RE model, red bars depict the decomposition of the myopic model. 0.01 on the y-axis corresponds to 1 pp.

Figure 4: Historical decomposition of real US GDP growth.

by additional markup shocks. This behaviour is consistent with the economic concept of cognitive discounting, but diverges from existing economic reasoning in the literature (e.g. Kollmann et al., 2016; Hohberger et al., 2023).

The results presented in this section highlight an economic caveat or trade-off associated with cognitive discounting when evaluating its overall macroeconomic implications. On the one hand, the introduction of myopia is favoured by the data and notably enhances the model's fit, particularly in capturing the inflation pattern. On the other hand, the substantial degree of inattention of firms leads to more price markup shocks, which, in turn, contribute significantly to the inflation variations during and after the financial crisis. We delve into this peculiarity in more detail in the next Section 6.



Note: Annual inflation is shown in percentage-point deviations from steady state (2.0%). Dark grey bars depict the decomposition of the RE model, red bars depict the decomposition of the myopic model. 0.01 on the y-axis corresponds to 1 pp.

Figure 5: Historical decomposition of US inflation (GDP deflator).

6 Robustness and evidence of rational price setters

Evidence from survey data suggests that firms' inflation expectations consistently outperform households' beliefs in predicting future inflation, demonstrating a similar forecast performance as the survey of professional forecasters (e.g. Bryan et al., 2014; Meyer et al., 2021; Verbrugge and Zaman, 2021). This observation raises the possibility that the degree of myopic behaviour for price setters, as described by the Phillips curve (Eq. 28), might differ compared to that of households. To explore this, we re-estimate the model, allowing for distinct myopic behaviour in the Phillips curve equation while maintaining a common myopic parameter in the remaining forward-looking optimality conditions. Our findings under this model specification indicate empirical evidence for rational price setters, with an estimated myopic parameter in the Phillips curve close to one.[23] This result

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[23] The remaining posterior parameter estimates remain qualitatively similar with quantitatively robust macroeconomic implications. The data density for this model specification is marginally lower than the one for the Myopic model discussed in Section 5.1. We conducted several additional sensitivity checks but found empirical evidence of more rationality only for the price-setting equation. For brevity, we do

aligns with microeconomic survey data and is economically reasonable, as price-setting decisions are less 'costly' for firms compared to long-term decisions in employment or investment. Rational price setters attribute a smaller role to price markup shocks in explaining inflation variations in the historical decomposition discussed in Section 5.3. Additional robustness and sensitivity checks, such as changing the prior of the cognitive discount factor, estimating different degrees of myopia between households and firms,[24] or modifying the Taylor-type monetary policy rule, do not significantly alter our empirical findings qualitatively or quantitatively.

The empirical result of heterogeneous behaviour among firm decisions is particularly intriguing and calls for further research. While standard NK models, such as those in Gabaix (2020) or Afsar et al. (2024), solely incorporate the Phillips curve as a supply-side component without explicitly modelling longer-term investment or capital decisions, medium- or large-scale DSGE models integrate more structural dynamic mechanisms. This makes them powerful macroeconomic tools for policy analysis compared to standard Vector Autoregressive (VAR) models. Moreover, we perceive the behavioural element of cognitive discounting, as proposed by Gabaix (2020), as a potential mechanism for detecting or addressing misspecifications.[25] Further research is needed to pursue questions such as: What kind of transmission channels could cognitive discounting, as an empirical element of bounded rationality, capture? Is it, for example, a tool to mimic credit-constrained firms or financially-constrained households? Or do we have other dynamic mechanisms and business cycle properties where the RE assumption faces challenges? This paper's objective is not to convince the reader that cognitive discounting is a necessary tool that all macroeconomic models should adopt because it is superior to the full-information RE assumption. Still, it can be seen as an empirical 'tool' for larger-scale macroeconomic models that might be beneficial in improving specific economic dynamics or detecting misspecifications, as it relaxes the *a priori* model-imposed restrictions.

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not include all the results in the paper.

[24] In contrast to Hirose et al. (2023), we find lower estimated cognitive discount parameters for households and firms, which might be due to the tighter prior imposed by the authors.

[25] One approach for detecting misspecifications has been proposed by Den Haan and Drechsel (2021) with the introduction of 'Agnostic Structural Disturbances'. Their approach is ex-ante agnostic but may result in a 'theory-free' alternative to specific structural shocks. An empirical application can be found in Cardani et al. (2022).

