LEARNING FROM NEWS

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Abstract

This paper contributes to two strands of business cycle literature –news shocks and bounded rationality– by assessing the empirical importance of total factor productivity (TFP) news shocks while relaxing the rational expectations assumption. We estimate a medium-scale dynamic stochastic general equilibrium (DSGE) model, incorporating financial frictions and TFP news shocks, under two different expectation formation mechanisms: rational expectations (RE) and adaptive learning (AL). The results suggest that AL amplifies the effects of financial market frictions, leading to three key findings. First, AL improves the model's fit, as shown in the related literature, and better replicates the volatility of several aggregate variables. Second, the AL amplification results in a deflationary response and a more persistent reaction of lending spreads to TFP news shocks. Third, AL increases the importance of pure news shocks (i.e. purely anticipated shocks), amplifying their effects through both expectation and credit channels. Finally, we show that the dynamics generated by the DSGE model under AL align more closely with empirical vector autoregression evidence than those produced by the RE version of the DSGE model.

Keywords: news shocks, bounded rationality, financial frictions.

JEL classification: E30, E32, E44.

Resumen

Este artículo contribuye a dos líneas de la literatura sobre ciclos económicos —los *shocks* de noticias y la racionalidad limitada— mediante la evaluación de la importancia empírica de los *shocks* de noticias sobre la productividad total de los factores (TFP, por sus siglas en inglés), relajando la hipótesis de expectativas racionales. Estimamos un modelo DSGE de escala media, que incorpora fricciones financieras y *shocks* de noticias sobre la TFP, bajo dos mecanismos distintos de formación de expectativas: expectativas racionales (RE) y aprendizaje adaptativo (AL). Los resultados sugieren que el AL amplifica los efectos de las fricciones en los mercados financieros, lo que conduce a tres hallazgos clave. En primer lugar, el AL mejora el ajuste del modelo, como se ha mostrado en la literatura relacionada, y replica mejor la volatilidad de diversas variables agregadas. En segundo lugar, la amplificación del AL da lugar a una respuesta deflacionaria y a una reacción más persistente de los diferenciales de crédito ante *shocks* de noticias sobre la TFP. En tercer lugar, el AL incrementa la importancia de los *shocks* de noticias puros (es decir, *shocks* puramente anticipados), amplificando sus efectos tanto a través del canal de expectativas como del canal crediticio. Finalmente, mostramos que la dinámica generada por el modelo DSGE bajo el AL se alinea más estrechamente con la evidencia empírica de modelos VAR que la versión del modelo DSGE con expectativas racionales.

Palabras clave: *shocks* de noticias, racionalidad limitada, rigideces financieras.

Códigos JEL: E30, E32, E44.

1 Introduction

There is a long tradition in macroeconomics (e.g. Pigou, 1927) of viewing agents' expectations as a key factor in explaining macroeconomic fluctuations. Changes in expectations, whether due to news about fundamentals or misperceptions and misinformation, are often considered major sources of aggregate fluctuations. In particular, there is a strand of this literature (Beaudry and Portier (2004)) that examines the empirical importance of TFP news shocks as a key driver of the business cycle. Alongside, there is a large literature on adaptive learning (AL) (e.g. Evans and Honkapohja (1999), Eusepi and Preston (2011)), which explores the consequences of deviating from rational expectations (RE). While the AL and news shock strands of literature are closely linked, as both emphasize the role of expectations in shaping aggregate fluctuations, they have been developed independently from each other.[1]

This paper is the first to explicitly combine TFP news shocks and adaptive learning in a DSGE framework. We analyze how TFP news shocks and AL interact and whether the role of TFP news shocks in the business cycle is affected by how agents form their expectations. Therefore, this paper offers a comprehensive approach to assessing Pigou's theory of the business cycle by combining expectation shifts caused by anticipated (news) shocks and a standard form of bounded rationality.

The closest related works in the area of news shocks are Görtz, Tsoukalas, and Zanetti (2022) and Herrera and Vázquez (2023), as they highlight the importance of financial frictions in the transmission of such shocks. This mechanism is further strengthened under adaptive learning in our framework. In the area of bounded rationality, Cole (2021) analyzes the implications of adaptive learning for the transmission of forward guidance monetary policy. The context of our paper in the literature is discussed further below.

News shocks

In a seminal paper Beaudry and Portier (2004) suggest a modeling approach for Pigou's theory of the business cycle, which suggests that TFP (anticipated) news shocks are a major source of business cycles. Since then, the literature has conducted extensive theoretical and empirical assessments on the importance of so-called news shocks.

More recently, Görtz and Tsoukalas (2017) highlight the importance of considering a financial sector (such as the one suggested in Gertler and Kiyotaki (2010), and Gertler and Karadi (2011); from now on GK) in a DSGE framework for assessing the role of TFP news shocks.[2] Moreover,

[1]Interestingly, these two strands of literature (see Beaudry and Portier (2004), Eusepi and Preston (2011), and Milani (2011), among others) are strongly motivated by insights from Pigou (1927)

[2]Moran and Queralto (2018) and Queralto (2020) uncover a close link between TFP and financial shocks. These papers emphasize demand-driven factors determining medium-term dynamics in TFP and show that financial shocks

Görtz, Tsoukalas, and Zanetti (2022) use VAR methods to show that TFP news is closely connected with lending spread indicators and that the dynamics of financial variables are decisive for the amplification of TFP news shocks. In sum, recent literature suggests that financial markets are crucial in determining the transmission mechanism of expected future events and, thus, in assessing the empirical importance of TFP news shocks.

Bounded rationality matters in the propagation of news shocks

The effects of (news) shocks on the economy are hard to predict in reality. Policy makers, economic pundits, and economic agents in general have limited knowledge about the economic effects of news shocks regarding the impact of a new technology, a pandemic-fighting vaccine, an armed conflict, a labor strike, a legislation change in the regulation of a specific market (e.g. a specific policy to reform the labor market), etc. In this scenario, agents have to learn the effects of news shocks. This learning process affects agents' decisions through the expectation channel, thereby shaping the transmission mechanism of news shocks.

This paper deviates from the RE hypothesis in assessing the role of TFP news shocks as a source of business cycles. RE is a strong assumption, and one that may have deeper implications when news shocks are analyzed in a framework that includes further financial markets for several reasons. Financial frictions play an important role in both the transmission mechanism of TFP news shocks (Görtz and Tsoukalas (2017); Görtz, Tsoukalas, and Zanetti (2022); Herrera and Vázquez (2023)). Moreover, the high flexibility of financial markets in incorporating information about future expected events is in sharp contrast to the sluggish/persistent behavior of real macro variables. This high flexibility also means that financial markets may often overreact to news in reality. This may be viewed by some as a major deviation from the RE assumption (see, for instance, Shiller (2016), Barberis and Thaler (2003), and references therein). In particular, the AL assumption considered in this paper introduces a different mechanism for financial markets to overreact to news. Finally, previous studies suggest that RE-DSGE models are misspecified in expectation formation, and different approaches to characterize deviations from RE improve the data fit (among others, Slobodyan and Wouters (2012), Levine et al. (2012), Blanchard, L'Huillier, and Lorenzoni (2013), Leeper, Walker, and Yang (2013), Cole and Milani (2019), Elias (2022)). Then, it is important to assess the role of news shocks in a better-specified expectation channel.

Our approach

We introduce bounded rationality by assuming that agents have a somewhat limited knowledge

impact business innovation activities and thus future TFP.

about the underlying model: They observe the minimum set of state variables as under RE, which includes the exogenous shocks that hit the economy, but they *do not* know the structural parameter values and, consequently, they have to learn the reduced-form coefficients—featuring the equilibrium mapping between state and endogenous variables— over time through a constant-gain AL process.

This is in sharp contrast with the theoretical literature on news shocks, which assumes RE and overlooks the possibility that agents may misperceive the effects of news shocks. Under RE, agents have full knowledge of the underlying model, the values of the structural parameters, and the minimum set of state variables. They fully understand the equilibrium mapping between all state variables (including news shocks) and the endogenous variables.

Although the bounded rationality approach considered in this article involves a rather minor departure from RE, as discussed below, many other forms of bounded rationality have been proposed in the related literature. For example, the Euler equation approach to AL based on small forecasting models (see, among others, Milani (2007); Slobodyan and Wouters (2012); Vázquez and Aguilar (2021); Cone (2022); Elias (2022) and references therein) considers larger departures from RE where agents do not know what the state variables are and, in addition, may not observe many of them (for example, the exogenous news shocks that hit the aggregate economy). Another influential AL approach, suggested by Bruce Preston, focuses on long-sighted agents (e.g. Preston (2005); Eusepi and Preston (2011)), as in RE, who consider the infinite-horizon forecasts associated with their intertemporal decision problem. In addition to AL approaches to bounded rationality, other departures from RE have been considered in the literature. For example, De Grauwe (2012) and De Grauwe and Ji (2019) propose another departure from RE in the form of reinforcement learning of various simple rule-of-thumb expectation rules using the seminal work of Brock and Hommes (1997). Gabaix (2020) has proposed a more recent approach to bounded rationality based on myopia, in which the more distant future is discounted more heavily.[3] Unlike other approaches to bounded rationality, the AL approach followed here allows us to focus on the effects of news shocks when these shocks are perfectly observed, as in the RE framework, but agents have to learn about how these shocks are transmitted to the aggregate variables.[4]

We consider a standard (medium-scale) New-Keynesian DSGE model with financial frictions à la GK. We estimate two alternative model specifications under two expectation hypotheses (RE and AL) with Bayesian techniques and using recent US macro and financial data. This approach

[3]For a recent comprehensive survey of different approaches to bounded rationality, see Jump and Levine (2019).

[4]Therefore, our approach deliberately leaves aside issues such as rational inattention (C. A. Sims (2003), Mackowiak and Wiederholt (2009)) in the processing of news information, or, alternatively, noisy rather than perfectly observed news, in which agents receive a signal that they use to decompose true information from noise, e.g. through a Bayesian updating process. The analysis of these questions is of course very interesting, but it is beyond the scope of this article.

is convenient because the forward-looking behavior of financial intermediaries in determining credit supply and lending rates helps to provide a solid identification strategy for TFP news shocks as emphasized by Görtz and Tsoukalas (2017) and Görtz, Tsoukalas, and Zanetti (2022), among others.[5]

Main findings

We find that AL improves model performance in two key ways. First, the DSGE model under AL shows a better overall fit in terms of marginal data density in line with findings in the related literature (e.g. Milani (2007), Slobodyan and Wouters (2012), Rychalovska (2016)). Second, it better replicates the volatility of aggregate variables. This improvement is largely due to the effect of TFP news shocks on financial variable expectations. In fact, the transmission of news shocks has a more persistent effect on the credit channel when RE is replaced by AL. The reaction of the lending spread to TFP news is larger and more persistent under AL. Additionally, we find that TFP news shocks behave as supply shocks under AL (i.e. they induce a negative comovement between output and inflation) whenever financial frictions and AL combine to induce a strong amplification mechanism through both the credit and expectations channels. In contrast, TFP news shocks always act as demand shocks under RE within the DSGE framework considered. Notably, evidence of a deflationary response of inflation to TFP news shocks, recently found in empirical models (e.g., Görtz, Tsoukalas, and Zanetti (2022) in VAR models and Forni, Gambetti, and Sala (2014) in factor-augmented VAR frameworks), is more difficult to reproduce in DSGE models.[6]

We also find that the importance of pure news shocks, as defined by E. Sims (2016), increases under AL. Pure news shocks, which represent the effects of anticipated but not yet realized shocks, are critical in assessing the role of news shocks because their impact on aggregate variables occurs through expectations alone. Finally, we show that the effects of news shocks on both macroeconomic and financial variables in an AL-DSGE model align more closely with those from an empirical

[5]The appendix reports the log marginal data density statistics for alternative specifications in which news are placed on different shocks. These show that the most preferred specification involves non-stationary TFP news shocks. Moreover, many studies on news shocks focus on TFP news shocks (e.g. Beaudry and Portier (2006); Barsky and Sims (2011); Fujiwara, Hirose, and Shintani (2011); Forni, Gambetti, and Sala (2014); Görtz, Tsoukalas, and Zanetti (2022)). Limiting our focus on TFP news allows further for a more straightforward comparison with previous findings and focuses the discussion on the differences arising from the two alternative expectation hypotheses. Also, caution is advised in considering a large number of different news shocks without including additional observables because it may affect their identification.

