INTERNATIONAL MONETARY FUND

The Diagnostic Financial Accelerator

Lahcen Bounader and Selim Elekdag

WP/24/132

2024
JUN

WORKING PAPER

 WP/24/132

IMF Working Paper
Institute for Capacity Development

The Diagnostic Financial Accelerator
Prepared by
Lahcen Bounader   Selim Elekdag*

June 2024

ABSTRACT: We develop a model with diagnostic expectations (DE) and a financial accelerator (FA) that generates mutually reinforcing shock amplification, especially in the case of demand shocks. However, supply shocks can be dampened via a debt deflation channel, which is strengthened amid DE. Importantly, the model results in a worsening of the inflation-output volatility trade-off confronting policymakers. In contrast to most of the literature—which argues against targeting the level of asset prices—our financial accelerator model with DE suggests that targeting house price growth may result in welfare gains.

RECOMMENDED CITATION: Bounader, Lahcen, and Elekdag, Selim, "The Diagnostic Financial Accelerator," IMF Working Paper 2024/132.

JEL Classification Numbers:	E32, E44, E52, E71
Keywords: Financial Accelerator; Diagnostic Expectations; Optimal monetary policy; Instrument rules	
Author's E-Mail Address:	Lbouander@imf.org Selekdag@imf.org

* We thank Francesco Bianchi, Dirk Muir, Ruy Lama, Marcin Kolasa, Fabian Lipinsky, and participants of the ICD Seminar for useful comments. The views expressed in this draft paper are those of the authors and do not necessarily represent the views of the IMF, its Executive Board, or its Management.

The Diagnostic Financial Accelerator*

Lahcen Bounader Selim Elekdag[†]

June 24, 2024

Abstract

We develop a model with diagnostic expectations (DE) and a financial accelerator (FA) that generates mutually reinforcing shock amplification, especially in the case of demand shocks. However, supply shocks can be dampened via a debt deflation channel, which is strengthened amid DE. Importantly, the model results in a worsening of the inflation-output volatility trade-off confronting policymakers. In contrast to most of the literature—which argues against targeting the level of asset prices—our financial accelerator model with DE suggests that targeting house price *growth* may result in welfare gains.

Keywords: Financial Accelerator, Diagnostic Expectations, Optimal monetary policy, Instrument rules.

JEL Classification: E32, E44, E52, E71.

*We thank Francesco Bianchi, Dirk Muir, Ruy Lama, Marcin Kolasa, Fabian Lipinsky, and participants of the ICD Seminar for useful comments. The views expressed in this draft paper are those of the authors and do not necessarily represent the views of the IMF, its Executive Board, or its Management.

[†]International Monetary Fund, Washington D.C. USA.

Contents

1 Introduction

Economies experience recurrent business cycle fluctuations. The lead up to the Global Financial Crisis (GFC) of 2008-2009 saw an unprecedented rise in mortgage debt amid a boom in property prices which was then followed by asset price declines, deleveraging, and a severe recession.[1] The drivers and aggravating factors underlying such harsh economic contractions continue to be actively debated in policy circles and in academia.

A long-standing tradition in macroeconomics, traced back to Fisher (1933) and Keynes (1936), gives a central role to financial frictions in generating business cycle fluctuations. Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) argue that turbulent business cycle fluctuations are a result of shocks being amplified by financial frictions. More generally, according to this view, deteriorating financial conditions are not just a passive reflection of an economic decline, but are themselves a major factor depressing economic activity.

An alternative view argues that non-rational beliefs are a key driver of macro-financial instability. Based on the work of Minsky (1977) and Kindleberger (1978), proponents argue that during good times, investors are too optimistic, resulting in an overexpansion of credit and investment. When sentiment sours, however, financial conditions tighten and economic activity falters. In fact, recent studies present evidence rejecting the pure version of the rational expectations hypothesis. These studies note that the expectations of professional forecasters, corporate managers, consumers, and investors appear to be systematically biased in the direction of an overreaction to news (Bordalo et al., 2020).[2] In other words, beliefs are too optimistic in good times, and too pessimistic in bad times. Put differently, this literature argues that the overreaction of beliefs can account for macroeconomic boom-bust cycles.