7 Conclusions

The assumption of full-information rational expectations (RE) in traditional macroeconomic models is crucial for the effectiveness of policies, relying on the capacity of policymakers to anchor private sector expectations. However, the formation of future expectations is not always rational, or it can be rational in the long term, but agents may not act on them in the short term. Gabaix (2020) proposes a tractable way of introducing behavioural elements in a standard New Keynesian model through an additional cognitive discount factor that measures the degree of (in)attention to the future, or myopia.

We incorporate this approach into an estimated medium-scale macroeconomic DSGE model, taking an agnostic perspective in exploring and evaluating the empirical implications of such an empirical tool of bounded rationality compared to a RE version of the model. Our estimation results on US data suggest (i) a strong preference towards myopic behaviour, (ii) a significant improvement of the Myopic model in fitting the US business cycle pattern and forecast performance, (iii) a more effective fiscal policy due to co-movements of public and private consumption and investment, (iv) co-movements of consumption and investment in case of demand shocks, mimicking the dynamics of risk or uncertainty shocks, (v) less powerful monetary policy due to a de-anchoring of expectations, and (vi) more persistent supply-shocks due to a high-for-longer monetary policy. However, we find empirical evidence of rational price-setting decisions in contrast to employment and investment decisions, matching the evidence from survey data of firms' outperforming inflation expectations.

Our findings offer a first comprehensive evaluation of cognitive discounting as a behavioural element of bounded rationality in a larger-scale macroeconomic DSGE model. However, the message of the paper is not to assert the overall superiority of a behavioural model compared to a full-information RE one. Our empirical finding of rational behaviour when firms are setting prices compared to making investment or employment decisions may already be one example that a careful case-by-case study is needed. It could be seen as a useful empirical 'tool' in detecting model misspecifications because it may soften ex-ante model-imposed restrictions and may help reveal 'theory-free' business cycle dynamics. We highly encourage future research to pursue this direction to better understand what different transmission channels this behavioural tool can capture in the economy.

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A Details on data and econometric approach

A.1 Observed time series

Real GDP
GDP deflator
TFP trend
Hours worked
Nominal wage share to GDP
Nominal short term interest rate
Private consumption to GDP
Total investment to GDP
Government consumption to GDP
Government investment to GDP
Government interest payments to GDP
Government transfers to GDP
Nominal government debt to GDP
Active population rate
Population

Table A.1: List of observables.

A.2 Calibrated shares and long-run targets

Monetary Policy		
Steady state nominal interest rate	$\bar{i}$	0.005
Steady state inflation (annually)	$\bar{\phi}$	0.02
Households		
Preference for government bonds	α^B	0.002
Preference for stocks	α^S	0.011
Intertemporal discount factor	β	0.998
Production		
Cobb-Douglas labour share	α	0.65
Depreciation of private capital stock	δ	0.017
Linear capacity utilisation adj. costs	$\gamma^{u,1}$	0.041
Fiscal policy		
Consumption tax	τ^C	0.20
Corporate profit tax	τ^k	0.20
Labour income tax	τ^n	0.25
Deficit target	def^T	0.036
Debt target	$\bar{BG}$	3.56
Steady state ratios		
Private consumption share	C/Y	0.68
Private investment share	I/Y	0.17
Govt consumption share	G/Y	0.15
Govt investment share	IG/Y	0.04
Closed-economy residual	D/Y	-0.04
Transfers share	T/Y	0.13