[6]This deflationary response to news shocks is also found in DSGE models under RE, where the effects of news shocks are amplified by the financial sector in one way or another. For example, Görtz, Tsoukalas, and Zanetti (2022) amplifies TFP news shock effects by including an investment sector tied to financial intermediaries in their two-sector DSGE model. Herrera and Vázquez (2023) adds a quality-of-capital news shock, which amplifies financial market impacts similar to those of TFP news shocks.

Bayesian VAR than with the RE version of the model.

The rest of the paper is structured as follows: Section 2 describes the DSGE model with financial frictions. Section 3 outlines the data and calibrated parameters. Section 4 discusses the estimation results, highlighting the transmission mechanisms under RE and AL, and assesses the relative importance of pure and realized news shocks. Section 5 concludes.

2 The model

This paper considers a medium-scale DSGE model with several sources of rigidity, closely following the New-Keynesian DSGE model suggested by Smets and Wouters (2007), and augmented with financial frictions à la GK. The model incorporates a non-stationary stochastic balanced growth path driven by TFP shocks. Alternative versions of this model have been widely used in recent macro-finance literature (see, among others, Villa (2016); Gelain and Ilbas (2017)).

This section outlines the key features of the model, focusing on the aspects necessary to address the main objectives of the paper.[7] On the demand side, households choose consumption, hours worked, and hold riskless assets such as bank deposits and government bonds. The supply side is characterized by a standard Cobb-Douglas production function that uses labor services and effective capital as inputs. Prices and wages are assumed to be sticky, modeled following Calvo (1983).

The DSGE model incorporates financial frictions through a banking sector where banks lend household deposits and their own equity to non-financial firms (capital-good producers). Banks act as intermediaries, channeling funds from household deposits to investors. However, without constraints, banks would expand their assets indefinitely by borrowing from households, as they face a positive discounted risk premium. To limit this, a moral hazard problem is introduced: banks may choose to divert a fraction of their assets and transfer them to the households to which they belong. The cost of diverting assets is bankruptcy, allowing depositors to recover a fraction of the remaining assets. Households, therefore, only deposit savings up to the point where the banks' gain from diverting assets equals their gain from abstaining. This incentive constraint introduces a credit supply friction, which depends on banks' future expected profitability. Since their ability to secure deposits depends on their incentives to remain solvent, the model's forward-looking financial sector is crucial for analyzing the effects of different expectation hypotheses.

The rest of the section incorporates TFP (news) shocks into the DSGE model, describes the financial channels through which these shocks are amplified, and explains the expectation formation process under AL.

[7] A more comprehensive description of the model is provided in a supplementary appendix.

Production channel

As is standard in the literature, we assume that intermediate goods firms produce according to a Cobb-Douglas production function, using capital and labor as endogenous inputs. This production function is affected by a TFP shock with two components: one stationary and one non-stationary. News shocks are assumed to arise from the non-stationary component. Formally, the production function is as follows:

$$Y_t = A_t \left(K_{t-1} u_t\right)^{\alpha} \left(L_t\right)^{1-\alpha} - \Psi_t \phi_p, \tag{1}$$

where $A_t = \epsilon_t^a \Psi_t$, ϵ_t^a is the stationary TFP shock, Ψ_t is the non-stationary TFP shock, and its growth rate is denoted by $\psi_t = ln\left(\frac{\Psi_t}{\Psi_{t-1}}\right)$. K_{t-1} denotes capital stock, u_t is the capital utilization rate, and ϕ_p is the share of fixed costs involved in production.

Financial channel

A fixed fraction of households consists of bankers who do not supply labor but act as financial intermediaries. These bankers face a survival probability, θ, and to keep their proportion constant, additional households become bankers each period. As described earlier, these financial intermediaries finance the acquisition of physical capital by purchasing claims S_t, which are funded through household liabilities. The balance sheet of financial intermediaries is represented as:

$$Q_t S_t = N_t + B_{t+1},$$

where Q_t is the price of capital (assets), N_t is the net worth of the bankers, and B_{t+1} represents household deposit liabilities in banks. The return on financial claims is R_{t+1}^k, and the cost of liabilities is R_t. Thus, the law of motion for the intermediaries' net worth is:

$$N_{t+1} = R_{t+1}^k Q_t S_t - R_t B_{t+1} = \left(R_{t+1}^k - R_t\right) Q_t S_t + R_t N_t.$$

Let $\beta \Lambda_{t+1}$ represent the stochastic discount factor for financial intermediaries. Bankers' decisions are endogenously determined by solving the following problem, in which they maximize their future expected terminal wealth:

$$V_t = \max\ E_t \sum_{i=0}^{\infty} (1-\theta)\,\theta^i \beta^i \Lambda_{t+1+i} N_{t+1+i} =$$

$$\max\ E_t \sum_{i=0}^{\infty} (1-\theta)\,\theta^i \beta^i \Lambda_{t+1+i} \left[\left(R_{t+1+i}^k - R_{t+i}\right) Q_{t+i} S_{t+i} + R_{t+i} N_{t+i}\right].$$

However, a moral hazard issue arises because $\beta^i \left(R_{t+1+i}^k - R_{t+i}\right) \geq 0$, implying that bankers would always have an incentive to borrow indefinitely from households. To limit this, an enforcement cost is introduced: bankers can divert a proportion λ of available funds at the start of the period, but depositors would recover $(1-\lambda)$ of the assets. Therefore, for lenders to be willing to supply funds, the following incentive constraint must hold:

$$V_t \geq \lambda Q_t S_t.$$

The gain from not diverting assets, V_t, can be expressed as:

$$V_t = \nu_t Q_t S_t + \eta_t N_t,$$

where:

$$\nu_t = E_t \left[(1-\theta) \Lambda_{t+1} \left(R_{t+1}^k - R_t \right) + \beta\theta x_{t,t+1} \nu_{t+1} \right],$$

$$\eta_t = E_t \left[(1-\theta) \Lambda_{t+1} R_t + \beta\theta z_{t,t+1} \eta_{t+1} \right].$$

Here, ν_t represents the expected marginal gain from expanding assets with net worth held constant, and η_t represents the expected value of an additional unit of net worth with assets held constant. $x_{t,t+i} = Q_{t+i}S_{t+i}/Q_tS_t$ is the gross growth rate of assets, and $z_{t,t+i} = N_{t+i}/N_t$ is the gross growth rate of net worth.

In equilibrium, the incentive constraint holds with equality:

$$Q_t S_t = \frac{\eta_t}{\lambda - \nu_t} N_t = \phi_t N_t,$$

where ϕ_t is the bankers' leverage ratio.

The leverage ratio, and consequently the capital price Q_t, depends on the forward-looking variables ν_t and η_t, which are determined by the expected future stream of excess returns on financial claims:

$$(1-\theta) \sum_{i=0}^{\infty} E_t \left[(\beta\theta)^i x_{t,t+i} \Lambda_{t+1+i} \left(R_{t+1+i}^k - R_{t+i} \right) \right],$$

and the expected future cost of liabilities:

$$(1-\theta) \sum_{i=0}^{\infty} E_t \left[(\beta\theta)^i z_{t,t+i} \Lambda_{t+1+i} R_{t+i} \right].$$

This implies that TFP news shocks affect financial expectations, leading to a distinctive transmission mechanism through the credit channel, alongside the standard transmission via the production function.

The law of motion for net worth is then rewritten as:

$$N_{t+1} = \left[\left(R_{t+1}^k - R_t \right) \phi_t + R_t \right] N_t.$$

Thus, the gross growth rates of assets and net worth are:

$$z_{t,t+1} = \frac{N_{t+1}}{N_t} = \left(R_{t+1}^k - R_t \right) \phi_t + R_t,$$

and

$$x_{t,t+1} = \frac{Q_{t+1}S_{t+1}}{Q_t S_t} = \frac{\phi_{t+1}}{\phi_t} z_{t,t+1}.$$

Finally, the law of motion for bankers' net worth is the sum of the net worth of surviving bankers and the net worth of new bankers:

$$N_t = N_t^s + N_t^n,$$

where:

$$N_t^s = \theta\left[\left(R_{t+1}^k - R_t\right)\phi_t + R_t\right] N_{t-1},$$

$$N_t^n = \omega \epsilon_t^{nw} Q_t S_{t-1},$$

with ω representing the fraction of assets households transfer to new bankers, and ϵ_t^{nw} capturing exogenous variations in the net worth of bankers.

In this model, the leverage of financial intermediaries is determined by their expectations of future profits. Since news shocks directly affect these expectations by anticipating changes in TFP, they have a direct impact on current financial conditions. The TFP news shock affects banks' expected future profitability, causing them to adjust their leverage in advance and thus triggering fluctuations in firms' borrowing costs.[8]

Expectation formation

The decisions of economic agents depend on their expectations about future (aggregate) macroeconomic variables. News shocks literature typically assumes that such expectations are formed according to the RE hypothesis. Here, we relax the strong informational assumptions imposed by RE and assume that agents form expectations using a perceived law of motion (PLM) of the economy, which is assumed to include the same state variables that appear in the minimum state variable solution of the system under RE. Thus, the departure from RE relies solely on agents' lacking knowledge about the reduced-form model coefficients (Marcet and Sargent (1989); Evans and Honkapohja (1999); Milani (2007)). Consequently, economic agents use historical filtered variables and news to infer unknown coefficients over time. They do so by estimating the following PLM:

$$\Gamma_t = a_t + b_t \Omega_t + c_t \varsigma_t^{TFP} + d_t \varsigma_t + \epsilon_t,$$

[8]The financial sector specification used in this paper follows the standard approach in the news shock literature to ensure consistency with previous studies. However, a more realistic framework could consider the endogenous creation of deposits by banks when they issue loans, as explored in Jakab and Kumhof (2015). We leave this extension to future research.

(2)

where $\mathit{\Gamma}_t$ is a vector containing the set of forward-looking variables of the model at time t, $\mathit{\Omega}_t$ is a vector containing the set of endogenous pre-determined state variables, ς_t^{TFP} is a vector including TFP (unanticipated and news) shocks,[9] and ς_t includes all other unanticipated shocks, a_t, b_t, c_t and d_t are conformable matrices of learning coefficients. As mentioned above, agents receive news at time $t-k$ about a shock that materializes at time t. Therefore, the news shock may affect the economy from time $t-k$ on. The matrix of coefficients c_t includes the time-varying belief parameters that show how news shocks shape agents' expectations over time. For instance, assume a 1% shock to TFP anticipated 8 quarters in advance. Economic agents know that this shock is going to be realized at time t (unless revisions occur through the standard mechanism described in equation (12) below) but can only infer its true effect on the economy through the learning process.