In this paper, we synthesize both views by assessing how a combination of financial frictions and non-rational beliefs can account for business cycle fluctuations. We adapt a well-known New Keynesian model with financial frictions by introducing Diagnostic expectations (DE)—a depar-

[1]See, for example, Cardarelli et al. (2011), Jorda et al. (2016), or Shiller (2016), among many others.

[2]For studies challenging the rational expectations hypothesis, see, for instance, Souleles (2004), Vissing–Jorgensen (2003), Mankiw et al. (2003), as well as Bordalo et al. (2022).

ture from rational expectations (RE)—which allows for an overreaction of beliefs. Specifically, we modify the framework developed by Iacoviello (2005) where financial frictions are modeled as collateral constraints tied to housing values. This framework is then augmented with DE, as developed by Bordalo et al. (2018), to model non-Bayesian beliefs that accounts for a broad range of well-documented departures from rationality. Under DE, good news leads an agent to focus on favorable future outcomes (such as an economic expansion), causing excessive optimism, and vice versa. This dynamic results in excessively volatile expectations and, consequently, more pronounced business cycle fluctuations.

The financial accelerator mechanism is intuitive: A monetary contraction that raises the policy rate, leads to lower output, inflation, and house prices. Lower house prices tighten collateral constraints, reducing entrepreneurial borrowing and activity. This slowdown further depresses house prices, creating a negative feedback loop. In contrast, with supply shocks, output and prices move in opposite directions. Higher inflation thereby reduces the real debt stock, mitigating the shock's impact since borrowers spend more than lenders. This debt deflation channel dampens supply shocks, resulting in financial deceleration.

The introduction of DE amplifies shocks due to volatile expectations. DE combines rational expectations (RE) with an over-weighted response to recent news. For example, a positive income shock leads to overly optimistic future output expectations and overconsumption. This overconsumption is followed by disappointment as expectations adjust to actual outcomes, causing an overreaction in the opposite direction. DE results in a higher marginal propensity to consume compared to RE and strengthens the interest rate, asset price, and debt deflation channels. Accordingly, DE and the financial accelerator (FA) can reinforce each other in the case of demand shocks by strengthening the asset price channel. At the same time, DE strengthens the debt deflation channel, thereby attenuating the impact of supply shocks.

The quantitative implications of introducing DE are significant. Consider a monetary contraction where the policy rate is increased by one percentage point. Under RE, the inclusion of the FA mechanism increases the severity of the immediate economic contraction to -0.8 percent in contrast to the baseline model (RE without FA) which results in a -0.7 percent decline in economic activity. The inclusion of the FA alone has only a muted impact on model dynamics, in line with the critiques of Kocherlakota (2000) and Christiano et al. (2018). By comparison, the incorporation of DE results in much greater shock amplification. For example, in the FA model with DE, the same shock generates a sharp -1.3 percent decline in output. Under alternative calibrations, which strengthen the effect of DE, the impact of both demand and supply shocks can be significantly larger. Moreover, DE combined with FA generate mutually reinforcing shock amplification, especially in the case of demand shocks.

Importantly, the presence of DE worsens the inflation-output volatility trade-off confronting policymakers. This is because, relative to the models with RE, DE results in greater shock amplification. Therefore, at any given level of inflation volatility, the policymaker is faced with a higher level of output volatility, and vice versa, in the DE models relative to the RE models. At the same time, under DE, the desire to reduce inflation volatility implies that policymakers would need to accept even greater levels of output instability as the policy frontier steepens faster relative to the RE case.

Given the deterioration in the policy trade-off, we then explore monetary policy strategies within our modeling framework. Specifically, we compare the consequences of simple policy rules in the presence of DE and financial frictions. The analysis can be summarized as follows: In the baseline model (RE without the FA), the policy rule of flexible inflation targeting (FIT) prevails. In contrast, with DE, a policy rule of price-level targeting (PLT) results in the lowest welfare costs, which is consistent with the optimal monetary policy literature (Woodford, 2003). Turning to the FA models, the analysis indicates that there is no value in targeting the *level* of house prices. This finding corroborates studies that can be traced back to Bernanke and Gertler (1999), among others, who underscore that once movements in inflation (and possibly the output gap) are taken into account, there is no need for monetary policy to respond to asset prices.