Table A.2: Calibrated key parameters

A.3 Posterior estimates

		Prior distribution		Posterior distribution	
		Distr	Mean St.Dev	RE	Myopia
Autocorrelations of forcing variables					
Subjective discount factor	ρ^{UC}	B	0.50	0.82	0.89
			0.20	(0.74, 0.91)	(0.79, 0.97)
Investment risk premium	ρ^{S}	B	0.85	0.91	0.88
			0.04	(0.88, 0.93)	(0.84, 0.93)
Labour demand	ρ^{ND}	B	0.50	0.81	0.74
			0.20	(0.77, 0.87)	(0.63, 0.84)
Government consumption	ρ^{G}	B	0.70	0.97	0.97
			0.10	(0.96, 0.99)	(0.96, 0.98)
Government investment	ρ^{IG}	B	0.70	0.93	0.92
			0.10	(0.90, 0.95)	(0.89, 0.95)
Government transfers	ρ^{T}	B	0.70	0.91	0.91
			0.10	(0.88, 0.96)	(0.88, 0.94)
Lump-sum taxes	ρ^{tax}	B	0.85	0.93	0.94
			0.06	(0.88, 0.97)	(0.90, 0.97)
Residual demand	ρ^{D}	B	0.50	0.94	0.93
			0.20	(0.90, 0.97)	(0.88, 0.96)
Standard deviations (%) of innovations to forcing variables					
Subjective discount factor	ε^{UC}	G	1.00	0.63	1.21
			0.40	(0.31, 1.32)	(0.61, 1.58)
Investment risk premium	ε^{S}	G	0.10	0.78	1.48
			0.04	(0.45, 1.16)	(0.67, 2.28)
Price mark-up	ε^{MUY}	G	2.00	7.11	5.85
			0.80	(6.24, 10.14)	(4.72, 7.67)
Labour demand	ε^{ND}	G	1.00	2.40	2.51
			0.40	(2.09, 2.77)	(2.35, 2.94)
Labour supply	ε^{U}	G	1.00	1.70	1.82
			0.40	(1.54, 2.72)	(1.61, 3.15)
Government consumption	ε^{G}	G	1.00	0.10	0.10
			0.40	(0.09, 0.12)	(0.09, 0.12)
Government investment	ε^{IG}	G	1.00	0.06	0.06
			0.40	(0.05, 0.07)	(0.05, 0.06)
Government transfers	ε^{T}	G	1.00	0.43	0.43
			0.40	(0.38, 0.48)	(0.39, 0.50)
Lump-sum taxes	ε^{tax}	G	1.00	1.13	1.13
			0.40	(1.04, 1.33)	(1.00, 1.27)
Temporary TFP level	ε^{LAY}	G	0.10	0.05	0.05
			0.04	(0.03, 0.09)	(0.03, 0.09)
Monetary policy	ε^{i}	G	1.00	0.11	0.11
			0.40	(0.10, 0.12)	(0.10, 0.12)
Residual demand	ε^{D}	G	0.50	0.32	0.32
			0.20	(0.30, 0.38)	(0.28, 0.36)

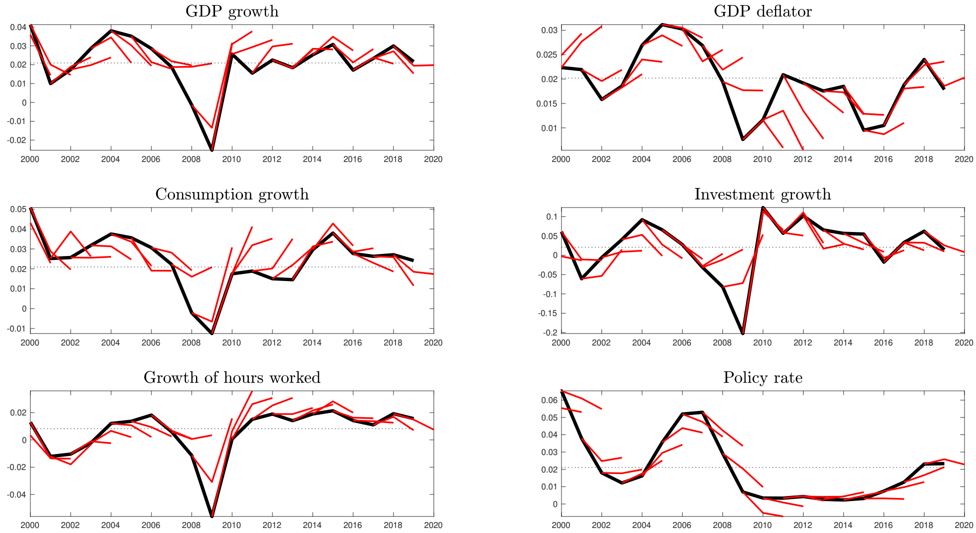
Note: Cols. (1)-(2) list exogenous shocks. Cols. (3)-(4) indicate the prior distribution function (B: Beta; G: Gamma). Identical priors are assumed across model versions. Cols. (5)-(6) show the mode and the 90% HPD intervals of the posterior shock processes.

Table A.3: Estimated shock processes.