We assume that agents update their beliefs (i.e. the coefficients in matrices a_t, b_t, c_t and d_t) following a constant-gain recursive least square scheme:

$$\Phi_t = \Phi_{t-1} + gR_t^{-1}Z_{t-1}\left(\Gamma_t - \Phi_{t-1}^T Z_{t-1}\right)^T,$$

$$R_t = R_{t-1} + g\left(Z_{t-1}Z_{t-1}^T - R_{t-1}\right),$$

where $\Phi_t = \{a_t, b_t, c_t, d_t\}$ is a matrix containing all belief coefficients and Z_t is a matrix of regressors that includes the minimum set of state variables (i.e. an intercept, all the endogenous state variables, $\mathit{\Omega}_t$, and both unanticipated and news shocks).[10] As pointed out by Eusepi and Preston (2011), an advantage of this learning scheme is that departure from RE is determined by a single parameter (i.e. the constant gain parameter). Moreover, Eusepi and Preston (2011) suggest a Kalman filter interpretation of this learning process in their online appendix.

[9]As in RE state-space representation, variables lagged by more than one period are included in the state-space form by using auxiliary variables (i.e. x_{t-2} is represented by ax_t^2, being $ax_t^0 = ax_{t-1}^1$; $ax_t^1 = ax_{t-1}^2$ and $ax_t^2 = x_{t-2}$). In our case, we consider 8 auxiliary variables since we assume that they are anticipated by up to 8 periods. All those auxiliary variables are contained in the vector ς_t^{TFP} as in Cole (2021).

[10]Notice that the RE equilibrium mapping does not contain an intercept, but it captures the uncertainty about the balanced-growth path under AL.

3 Data and estimation

We estimate the model using Bayesian techniques, considering a dataset with U.S. data for nine macroeconomic variables: output growth, consumption growth, investment growth, wage growth, hours worked, inflation, the nominal interest rate, the GZ spread as suggested by Gilchrist and Zakrajšek (2012), and the growth rate of banks' net worth. The set of observables is the same as in Smets and Wouters (2007), with the addition of the GZ spread and banks' net worth, which aim to provide information about financial market dynamics.[11] The GZ spread is regarded in the related literature as a reasonable proxy for the corporate bond premium, as Gilchrist and Zakrajšek (2012) show that this spread is closely related to measures of financial distress and has predictive power for future GDP, which might help identify news shocks. Moreover, since the sample period for the estimation includes the Great Recession, which began around 2008, we replaced the values of the federal funds rate that hit the zero lower bound with the shadow rate constructed by Wu and Xia (2016) to deal with the zero-lower-bound issue that affects the economy. The shadow rate is the same as the federal funds rate when the zero-lower-bound is not binding, but it becomes negative to account for unconventional policy tools implemented when the federal funds rate is close to the zero lower bound (roughly from 2009:1 to 2015:4).[12] The sample covers the period from 1987Q1 to 2018Q4, with the starting quarter determined by data availability for all time series included in the empirical analysis. All time series used in the estimation procedure are transformed into (log) deviations from their respective means, making the measurement equations straightforward.[13] We also consider a 16-quarter presample to mitigate the effects of estimated news shocks assumed to be observed before the sample period begins.

We estimate a subset of parameters for the two expectation hypotheses using Bayesian techniques. The remaining parameters are calibrated. We perform the Iskrev (2010) identification test to check if all the estimated parameters are identified given the considered information set. Figure 1 shows

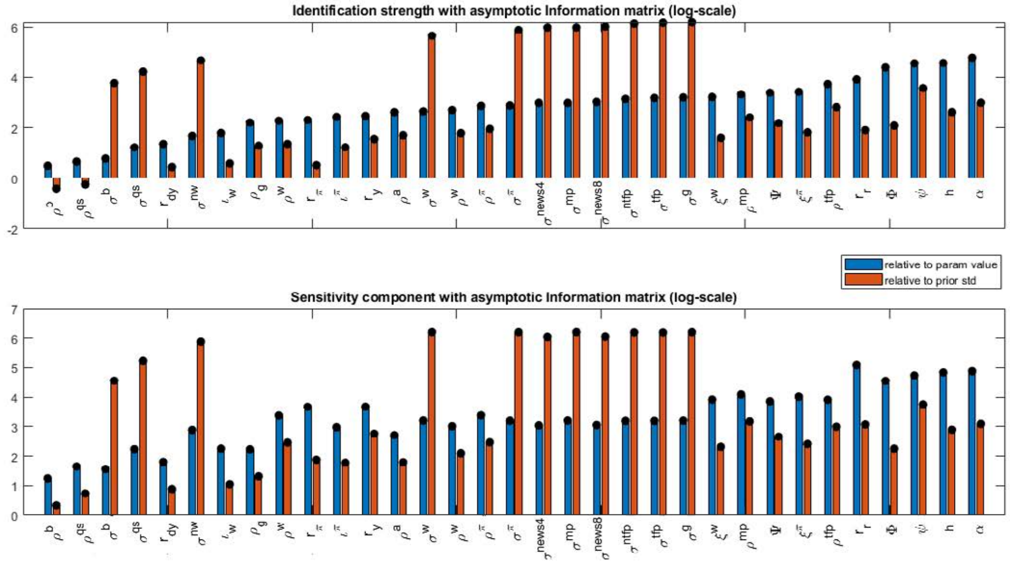
[11] The net worth observable is the total equity capital for U.S. commercial banks as considered in Görtz and Tsoukalas (2017). The GZ spread is also included in the set of observables considered by Gelain and Ilbas (2017) and Görtz, Tsoukalas, and Zanetti (2022), among others.

[12] Recent studies, such as Wu and Zhang (2019) and Aguirre and Vázquez (2020), use the shadow rate instead of the federal funds rate in the estimation of DSGE models to deal with the zero-lower bound issue.

[13] As advocated by many papers in the related literature (e.g., Del Negro et al. (2007), Christiano, Motto, and Rostagno (2014), Görtz and Tsoukalas (2017), Görtz, Tsoukalas, and Zanetti (2022)), we remove sample means from the data to prevent the model's counterfactual implications at low frequencies from distorting inferences on business cycle dynamics. For instance, in our sample, consumption grew faster than GDP on average, while our model features a balanced growth path that implies a common long-run growth rate for both consumption and GDP. As emphasized by Görtz, Tsoukalas, and Zanetti (2022), imposing a counterfactual common long-run growth rate on the two series may distort inferences on the business cycle dynamics that are crucial to our analysis.

that all the estimated parameters are identified. The rest of the parameters are calibrated as follows. Specifically, the discount factor β is set at 0.99, which implies a quarterly real interest rate of one percent. Both wage and price markups are assumed to be 0.2. The quarterly depreciation rate is set at 0.025, and the share of government spending is assumed to be 0.2. The parameters related to the financial sector –such as the bankers' survival rate, the steady-state fraction of funds given to new bankers, and the fraction of funds bankers can divert– are calibrated to match an (annualized) lending spread of 200 basis points and a leverage ratio of 5.47, as observed in the sample period considered. The bankers' survival rate parameter, θ, is fixed at 0.96, following Görtz and Tsoukalas (2017), which analyzes a similar sample period that includes the Great Recession.

Figure 1: Identification test



4 Estimation results

This section presents and analyzes the estimation results from the Bayesian estimation of the medium-scale DSGE model under the two alternative expectation hypotheses considered. We focus on three key aspects: the model fit, the transmission mechanisms of the news shocks, and the empirical relevance of these shocks as driving forces of the business cycle.

4.1 Model fit

In this section, we analyze the differences in model fit when AL is used instead of RE. Table 1 presents several alternative measures of model fit. The upper panel of Table 1 displays the (log) marginal data density (MDD) for each expectation hypothesis.[14] The AL specification clearly outperforms the RE specification by approximately 21 points. This significant improvement in model fit not only highlights the substantial differences between the two specifications but also suggests that AL offers a more accurate framework for assessing the role of news shocks in DSGE models.

The bottom-left panel of Table 1 presents the RMSE statistics relative to the actual data for each expectation hypothesis (i.e., these statistics are computed based on the differences between the one-step-ahead forecasts and the corresponding actual data). While the MDD statistic provides an overall measure of model fit under both expectation hypotheses, the RMSE statistics help us determine for which specific observable variables the model fit improves under AL. These RMSE results show that the AL model performs better for most observable variables, particularly for consumption growth and hours worked. To evaluate business cycle dynamics under both expectation hypotheses, the bottom-right panel of Table 1 shows the actual and model-implied volatilities for each observable variable. Consistent with the actual data, the AL specification results in a less volatile business cycle than the RE model.[15]

In summary, our empirical results clearly indicate that introducing bounded rationality through AL enhances model fit across several important dimensions.

[14]The *marginal data density* represents the likelihood of observing the data under a particular model, integrating out all model parameters. It is expressed as the integral of the likelihood function multiplied by the prior distribution of the model parameters:

$$p(y) = \int p(y \mid \theta) p(\theta)\, d\theta$$

where $p(y)$ is the marginal likelihood (marginal data density), $p(y \mid \theta)$ is the likelihood of the data given the model parameters θ, and $p(\theta)$ is the prior distribution of the model parameters. This statistic is commonly used in the literature to evaluate how well different models fit the observed data, with higher values indicating a better fit.

[15]Despite the better fit provided by AL in many dimensions, the model clearly performs poorly in reproducing the volatility of the net worth growth rate under both expectations hypotheses. This is further corroborated by the RMSE statistics, which show that the model has difficulty fitting this observable variable under both expectation hypotheses.

Table 1: Model fit

	RE	AL			
MDD	-856.37	-837.35			
	RMSE		Standard deviation		
	RE	AL	Actual	RE	AL
Output growth	0.46	0.43	0.59	0.80	0.69
Consumption growth	0.36	0.27	0.55	0.72	0.64
Investment growth	0.85	0.84	1.86	3.20	2.94
Hours	0.34	0.28	4.44	2.53	2.29
Wage growth	0.90	0.88	0.90	0.98	0.93
Inflation	0.15	0.15	0.21	0.24	0.24
Spread	0.13	0.12	0.26	0.41	0.38
Interest rate	0.07	0.06	0.68	0.33	0.28
Net worth growth	1.96	2.52	1.57	7.73	6.57

Notes: The marginal data density is computed using Geweke (1999) modified harmonic mean method. The computations are based on a Monte Carlo Markov chain of length 2,4 millions draws for each model and discard the first 20% of the draws.

4.2 Parameter estimates

This section discusses the estimates of structural parameters and shock process parameters, including those that characterize TFP news shock processes. Interestingly, Tables 2-3 show that the estimation results are rather robust across the two alternative expectation hypotheses. Indeed, the highest posterior density intervals associated with the estimated parameters under the two expectation assumptions largely overlap. The only striking difference appears for the two parameters associated with the (unanticipated) net-worth shock shown in Table 3. Thus, the persistence parameter of this shock is high under AL and close to zero under RE, while the opposite occurs for the estimated standard deviation of this shock. The constant gain learning parameter points to the importance of the beliefs' updating in the AL process. The posterior mean estimate of this parameter is 0.016, which lies a bit below from the middle range of estimates (0.01 0.05) found in the related literature surveyed by Evans and McGough (2020).

These robust estimates, together with the different transmission mechanisms of TFP news shocks resulting from the two expectation hypotheses as discussed below in Section 4.3, underline the importance of belief formation in the transmission of news shocks.