Importantly, however, the analysis also suggests that rules which target the *growth* rate of house prices are the best within our modeling framework. The welfare gains are especially notable in the FA model with DE. For instance, in contrast to the next best alternative rule, the analysis indicates a potential welfare gain of over 3 percentage points of steady state consumption. By more aggressively responding to fluctuations in house price growth, this rule seems to strike the right balance by sufficiently suppressing the asset price channel (which dampens the impact of demand shocks) and by taking advantage of the stabilization benefits of a stronger debt deflation channel (which is strengthened under DE and helps attenuate the effects of supply shocks). Although this finding challenges many studies in the literature, it does echo the results of Gilchrist and Saito (2008) who consider the value of targeting equity price growth under imperfect information. A key advantage of targeting asset price *growth* is that the policy maker does not need to make a judgement call regarding the fundamental value of the asset. In this context, targeting the growth of the asset prices thereby renders such a policy more robust. In summary, our modeling framework suggests that although there is no case for targeting the *level* of house prices, there seems to be merit in considering the *growth* of asset prices when formulating a monetary policy strategy.

Literature Review

This paper is related to three broad strands of the literature. First, it examines the macroeconomic implications of financial frictions, as studied by influential works like Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) who endogenize financial market frictions by introducing agency problems between borrowers and lenders. Motivated by the Global Financial Crisis (GFC), more recent studies have included balance sheet constraints on banks.[3] We contribute to this literature by illustrating how the combination of DE and FA can generate mutually reinforcing shock amplification. Hence, our paper addresses the critique that financial frictions have only modest quantitative effects on model dynamics (see, for instance, Kocherlakota (2000), and Christiano et al. (2018)).

Second, this paper explores departures from rational expectations, by focusing on Diagnostic Expectations (DE), as developed by Bordalo et al. (2018).[4] As discussed in the next section, DE models can generate greater macroeconomic fluctuations owing to overreaction by agents. Under DE,

[3]See for example Curdia and Woodford (2011), He and Krishnamurthy (2013), Stein (2010), Gertler et al. (2020), Christiano et al. (2014), and Curdia (2007). For open economy variants, see Gertler et al. (2007) and Elekdag and Tchakarov (2007). Non-linear effects are introduced in Sims et al. (2021), Monacelli (2009), Jermann and Quadrini (2012), Jeanne and Korinek (2019), Brunnermeier et al. (2013), and Gertler et al. (2020). See also Adrian and Shin (2011), Allen and Gale (2007), Diamond and Rajan (2006), and Holmstrom and Tirole (1997). For a survey of the literature, see Gertler and Gilchrist (2018), Brunnermeier et al. (2013), and Gertler and Kiyotaki (2015).

[4]For other approaches, see for example, Mankiw and Reis (2002), Sims (2003), Coibion and Gorodnichenko (2015), and Benchimol and Bounader (2023).

agents are too optimistic after good news, and too pessimistic after bad news. Bordalo et al. (2018) use DE to explain several features of credit cycles and macroeconomic volatility in the spirit of Minsky (1977).[5] Two particularly noteworthy studies are by Bianchi et al. (2023) and L'Huillier et al. (2023), who introduce DE into New Keynesian models.[6] We contribute to this growing literature by investigating how the incorporation of DE into a model with financial frictions affects the desirability of optimal simple monetary policy rules.

Third, this paper contributes to the debate on whether central banks should respond to asset price fluctuations.[7] While some argue that monetary policy should not directly respond to asset prices,[8] others believe that incorporating asset prices into policy can reduce the likelihood of misalignments.[9] Our assessment of optimal simple (monetary policy) rules suggests that there is merit for a central bank to consider targeting house price *growth* rather than the level of house prices.

The paper is organized as follows. Section 2 presents a primer on Diagnostic Expectations (DE), where Section 3 provides an overview of the model. Section 4 contains the main results of the paper and includes subsections covering model dynamics, policy frontiers, simple monetary policy rules, and sensitivity analysis. Concluding remarks are contained in Section 5.