B Additional results

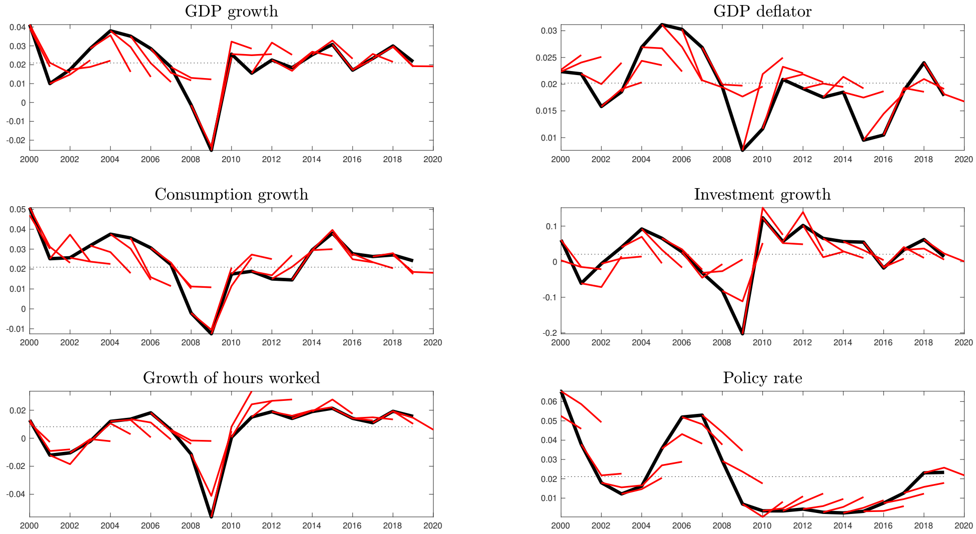
B.1 Model fit

(a) RE model



GDP growth; GDP deflator; Consumption growth; Investment growth; Growth of hours worked; Policy rate

(b) Myopic model



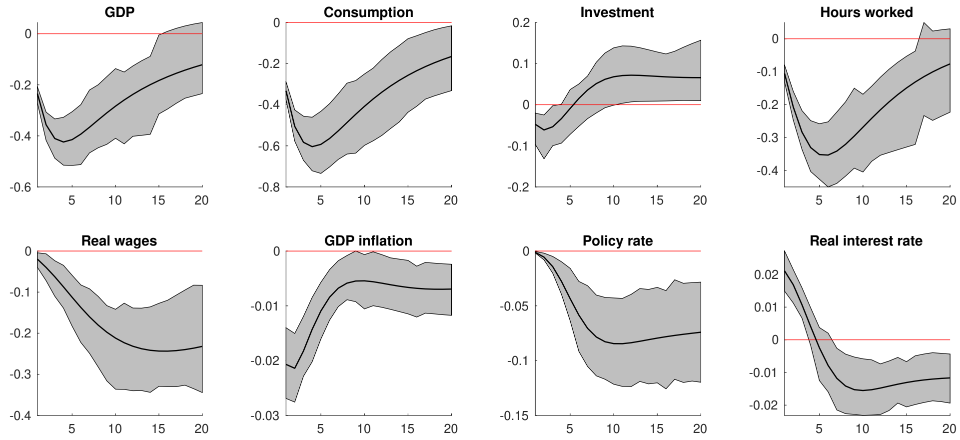
GDP growth; GDP deflator; Consumption growth; Investment growth; Growth of hours worked; Policy rate

Figure B.1: Comparison of the annual fit.

Note: The black solid lines depict the observed annual time series, as deviations from steady state (black dotted lines). The red lines show the unconditional 1-year and 2-year ahead prediction at each point in time.

B.2 Posterior impulse responses

(a) Positive private saving shock


GDP, Consumption, Investment, Hours worked, Real wages, GDP inflation, Policy rate, Real interest rate