Table 2: Structural and policy parameter estimates

Parameter	Prior distribution		Posterior Mean	
	Type	Mean/Std	RE	AL
Structural parameters				
Investment adjustment cost	Normal	4/1.5	1.87 [0.92,2.81]	1.71 [1.13, 2.42]
Habit formation	Normal	0.7/0.1	0.62 [0.50,0.75]	0.59 [0.52,0.66]
Calvo probability for wages	Beta	0.5/0.1	0.81 [0.76,0.89]	0.82 [0.78,0.87]
Calvo probability for prices	Beta	0.5/0.1	0.94 [0.93,0.95]	0.949 [0.94,0.95]
Indexation of past inflation in wages	Beta	0.5/0.15	0.39 [0.16,0.61]	0.26 [0.09,0.44]
Indexation of past inflation in inflation	Beta	0.5/0.15	0.19 [0.07,0.31]	0.18 [0.07,0.30]
Utilization adjustment cost	Gamma	0.5/0.15	0.86 [0.77,0.95]	0.89 [0.83,0.96]
Fixed cost in production	Normal	1.25/0.125	1.59 [1.44,1.74]	1.57 [1.42,1.71]
Capital share in production	Normal	0.3/0.05	0.16 [0.12,0.19]	0.14 [0.11,0.16]
Constant gain learning	Gamma	0.05/0.03	-	0.016 [0.01,0.02]
Monetary policy parameters				
Interest rate smoothing	Beta	0.75/0.1	0.77 [0.73,0.82]	0.78 [0.73,0.82]
Response to inflation	Normal	1.5/0.25	1.21 [0.99,1.44]	1.002 [1,1.01]
Response to output	Normal	0.125/0.05	0.09 [0.07,0.11]	0.08 [0.06,0.09]
Response to output growth	Normal	0.125/0.05	0.23 [0.16,0.30]	0.19 [0.12,0.27]

Table 3: Shock parameter estimates

Parameter	Prior distribution		Posterior Mean	
	Type	Mean/Std	RE	AL
Non-stationary TFP shocks				
Persistence of TFP shock	Beta	0.5/0.2	0.92 [0.89, 0.96]	0.94 [0.92 , 0.97]
Std of unanticipated TFP shock	Inv-gamma	0.1/2	0.06 [0.05, 0.08]	0.05 [0.04 , 0.06]
Std of TFP news shock - 4 quarter ahead	Inv-gamma	0.1/2	0.05 [0.03, 0.06]	0.04 [0.03 , 0.05]
Std of TFP news shock - 8 quarter ahead	Inv-gamma	0.1/2	0.08 [0.06 , 0.09]	0.06 [0.04 , 0.08]
Stationary unanticipated shocks				
Persistence of TFP shock	Beta	0.5/0.2	0.93 [0.90, 0.95]	0.92 [0.90, 0.94]
Persistence of risk shock	Beta	0.5/0.2	0.83 [0.75, 0.91]	0.94 [0.92, 0.96]
Persist. of government spend. shock	Beta	0.5/0.2	0.90 [0.86, 0.94]	0.91 [0.88, 0.95]
Persist. of investment-specific shock	Beta	0.5/0.2	0.84 [0.76, 0.92]	0.93 [0.90, 0.95]
Persist. of monetary shock	Beta	0.5/0.2	0.42 [0.33, 0.52]	0.38 [0.27, 0.48]
Persist. of net-worth shock	Beta	0.5/0.2	0.03 [0.00, 0.07]	0.93 [0.89, 0.96]
Persist. of price-markup shock	Beta	0.5/0.2	0.14 [0.02, 0.25]	0.21 [0.07, 0.35]
Persist. of wage-markup shock	Beta	0.5/0.2	0.13 [0.02, 0.23]	0.05 [0.01, 0.10]
Std of TFP shock	Inv-gamma	0.1/2	0.42 [0.37, 0.47]	0.43 [0.38, 0.48]
Std of risk shock	Inv-gamma	0.1/2	2.24 [1.11, 3.38]	2.03 [1.64, 2.44]
Std of government spend. shock	Inv-gamma	0.1/2	0.39 [0.35, 0.44]	0.39 [0.35, 0.43]
Std of investment-specific shock	Inv-gamma	0.1/2	1.05 [0.50, 1.61]	0.92 [0.67, 1.17]
Std of monetary shock	Inv-gamma	0.1/2	0.10 [0.09, 0.12]	0.09 [0.08, 0.11]
Std of net-worth shock	Inv-gamma	0.1/2	1.70 [1.39, 2.02]	0.09 [0.06, 0.12]
Std of price-markup shock	Inv-gamma	0.1/2	0.15 [0.12, 0.17]	0.14 [0.11, 0.16]
Std of wage-markup shock	Inv-gamma	0.1/2	0.50 [0.42, 0.57]	0.46 [0.41, 0.51]

4.3 News shock transmission mechanism

This section shows the main differences in the transmission mechanisms of TFP news shocks implied by RE and AL. Figure 2 shows the impulse-response functions (IRFs) of the observable variables for a one-percent 4-quarter ahead news shock.[16] The blue line shows the median pseudo-IRFs of the

[16]The IRFs associated with an 8-quarter ahead TFP news shocks are more similar for the two expectation assumptions. Hence, for the sake of brevity, we have decided to only show the IRFs for 4-quarter ahead TFP news

AL model over the sample.[17] The black line shows the median IRFs of the RE model. Dashed lines show the associated 16%-84% posterior bands.

The first two rows of graphs in Figure 2 show the IRFs for output, investment, consumption, and labor (hours worked). They clearly show the high persistence of macroeconomic variables to news shocks under the two expectation hypotheses. The median IRFs show that the effect of TFP news shocks on these real macroeconomic variables is larger under AL over most IRF horizons,[18] especially the response of consumption, whose median IRF under RE lies well below the lower bound of the AL posterior band across all horizons. This feature highlights that the effects of TFP news shocks on consumption are larger and much more persistent under AL.

The third row of the IRFs in Figure 2 shows the responses of inflation and the nominal interest rate to a TFP news shock. The monetary policy response is nearly identical under both RE and AL. However, the inflation response differs drastically: the news shock behaves like a supply shock under AL, while it acts as a demand shock under RE. More specifically, AL characterizes news as supply shocks, but this is not a sufficient condition since financial frictions also play a crucial role.[19] The main change in the transmission mechanism is driven by AL amplifying the importance of financial variables in forming expectations. Empirical evidence from recent literature (such as Barsky and Sims (2011), Forni, Gambetti, and Sala (2014), and Görtz, Tsoukalas, and Zanetti (2022)) suggests that TFP news shocks are typically interpreted as supply shocks. However, in RE-DSGE models, this result is harder to achieve, as agents react to TFP news shocks before they materialize, causing

shocks.

[17]To plot the IRFs of the AL model, we consider that the PLM are fixed at the values in which the shock is realized. As in Slobodyan and Wouters (2012) and Aguilar and Vázquez (2021), we have also computed the time-varying AL pseudo-IRF, which are computed using the fixed belief coefficients obtained using the information available at each point in time, but then ignoring the updating of those beliefs driven by the shock. Since these time-varing IRFs look very similar across sample periods we do not report them here, but they are available in a supplementary appendix.

[18]A reader might see these larger responses for output, consumption, and investment under AL as somehow contrasting with the lower volatility of these variables under AL shown in Table 1. However, it should be clear that the volatility of a variable, say output, depends on all shocks and, more importantly, on the relative importance of each alternative structural shock in the variance decomposition. The estimated variance decomposition is rather sensitive to the assumed expectation process. For example, the unconditional variance decomposition of output (shown in Table 5 in the Appendix) shows an increase in the relative importance of news shocks under AL, but this increase is much smaller than the increase in the relative importance of both the risk premium shock and the net worth shock under AL. This clearly suggests that the AL specification strengthens the transmission mechanism of the (forward-looking) financial sector and, consequently, these shocks become more important in explaining aggregate fluctuations. Meanwhile, unanticipated monetary and non-stationary TFP shocks become less important in explaining fluctuations in real macroeconomic variables under AL.

[19]A sensitivity analysis, not shown here but available upon request from the authors, shows that the absence of financial frictions results in a positive response of inflation even under AL.

demand to shift before productivity, which in turn raises marginal costs and thus inflation since inflation is determined by the discounted sum of future marginal costs under RE. In contrast, inflation expectations do not necessarily match the discounted sum of future marginal costs under AL since they are determined by the PLM (eq. 2). The estimated PLM relies more on financial variables, which from the outset indicates a reduction in financial costs due to a positive TFP news shock, thereby anticipating less costly capital accumulation.

The last row of graphs in Figure 2 shows the IRFs of the two observable financial variables. There are notable differences in the medium-term lending spread behavior. The lending spread response is more persistent under AL. Under RE, the lending spread quickly returns to its steady state in less than a year, while the negative response of the spread remains significant for over three years under AL.

This difference in the lending spread's response has important implications for how news shocks are transmitted through the credit channel. Under RE, the short-lived lending spread response minimizes the role of the credit channel in transmitting TFP news shocks to the real economy. In contrast, under AL, the more persistent lending spread amplifies the impact of news shocks on real variables via the credit channel. Additionally, the financial amplification under AL leads to larger expected changes in credit conditions, which in turn drive inflation expectations through anticipated future financial conditions.[20] This tight connection between low inflation and expectations on credit expansion is aligned with the empirical evidence reported in Christiano, Ilut, et al. (2010) showing that inflation is low during stock market booms, and also with the theoretical modelling suggesting that financial frictions reduce the procyclicality of inflation (Christiano, Eichenbaum, and Trabandt (2015), and Gilchrist, Schoenle, and Zakrajšek (2017)). These more persistent lending spread responses of the AL model to TFP news shocks are also in line with the VAR findings reported in Görtz, Tsoukalas, and Zanetti (2022), where news shocks are also associated with persistent fluctuations in lending spreads.

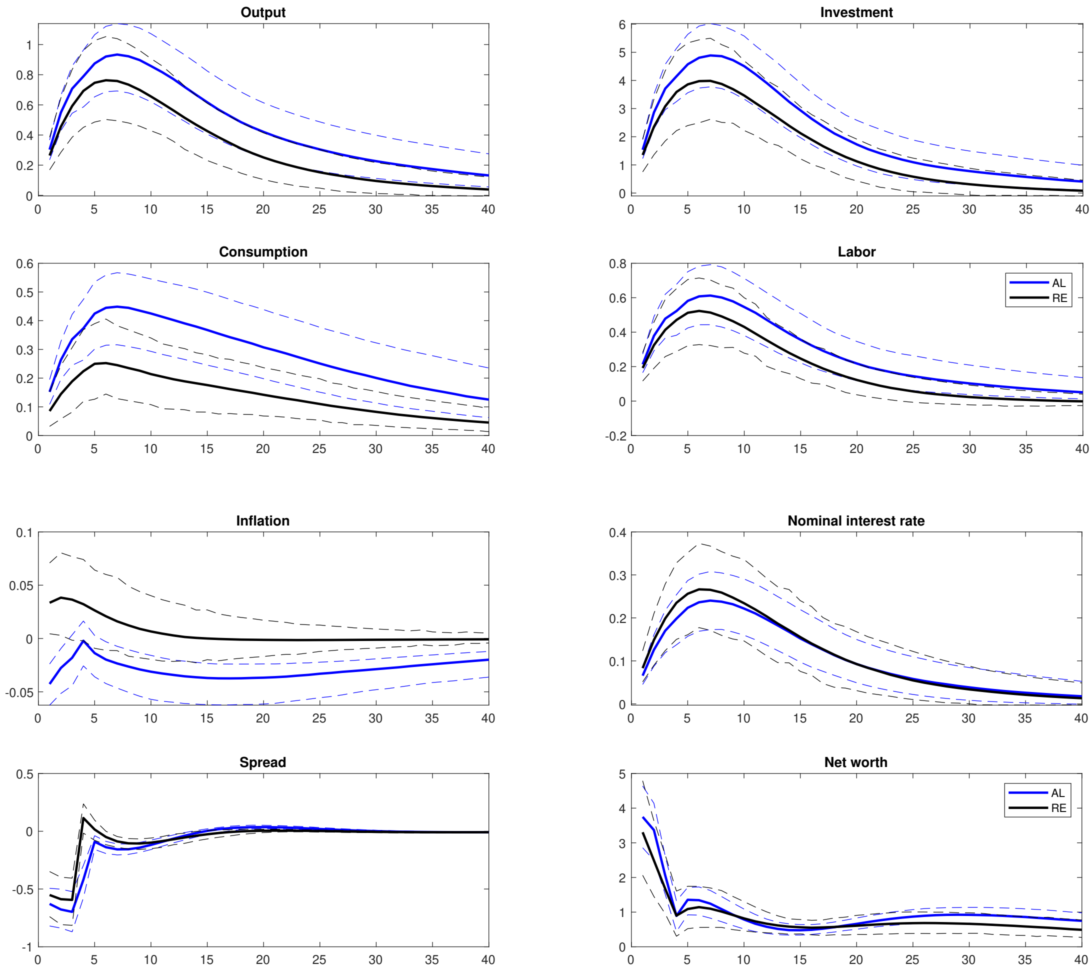
To further investigate the role of financial frictions in this mechanism, we simulate the model with significantly lower financial rigidities, here characterized by a counterfactual reduced leverage level for the sample period studied.[21] The results, shown in Figure 3, indicate that with milder financial frictions, the AL model loses its ability to replicate the countercyclical response of inflation to TFP news shocks. This result underlines the crucial role of financial leverage in the persistence

[20]Here, it is useful to emphasize again the importance of the interaction between the credit and expectation channels under AL. In contrast, these two channels are rather weak under RE because the credit channel shows a weak persistence which reduces the capacity of TFP news shocks in affecting inflation expectations.

[21]We have chosen an illustrative reduction in leverage to one-third of the target level used in the calibration. This results in a counterfactual leverage ratio of 3.65.

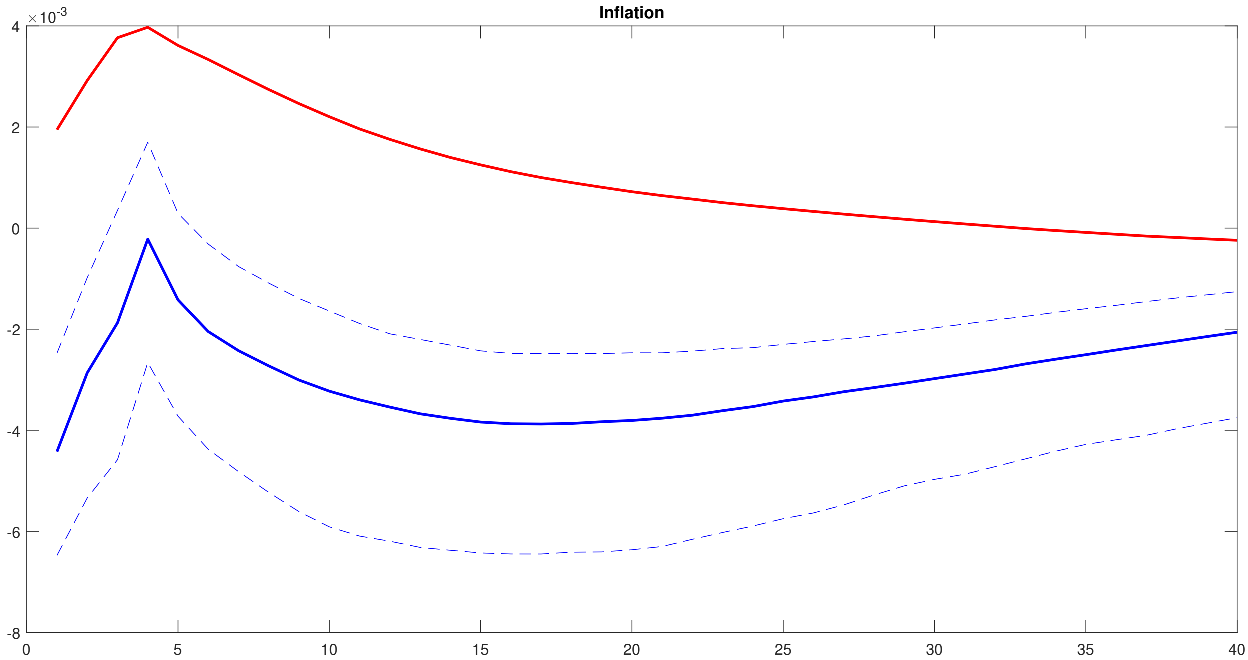
and amplification of the effects of the credit channel on inflation dynamics. Lower financial frictions reduce the expected adjustments in credit conditions, thereby weakening the feedback between inflation expectations and credit expansion, and ultimately reducing the model's consistency with observed countercyclical inflation responses to news shocks.

Figure 2: Impulse-response functions following a TFP news shock



Notes: The blue (black) solid line shows the median of the responses obtained from the posterior distribution of the model under AL (RE), while dashed lines show the corresponding 16%-84% posterior bands. The vertical axes represent percentage deviations from the steady state for most variables, except for inflation, nominal interest rates, and lending spreads, which are expressed as annualized deviations from the steady state.

Figure 3: Impulse-response functions of inflation to a TFP news shock under different degrees of financial frictions



Notes: The blue solid line shows the estimated (median) impulse response of inflation to a TFP news shock of the baseline AL model, and the blue dashed lines show the corresponding 16%-84% posterior bands already shown in Figure 2. The red line shows the simulated response of inflation to a TFP news shocks for the counterfactual reduced leverage considered. The vertical axes represent annualized deviations from the steady state.

4.4 Beliefs and the financial channel

This section shows how TFP news shocks shape the PLM of several forward-looking variables. More precisely, Figure 4 shows changes in the coefficients of auxiliary variables that keep track of TFP news shocks until they are realized.[22] The blue (black) lines represent belief coefficients under AL (RE), while the solid (dashed) lines show belief coefficients associated with 8-quarter and 4-quarter TFP news shocks. RE belief coefficients are constant by construction while AL coefficients are time-varying due to the belief updating process.

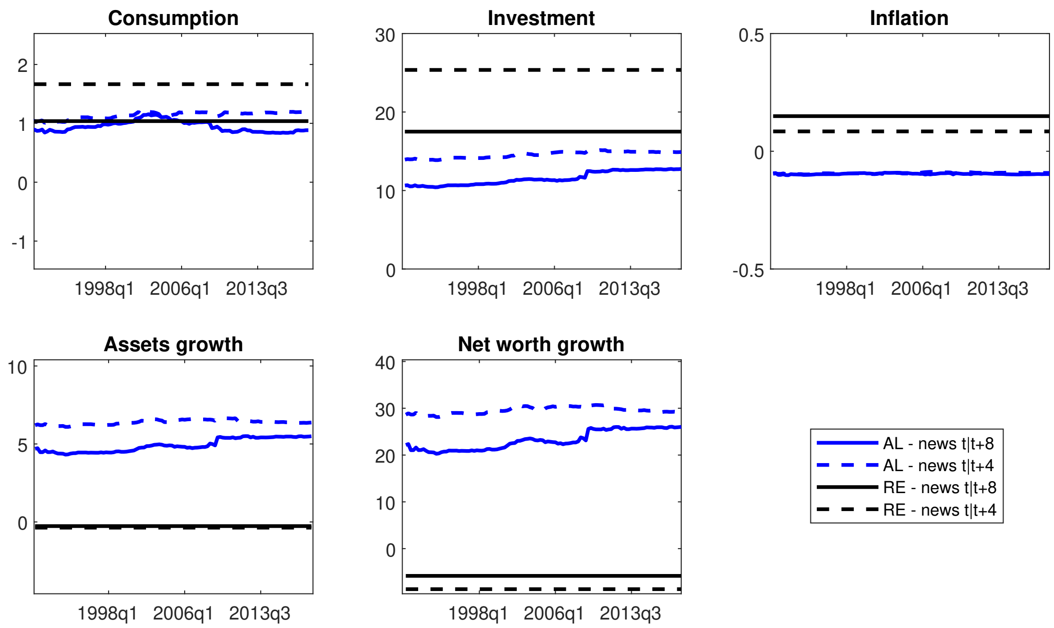
The belief coefficients for news shocks associated with the PLM of consumption are relatively similar across the two alternative hypotheses on expectations. However, the belief coefficients exhibit important differences for the rest of PLMs. Thus, while the belief coefficients for news shocks associated with investment are much smaller under AL, those belief coefficients for news shocks on financial variables (i.e., the growth rates of the value of assets and net worth) are much larger under

[22] Here, for the sake of clarity, we show only parameters associated with the auxiliary variables at time $t-4$ and $t-8$ (i.e. the parameters associated with the anticipation horizon of each news shock). The learning coefficients associated with the rest of the auxiliary variables are consistent with those shown in Figure 4 and are available upon request.

AL, showing a sort of overreaction of financial markets' expectations to news, much in line with the irrational exuberance hypothesis (Shiller (2016)). These larger belief coefficients for news shocks on financial variables further explain the amplified power of the credit channel under AL discussed above.[23] The degrees of freedom inherent in AL expectation formation allow expectations to react more strongly in financial markets, which subsequently expands into the real economy through the credit supply, instead of directly affecting investment through large investment belief coefficients as is the RE case. Therefore, it is crucial to consider the financial sector alongside AL to fully observe changes in the transmission mechanisms of news shocks as discussed above.

Finally, note also the negative (positive) response of inflation expectations to TFP news shocks under AL (RE), which is consistent with the IRF analysis discussed above showing a distinctive deflationary response of inflation to TFP news shocks under AL.

Figure 4: Belief coefficients associated with TFP news



Notes: The blue (black) lines represent belief coefficients under AL (RE), while the solid (dashed) lines show belief coefficients associated with 8-quarter (4-quarter) TFP news shocks.

4.5 Variance decomposition and pure news

This section analyzes the decomposition of news shocks into pure and realized shocks, as emphasized by E. Sims (2016). A pure news shock captures the effects of a news shock on the aggregate variables

[23]These findings are also in line with Rychalovska (2016), who finds that the dynamics of real variables in a DSGE model under learning are driven to a significant extent by the time variation of agents' beliefs about financial sector variables.

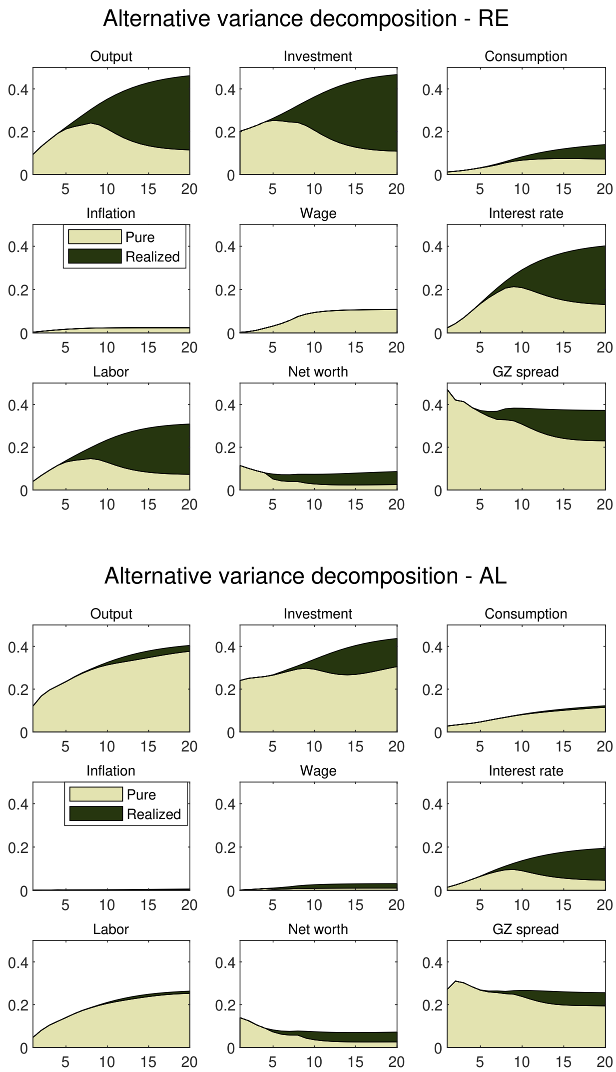
before the realization of the shock. Still, its effect once realized is not conceptually different from that of an unanticipated shock. Indeed, in analyzing the importance of news shocks we are interested in their ability to shape agents' expectations as drivers of aggregate fluctuations. Since we are analyzing the consequences of a deviation from the RE hypothesis, it is important to assess the extent to which the contribution of pure news shocks in explaining the business cycle is affected by considering some form of bounded rationality. Figure 5 shows the sum of the proportions in the variance decomposition explained by the 4- and 8-quarter ahead news shocks considering RE (upper-panel) and AL (bottom-panel) for alternative (from 1- to 20-quarter) forecasting horizons. Following Barsky, Basu, and Lee (2015) and E. Sims (2016), the variance decomposition is further decomposed into two areas that represent pure news (yellow) and realized news shocks (dark). The effect of a pure news shock is computed by subtracting the effect of an unanticipated shock at a particular anticipation horizon from the total effect of a news shock so as to leave the relevant exogenous variable unchanged.[24]