(b) Positive government expenditure shock

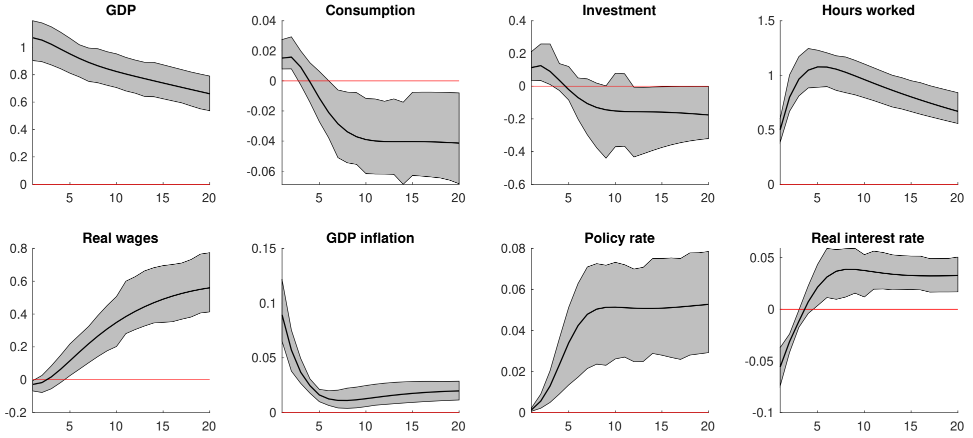
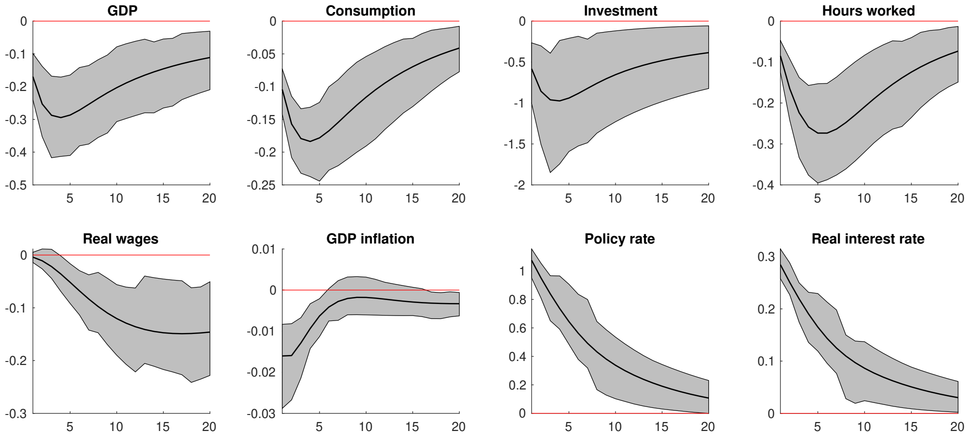

GDP, Consumption, Investment, Hours worked, Real wages, GDP inflation, Policy rate, Real interest rate

Figure B.2: Posterior IRFs I.

Note: Real variables are presented as percentage deviation from steady state, GDP inflation and the policy rate are expressed as percentage-point and annualised percentage-point deviations from steady state. IRFs are plotted with the estimated persistence of the shocks.

(a) Positive shock to the policy rate



(b) Positive cost-push shock

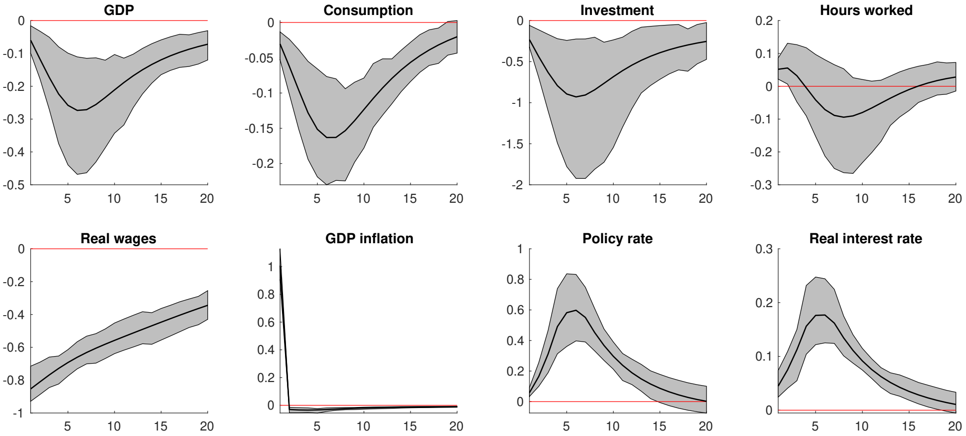


Figure B.3: Posterior IRFs II.

Note: Real variables are presented as percentage deviation from steady state, the price level and the policy rate are expressed as percentage-point and annualised percentage-point deviations from steady state.