There is a noteworthy difference between the RE and AL models: The proportion in the variance decomposition attributed to pure news shocks in the AL model is much larger than in RE. These findings are clearly in contrast with E. Sims (2016), who finds that in the DSGE model considered in Schmitt-Grohé and Uribe (2012) (i.e. a non-financial RE-DSGE model) the proportion of pure news shocks is rather small.[25]

[24] As explained in Sims (2016), this decomposition does not deliver separate percentages of pure and realized news that add up to the total proportion explained by the total news shock. Therefore, for illustrative purposes we add up both (pure and realized news) proportions and compute their pseudo-proportion in the actual total news proportion shown in Figure 5 as follows: $\frac{\epsilon^{pure}}{\epsilon^{pure}+\epsilon^{realized}}\epsilon^{total}$, and $\frac{\epsilon^{realized}}{\epsilon^{pure}+\epsilon^{realized}}\epsilon^{total}$.

[25] The high significance of pure news shocks found is also in line with Herrera and Vázquez (2023), who consider a similar DSGE model with financial frictions à la GK but under RE. These two papers introduce two alternative specifications that boost the importance of pure news shocks by amplifying the transmission mechanism of (TFP) news shocks through the financial sector. Thus, in this paper, the departure from RE amplifies the responses of the macroeconomy to TFP news shocks, while the quality-of-capital news shocks considered in Herrera and Vázquez (2023) have a similar amplifying impact through the financial market. Altogether, these papers emphasize the importance of including an explicit financial sector in DSGE modeling to properly identify the transmission mechanisms of news shocks.

Figure 5: Decomposition of news in pure and realized



4.6 VAR evidence

This section focuses on the ability of the DSGE model to match empirical responses that we estimate through a VAR model. Following Barsky, Basu, and Lee (2015) and Görtz, Tsoukalas, and Zanetti (2022), we compare the empirical IRF from the VAR model with those estimated with identical VAR specification on artificial data samples generated by each (RE and AL) version of the DSGE model.[26] All estimations consider a seven-variable empirical VAR model using five lags with

[26]News shocks might pose an identification challenge for the VAR due to the non-invertibility problem. Since their effects are delayed, the current values of the series do not convey information about the current shocks. However, Forni, Gambetti, and Sala (2019) suggest that invertibility is not a necessary condition for identifying a specific shock and propose an indicator that summarizes the condition of sufficient information required for correct identification. In this analysis, we adopt the same VAR specification as in Görtz, Tsoukalas, and Zanetti (2022), which is the same specification that maximizes the sufficient information indicator in Forni, Gambetti, and Sala (2019). We compute this indicator for our TFP news shocks and obtain values below 0.2, indicating that there is sufficient information for

a Minnesota prior. In contrast to the observables used in the estimation of the alternative versions of the DSGE model, all time series considered in the VAR enter in (log) levels as is standard practice in the empirical VAR literature. Moreover, as an observable measure of TFP we use the utilization-adjusted aggregate TFP, described in Fernald (2014) in all VARs estimated (either with actual or simulated data). We follow the identification scheme suggested in Francis et al. (2014) to identify the TFP news shock from the VAR model.[27] This identification method estimates the TFP news shock by (i) maximizing the variance of TFP at a specific long but finite horizon (we set the long horizon to 40 quarters), and (ii) imposing a zero impact restriction on TFP conditional on the news shock.

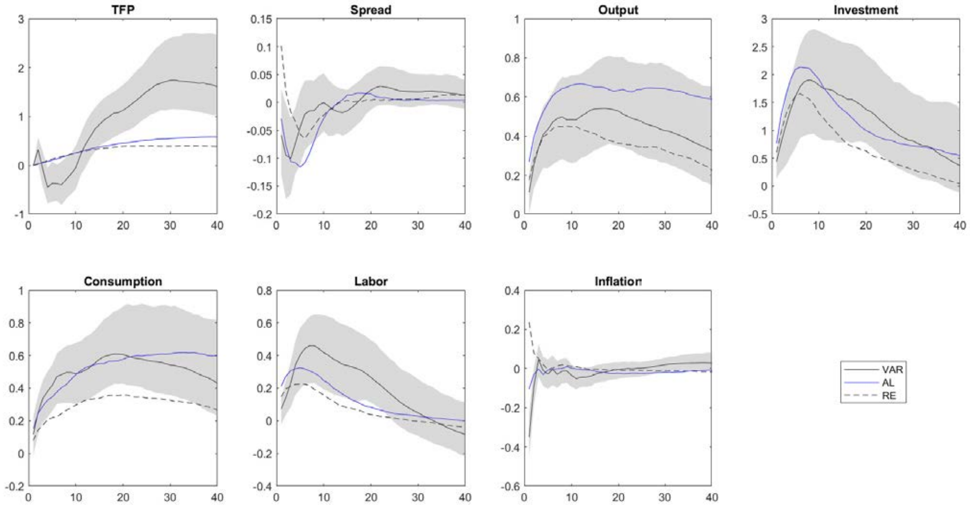
Figure 6 shows the empirical responses of the seven variables to a TFP news shock (black line), their 16%-84% posterior bands (shaded-gray areas), and the median of the responses obtained from the estimation of the VAR across 500 simulated time series resulting from the AL (blue line) and the RE (dashed line) versions of the DSGE model. The IRFs from the VAR estimated on actual data are largely similar to those reported in Görtz, Tsoukalas, and Zanetti (2022):[28] Namely, (i) the TFP confidence band only excludes the zero value after roughly three years; (ii) the TFP news shock rise output, consumption, investment, and hours significantly on impact, and they exhibit hump-shaped dynamics; (iii) the spread decreases, which is in line with an economic boom favored by credit expansion; and (iv) a short-lived fall in inflation. Many of these features are well captured, at least qualitatively, by the two versions of the DSGE model, but there are a few remarkable differences. First, the median IRFs from the DSGE model under AL lie inside the confidence bands of the empirical VAR for all variables and across most forecast horizons. Meanwhile, the IRFs corresponding to the RE version of the DSGE model have trouble in capturing the short-run responses of many variables featured by the empirical VAR, such as output, investment, spread, and inflation. In particular, as pointed out above, TFP news shocks are inflationary under RE but have a negative effect on inflation both in the empirical VAR and in the DSGE under AL. Second, the ability of the AL model to reproduce the countercyclical response of the spread at impact suggests that the bounded rationality assumption underscores the importance of the credit channel in the transmission mechanism of TFP news shocks.

identification.

[27]The results are robust to other identification strategies that are also commonly used in news literature (e.g. long- and short-run restrictions and Barsky and Sims (2011) identification method).

[28]In spite of considering a different sample period—we use the same sample period considered in the estimation of the DSGE model— and including investment (instead of S&P 500).

Figure 6: Comparison of empirical and DSGE-simulated VAR responses to a TFP news shock



Notes: The black line shows the empirical responses to a TFP news shock, while shaded-gray areas show their corresponding 16%-84% posterior bands. The blue line (dashed line) shows the median of the responses obtained from the estimation of the VAR across 500 simulated time series resulting from the AL (RE) DSGE model. The units of the vertical axes are percentage deviations from the steady state.

5 Conclusions

This paper builds on the growing literature that analyzes the expectation-driven business cycle by (i) analyzing the empirical importance of TFP news shocks as one of the main driving forces of the business cycle; and (ii) assessing the consequences of deviating from the rational expectations (RE) assumption through adaptive learning (AL). In principle, the AL and news shocks strands of literature are closely related since both try to assess how expectations may affect the aggregate economy. Therefore, it is crucial to investigate how the role of news shocks in explaining the business cycle is affected by the way in which agents form their expectations. All empirical analyses in news shock literature to date have been carried out through the prism of the RE assumption, but here we consider AL instead. This introduces distinctive dynamics into the model through the effects of news shocks on the expectation channel, which substantially change their transition mechanism and their relative empirical significance.

We find that a rather minor departure from the RE assumption via AL improves model performance. In line with the related empirical literature, the AL specification provides a better overall fit in terms of marginal data density. Moreover, AL does a better job in replicating the size of aggregate fluctuations. We show that these findings are mainly due to the impact of TFP news shocks on financial expectations under AL We also find that introducing this form of bounded rationality has a significant impact on the transmission mechanism of news shocks. In particular, the lending spread shows different effects, with TFP news shocks triggering a more persistent effect under the AL hypothesis. Furthermore, the effects of news shocks on inflation are reversed, so that news shocks behave as supply shocks under AL, as long as financial frictions are sufficiently pervasive. This finding is in line with recent literature (Forni, Gambetti, and Sala (2014); Görtz, Tsoukalas, and Zanetti (2022)), but in sharp contrast with the inflationary response to news shocks obtained in the RE specification.

Interestingly, we find that the importance of pure news shocks increases under AL. This is a particularly important finding because the importance of (anticipated) news shocks is usually assessed on their ability to affect the economy via the expectation channel as pure news shocks do by construction—i.e. pure news shocks are computed as in E. Sims (2016) to be distinguished from *realized* news shocks, which can be viewed just as unanticipated shocks. Finally, we also show that the AL-DSGE, rather than the RE-DSGE, model generates dynamics implied by news shocks that are more in line with those estimated through an empirical Bayesian VAR.

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Appendix

The model

In this appendix, we first describe the DSGE model augmented with financial frictions à la Gertler and Karadi (2011).

Households

The representative household i decides consumption, hours worked, and savings in riskless assets to maximize a utility function that incorporates internal habit formation. Formally,

$$E_t \sum_{k=0}^{\infty} \beta^k \epsilon_{t+k}^b \left[ln\left(C_{t+k}(i) - hC_{t+k-1}\right) - \frac{L_{t+k}(i)^{1+\sigma_l}}{1+\sigma_l} \right], \tag{3}$$

where β is the household subjective discount factor, h represents the degree of habit persistence, σ_l is the elasticity of labor supply (i.e. the Frisch elasticity), and ϵ_{t+k}^b is an exogenous process that affects the intertemporal preferences of households. Household savings are represented by deposit liabilities in banks and government bonds. These riskless assets, B, are perfect substitutes and pay the same nominal interest rate, R^n. Households also receive dividends from intermediate goods firms, capital goods producers, and labor unions, D. Hence, the budget constraint is

$$C_{t+k}(i) + \frac{B_{t+k}(i)}{R_{t+k}^n P_{t+k}} - T_{t+k} = \frac{W_{t+k}(i)L_{t+k}(i)}{P_{t+k}} + \frac{B_{t+k-1}(i)}{P_{t+k}} + \frac{D_{t+k}}{P_{t+k}}, \tag{4}$$

where T represents lump-sum taxes, and W is the nominal wage.

Labor unions and wage decision

As in Smets and Wouters (2007), households supply homogeneous labor to intermediate labor unions that differentiate labor services. Intermediate labor unions set wages and sell labor services to a labor packer who aggregates the differentiated labor and resells it to intermediate goods firms. Aggregation of labor services follows

$$L_t = \left[\int_0^1 L_t(i)^{\frac{1}{1+\epsilon_t^w}} di \right]^{1+\epsilon_t^w},$$

where $1 + \epsilon_t^w$ is the desired markup of wages over the household's marginal rate of substitution, which is assumed to follow a stochastic process around its steady-state value.

Labor packers maximize profits in a perfectly competitive market. Formally,

$$max_{L_t(i)} W_t L_t - \int_0^1 W_t(i) L_t(i),$$

where W_t is the aggregate wage that intermediate firms pay for labor services, and $W_t(i)$ is the wage that labor packers pay for the differentiated labor. This optimization problem results in the following labor demand function:

$$L_t(i) = \left(\frac{W_t(i)}{W_t}\right)^{-\frac{1+\epsilon_t^w}{\epsilon_t^w}} L_t.$$

The labor demand function and the labor services aggregation function together result in the wage aggregation function:

$$W_t = \left(\int_0^1 W_t(i)^{\frac{1}{\epsilon_t^w}} di\right)^{\epsilon_t^w}. \tag{5}$$

Following Calvo's lottery scheme, labor unions are assumed to adjust prices with probability $1-\xi_w$. The fraction of labor unions ξ_w that cannot adjust prices is assumed to follow the indexation rule, $W_{t+1}(i) = W_t(i)\left(\frac{P_t}{P_{t-1}}\right)^{\iota_w}$. Hence, the labor unions choose an optimal W to maximize

$$E_t \sum_{k=0}^{\infty} \beta^k \xi_w^k \left[\Lambda_{t+k} W_t(i) L_{t+k}(i) - \epsilon_{t+k}^b \frac{L_{t+k}(i)^{1+\sigma_l}}{1+\sigma_l}\right], \tag{6}$$

subject to labor demand and the indexation rule.

Final goods firms

Competitive final goods producers buy intermediate goods and combine them to finally sell homogeneous goods to households. The intermediate goods aggregation follows:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{1+\epsilon_t^p}} di\right]^{1+\epsilon_t^p},$$

where Y_t is the homogeneous good, $Y_t(i)$ is the heterogeneous good supplied by firm i, and $1+\epsilon_t^p$ is the desired markup of prices over firms' marginal cost, which is assumed to follow a stochastic process around its steady-state value.

Final goods firms maximize profits in a perfectly competitive market. Formally,

$$max_{Y_{t(i)}} P_t Y_t - \int_0^1 P_t(i) Y_t(i) di,$$

where Y_t is subject to the goods aggregation function, $P_t(i)$ is the price for differentiated goods, and P_t is the aggregate price index. The optimal condition of this maximization problem results in the following goods demand function for goods:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\frac{1+\epsilon_t^p}{\epsilon_t^p}} Y_t. \tag{7}$$

Hence, the goods demand function and the intermediate goods aggregator result in the following price aggregator

$$P_t = \left[\int_0^1 P_t(i)^{\frac{1}{\epsilon_t^p}} di\right]^{\frac{1}{1-\epsilon_t^p}}. \tag{8}$$

Intermediate goods firms

As in the labor market, it is assumed that intermediate goods firms can only adjust prices with probability ξ_p. Those firms which cannot adjust prices in period t simply reset their prices according to the indexation rule: $P_{t+1}(i) = P_t(i)\left(\frac{P_t}{P_{t-1}}\right)^{\iota_p}$. Firms able to set their optimal prices P_t^* at time t choose them by maximizing current and future expected profits. Denoting the marginal costs and the inflation rate by MC_t and π_t, respectively; the price setting optimization problem faced by intermediate goods firms can be written as follows:

$$max_{P_t^*(i)} E_t \sum_{k=0}^{\infty} \beta^k \xi_p^k \Lambda_{t+k} \frac{P_t}{P_{t+k}} \left[P_t^*(i) \prod_{l=1}^{k} \pi_{t+l-1}^{\iota_p} - MC_{t+k}\right] Y_{t+k}(i), \tag{9}$$

subject to the price indexation rule, and the demand function for intermediate goods.

In addition to setting prices, intermediate goods firms decide on the output of goods. They choose the amount of production inputs by maximizing the flow of discounted profits

$$E_t \left\{\beta\Lambda_{t+1}\left[Y_{t+1}(i) - r_{t+1}^k K_{t+1}^s(i) - \frac{W_{t+1}}{P_{t+1}} L_{t+1}(i)\right]\right\}, \tag{10}$$

where $\beta\Lambda_{t+1} = \frac{\beta\lambda_{t+1}}{\lambda_t}$ is the stochastic discount factor, λ_t is the marginal utility of consumption for households at time t, r_{t+1}^k is the rental rate of capital, and $K_{t+1}^s(i)$ denotes capital services.

The production function is assumed to follow a Cobb-Douglas technology:

$$Y_t = TFP_t \left(K_t^s\right)^{\alpha} L_t^{1-\alpha} - \Psi_t \phi_p, \tag{11}$$

where ϕ_p is the share of fixed costs involved in production, and TFP_t denotes TFP shocks. The optimal inputs decision results in the following optimal conditions:

$$r_t^k = \alpha MC_t TFP_t \left(K_t^s\right)^{\alpha-1} L_t^{1-\alpha}, \tag{12}$$

$$\frac{W_t}{P_t} = (1-\alpha) MC_t TFP_t \left(K_t^s\right)^{\alpha} L_t^{-\alpha}. \tag{13}$$

Capital services firms

Capital services firms purchase physical capital from capital goods producers and turn it into effective capital by choosing the utilization rate, U_t:

$$K_t^s = U_t K_{t-1}. \tag{14}$$

Capital services firms decide the optimal capital utilization rate and face a utilization cost. They solve the following maximization problem:

$$max_{U_t} \left[r_t^k U_t - a\left(U_t\right)\right] K_{t-1},$$

where $a\left(U_t\right)$ is the utilization cost function. The optimal solution implies

$$r_t^k = a'\left(U_t\right). \tag{15}$$

This equilibrium condition states that the degree of capital utilization depends on the rental rate of capital. The utilization cost function assumes the following standard properties $U = 1$, $a(U) = 0$, and $\frac{a''(U)}{a'(U)} = \psi$ in the steady state. Hence, the parameter ψ is a positive function of the elasticity of the capital utilization cost, and is normalized to be between zero and one. A higher value of ψ means a higher cost of adjustment in capital utilization.

Capital services firms finance their physical capital acquisition by borrowing from financial intermediaries. At equilibrium, the following condition holds:

$$Q_t K_t = Q_t S_t, \tag{16}$$

which states that state-contingent claims, S_t, are equal to the number of units of physical capital acquired, K_t, where firms price their claims at the price of one unit of capital, Q_t. Each claim pays the stochastic return R^k_{t+1} over period t. Capital services firms operate in a perfectly competitive market, so the revenue from renting effective capital must be equal to the cost of purchasing physical capital. Hence, the optimal capital demand satisfies

$$R^k_{t+1} = \frac{r^k_{t+1} U_{t+1} - a\left(U_{t+1}\right) + (1-\delta) Q_{t+1}}{Q_t}, \tag{17}$$

which shows that the expected real interest rate on external funds is equal to the marginal return on capital.

Capital goods producers

Capital goods producers turn out physical capital and sell it to capital services firms at price Q_t. Investment goods are purchased from final good producers. Capital goods producers are assumed to face quadratic adjustment costs, $S(I_t/I_{t-1})$. This adjustment costs function is assumed to be a strictly increasing twice differentiable function. The optimization problem of the capital goods producers is

$$max_{I_t} E_t \left\{ \sum_{k=0}^{\infty} \beta^k \Lambda_{t+k} \left[Q_{t+k} I_{t+k} \epsilon^i_{t+k} - I_{t+k} - Q_{t+k} I_{t+k} \epsilon^i_{t+k} S\left(\frac{I_{t+k}}{I_{t+k-1}}\right)\right]\right\}, \tag{18}$$

where $S(.)$ is assumed to have the properties $S(1) = S'(1) = 0$, $S''(1) = \varphi > 0$. Therefore, the parameter φ measures the degree of investment adjustment cost, and the disturbance ϵ^i_t is the investment specific-technology shock. Capital accumulation evolves following the standard equation

$$K_t = (1-\delta) K_{t-1} + \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t. \tag{19}$$

Financial intermediaries

Görtz and Tsoukalas (2017) find that the financial sector is crucial for identifying TFP news shocks. We closely follow their characterization of financial intermediaries, which was suggested by

Gertler and Kiyotaki (2010) and gertler2011model. A fixed fraction of households includes bankers, who do not supply labor but behave as financial intermediaries. These bankers face a survival probability, θ, and in order to keep the proportion constant further households become bankers in each period.

The financial intermediaries finance the acquisition of physical capital by purchasing claims S_t. These purchases are funded through household liabilities. Hence, the balance sheets of financial intermediaries are

$$Q_t S_t = N_t + B_{t+1},$$

where N_t is the net worth of the bankers. Since the return on financial claims is R^k_{t+1} and the cost of liabilities is R_t, the law of motion of the net worth of intermediaries is given by:

$$N_{t+1} = R^k_{t+1} Q_t S_t - R_t B_{t+1} = \left(R^k_{t+1} - R_t\right) Q_t S_t + R_t N_t.$$

Let $\beta\Lambda_{t+1}$ be the stochastic discount factor of financial intermediaries. The bankers' decisions are endogenously determined in the model through the following problem in which they maximize future expected terminal wealth:

$$V_t = max\ E_t \sum_{i=0}^{\infty} (1-\theta)\, \theta^i \beta^i \Lambda_{t+1+i} N_{t+1+i} =$$

$$max\ E_t \sum_{i=0}^{\infty} (1-\theta)\, \theta^i \beta^i \Lambda_{t+1+i} \left[\left(R^k_{t+1+i} - R_{t+i}\right) Q_{t+i} S_{t+i} + R_{t+i} N_{t+i}\right].$$

However, a moral hazard issue arises in this maximization problem because $\beta^i \left(R^k_{t+1+i} - R_{t+i}\right) \geq 0$. Otherwise bankers would not be willing to purchase assets. Thus, bankers have an incentive to keep borrowing additional funds indefinitely from households. In order to restrict their ability to do this, an enforcement cost is introduced: At the beginning of the period bankers can divert a proportion λ of the funds available. If that is the case, the depositors can then only recover a fraction $(1-\lambda)$ of the assets. Hence, for lenders to be willing to supply funds to bankers the following incentive constraint must be satisfied:

$$V_t \geq \lambda Q_t S_t,$$

where V_t, the gain from not diverting assets, can be expressed as follows

$$V_t = \nu_t Q_t S_t + \eta_t N_t,$$

with

$$\nu_t = E_t \left[(1-\theta)\, \Lambda_{t+1} \left(R^k_{t+1} - R_t\right) + \beta\theta x_{t,t+1} \nu_{t+1}\right], \tag{20}$$

$$\eta_t = E_t \left[(1-\theta)\, \Lambda_{t+1} R_t + \beta\theta z_{t,t+1} \eta_{t+1}\right], \tag{21}$$

where ν_t is the marginal gain from expanding assets with net worth held constant, η_t is the expected value of one additional future unit of wealth net worth with assets held constant, $x_{t,t+i} = Q_{t+i}S_{t+i}/Q_tS_t$ is the gross growth rate of assets, and $z_{t,t+i} = N_{t+i}/N_t$ is the gross growth rate of net worth.

The incentive constraint holds with equality at equilibrium:

$$Q_tS_t = \frac{\eta_t}{\lambda - \nu_t}N_t = \phi_t N_t, \tag{22}$$

where ϕ_t is the leverage ratio of bankers. Thus, from the law of motion of net worth and the incentive constraint, net worth can be rewritten as

$$N_{t+1} = \left[\left(R^k_{t+1} - R_t\right)\phi_t + R_t\right]N_t.$$

Using this equation, the gross growth rates of assets and net worth can be written as

$$z_{t,t+1} = N_{t+1}/N_t = \left(R^k_{t+1} - R_t\right)\phi_t + R_t, \tag{23}$$

and

$$x_{t,t+1} = Q_{t+1}S_{t+1}/Q_tS_t = \left(\phi_{t+1}/\phi_t\right)\left(N_{t+1}/N_t\right) = \left(\phi_{t+1}/\phi_t\right)z_{t,t+1}. \tag{24}$$

Finally, the law of motion of bankers' net worth is given by the law of motion of the net worth of existing bankers plus the net worth of households that become bankers in this period:

$$\tilde{N}_t = N^e_t + N^n_t, \tag{25}$$

with

$$N^e_t = \theta\left[\left(R^k_{t+1} - R_t\right)\phi_t + R_t\right]N_{t-1}, \tag{26}$$

$$N^n_t = \omega Q_t S_{t-1}, \tag{27}$$

$$\tilde{N}_t = N_t \epsilon^{nw}_t, \tag{28}$$

where ω is the fraction of the total assets that households transfer to new bankers, which enable them to start operating in the banking sector, and the disturbance ϵ^{nw}_t captures exogenous variations in the net worth of bankers due, for instance, to exogenous changes in bank profits.

Market clearing condition

The market clearing condition is

$$Y_t = C_t + I_t + a(U_t) + \epsilon^g_t, \tag{29}$$

where ϵ^g_t is an exogenous process that captures government spending and exogenous net export shocks.

The central bank

The model is closed with a Taylor-type rule in which the nominal interest rate set by the central banker reacts to inflation, output, and output growth (where all variables are measured in deviations from their steady-state values) in addition to a smoothing component, $\left[\frac{R^n_{t-1}}{R^n}\right]^{\rho}$:

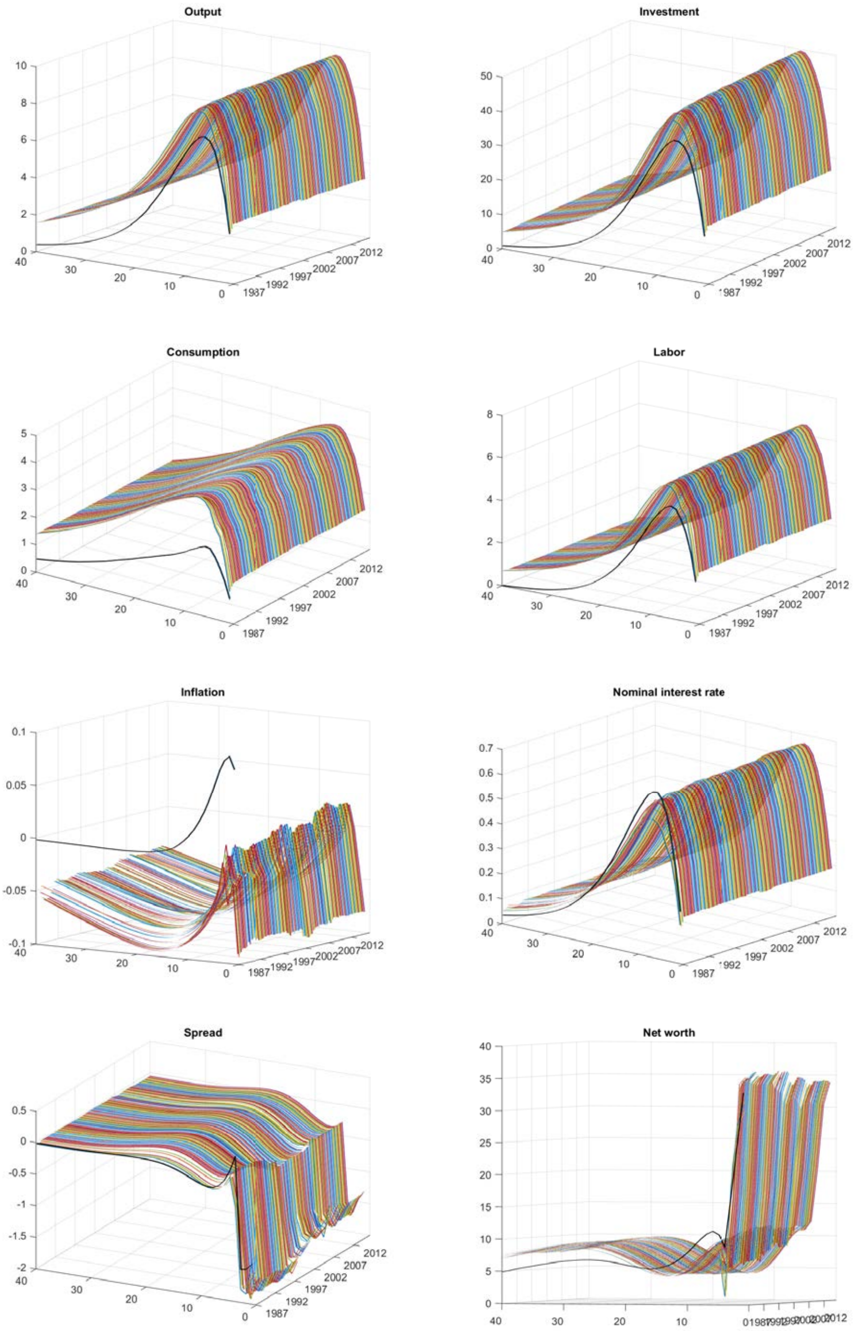
$$\frac{R^n_t}{R^n} = \left[\frac{R^n_{t-1}}{R^n}\right]^{\rho} \left\{ \left[\frac{\pi_t}{\pi}\right]^{r_\pi} \left[\frac{Y_t}{Y}\right]^{r_y} \right\}^{1-\rho} \left[\frac{Y_t}{Y_{t-1}}\right]^{r_{\Delta y}} exp(\epsilon^R_t). \tag{30}$$

As emphasized in the main text, unconventional monetary policies dealing with the zero-lower-bound issue are addressed in this paper by considering the Wu-Xia shadow rate, which allows for negative policy rates.

Time-varying AL-IRFs to a TFP news shock

Figure 7 shows the pseudo IRF of the observable variables to a TFP news shock. The black line shows the IRF of the RE-DSGE model, while the colored lines show the pseudo IRF generated by the AL-DSGE model. According to Slobodyan and Wouters (2012), the pseudo IRFs are IRFs computed using the fixed belief coefficients obtained using the information available at each point in time, but then ignoring the updating of those beliefs driven by the shock. Therefore, these IRFs may underestimate the magnitude and persistence of the true responses.

Figure 7: Time-varying impulse-response functions to a TFP news shock



Alternative specifications

Table 5 reports the log marginal data density (MDD) statistics for alternative specifications in which news, anticipated 4 and 8 quarters in advance, are placed on alternative shocks. These statistics suggest that the most preferred shock to put news on is the trend TFP shock as considered in the baseline specification. All estimated specifications, but the baseline, include an i.i.d. measurement error term in the measurement equation associated with the GZ spread in order to account for potential measurement errors associated with this variable. It turns out that the model fit barely changes by removing this measurement error, as is shown by a comparison of lines 1 and 2. Moreover, adding news to transitory TFP, government speding, and monetary policy shocks rather than to the trend TFP barely deteriorates model fit, while ignoring news on any shock results in a fall of roughly 20 log points in the log MDD. Table 5 also shows that adding news on all quarters (from 1 to 8) to trend TFP shocks, as shown in line 4, results in a large fall in model fit of roughly 70 log points, which is likely due to the difficulties of identifying news from each of a large number of alternative (anticipated) horizons.

Table 4: Log marginal data density (MDD) for alternative news specifications

Trend TFP news (baseline specification)	-847.328
Trend TFP news	-850.475
Transitory TFP news	-854.659
Trend TFP news on all quarters from 1 to 8	-918.894
Risk news	-865.707
Government spending news	-854.847
Investment-specific news	-890.070
Monetary policy news	-854.945
Price markup news	-919.353
Wage markup news	-858.589
Net worth news	-867.540
No news on any shock	-869.621

Notes: The marginal data density is computed using geweke1999 modified harmonic mean method. The computations in this table are based on a Monte Carlo Markov chain of length 200,000 draws for each specification and discard the first 20% of the draws. All specifications, but the baseline specification, include a measurement error in the measurement equation associated with the GZ spread.

Variance decomposition

Table 5: Unconditional variance decomposition

	Output	Invest.	Cons.	Inflation	Wage	Interest rate	Labor	Net worth	Spread
Rational Expectations									
Stat. TFP	0	0	1	9	2	4	24	1	1
Risk premium	10	2	69	0	4	4	11	3	2
Public spending	3	1	2	0	1	1	3	1	0
IST	2	4	1	0	1	1	2	13	4
Monetary policy	12	11	6	0	4	25	9	24	8
Price markup	2	1	1	84	4	6	1	3	2
Wage markup	0	0	0	4	73	2	0	1	1
Net worth	1	3	0	0	0	1	1	19	25
Non-stat. TFP	22	29	4	0	0	14	17	22	20
News 4	14	15	4	0	2	11	10	4	9
News 8	34	33	13	2	10	31	21	8	28
Adaptive Learning									
	Output	Invest.	Cons.	Inflation	Wage	Interest rate	Labor	Net worth	Spread
Stat. TFP	0	1	0	6	1	3	21	2	1
Risk Premium	23(↑13)	5	74	2	0	23(↑19)	26(↑15)	4	3
Public spending	3	0	2	0	0	3	3	0	2
IST	8	9	3	0	0	26(↑25)	6	19	12
Monetary policy	1(↓11)	2	0	0	3	1(↓24)	1	12(↓12)	29(↑21)
Price markup	1	2	0	70(↓14)	4	5	1	2	2
Wage markup	1	4	0	2	0	1	1	29(↑28)	5
Net worth	18(↑17)	25(↑22)	5	1	0	8	13(↑12)	13	16
Non-stat. TFP	1(↓21)	4(↓25)	0	17(↑17)	87(↑87)	10	1(↓16)	7(↓15)	4(↓16)
News 4	18	21	6	1	1	9	11	5	12
News 8	26	26	10	1	2	12(↓19)	16	6	14(↓14)

Table 5 shows the unconditional variance decomposition for each model specification. The top panel shows the variance decomposition for the RE model while the bottom panel shows the one associated with AL. The arrows and the numbers in some entries in the bottom panel highlight the direction and the quantity of the change in the variance decomposition, respectively, when one shifts from RE to AL. Two major differences are noteworthy. First, we find an increase in the relative empirical importance of both the risk premium shock and the net worth shock. This clearly suggests that the AL specification amplifies the transmission mechanism of the (forward-looking) financial sector and, consequently, these shocks become more significant in explaining aggregate fluctuations. Second, we find that *unanticipated* monetary and non-stationary TFP shocks become less significant in explaining fluctuations in real macroeconomic variables under AL.

Regarding the importance of TFP news shocks as a source of aggregate fluctuations, the unconditional variance decomposition shows that the sum of the two TFP news shocks considered explains a large proportion, roughly 46%, of the output and investment fluctuations under the two expectation specifications, whereas the contributions of TFP news in explaining labor and consumption fluctuations are more modest (at around 30% and 17%, respectively). Interestingly, the contribution of 8-quarter ahead news shocks is larger than that of 4-quarter ahead shocks under the two specifications, mainly due to the larger size of the former, but bounded rationality seems somewhat to reduce the importance of the anticipation period due to the larger belief coefficients in the PLM of financial variables associated with the latter.

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