[5]Related studies include Gennaioli et al. (2012), Gennaioli et al. (2012), Jin (2015), Greenwood et al. (2019), Barberis et al. (1998), and Pflueger et al. (2020)

[6]DE has also been used to investigate stock market bubbles Bordalo et al. (2016), stock returns Bordalo et al. (2019), bond yields d'Arienzo (2020), and bond pricing Favero et al. (2023). See also Maxted (2023), Bordalo et al. (2021), and Camous and Van der Ghote (2022).

[7]For surveys, see Smets (2014), Ajello et al. (2016), and IMF (2015).

[8]See Bernanke and Gertler (1999), Bernanke and Gertler (2001), and Gilchrist and Leahy (2002). Korinek and Simsek (2016) and Farhi and Werning (2016) argue that financial stability concerns could be better addressed by macroprudential policies (the "separation principle").

[9]See, for instance, Checchetti et al. (2000), Gourio et al. (2018), and Filardo and Rungcharoenkitkul (2016). Dudley (2015) argues that the separation principle is hard to implement in practice and Stein (2013) notes that monetary policy has broad effects as it "gets in all the cracks" while macroprudential policies may be too narrow.

2 Diagnostic Expectations: A Primer

This section provides an overview of diagnostic expectations. As summarized by Bordalo et al. (2022), there is a growing body of survey-based evidence rejecting the pure version of the rational expectations hypothesis. Therefore, building on Kahneman and Tversky (1972)'s representative heuristic, Bordalo et al. (2018) introduce Diagnostic Expectations (DE) as an alternative to Rational Expectations (RE). Importantly, DE generates enhanced shock amplification owing to excessively volatile expectations, which can help account for significant business cycle fluctuations.

To develop the intuition of DE, consider an agent who must assess the future value of a random variable X conditional on data D. When contemplating the future realization of X given data D, the agent selectively recalls states X that are most similar to the data (relative to other information). In other words, memory is associative in that a given event automatically prompts the retrieval of similar experiences from the past as in Kahana (2012). Importantly, the agent who disproportionately samples such distinctive states then overemphasizes their probability in forming expectations.

Consider an example from Bordalo et al. (2022) where an agent must guess the hair color of a person coming from Ireland (X will consist of the states "red" and "not red", whereas the data, D, is Irish). As the agent considers the likelihood that the hair color is X=red, examples of red-haired Irish come to mind because they are more similar to red hair than other populations (red hair is relatively more frequent in Ireland than in the rest of the world). Consequently, even though the Irish with non-red hair outnumber the red-haired ones, the agent will oversample from memory the red hair color and overestimate its incidence.[10]

DE can be used to formalize expectation formation in dynamics settings. As demonstrated by Bordalo et al. (2018), DE consists of two components: the first is RE, while the second component over-weights news received in the most recent periods. This overweighting of recent news

[10]Consider a numerical example based on Gennaioli and Shleifer (2010). Assume the probability of X=red is 10 percent and 2 percent when D=Irish and D=Not Irish, respectively. Despite the low chance of occurrence, after receiving data D=Irish, red hair color becomes representative (and, indeed, is associated with the highest likelihood ratio among hair colors). This notion of representativeness cause the agents to therefore overestimate the incidence of red hair color.

captures the disproportionate retrieval of states that are associated with the observed news (or incoming data). Therefore, under DE, agents overweight future states whose likelihood increases the most in light of current news relative to what they know already. That is, agents overestimate the probability of a good future state (e.g., an economic expansion) when the current news is good (e.g., a favorable GDP growth data release). A string of improving news leads an agent to focus on good future outcomes and neglect bad ones, causing excessive optimism. When the good news ceases to continue, beliefs cool down (even in the absence of bad news), triggering a reversal that is not driven by a deterioration in news (as expectations are aligned with outcomes). Likewise, a string of bad news leads agents to center on bad future outcomes (and neglect good ones), triggering excessive pessimism. In this way, relative to RE, expectation formation under DE is excessively volatile.

Following Bordalo et al. (2018), DE can be formalized as follows. Consider a standard AR(1) process: $z_t = \rho z_{t-1} + \varepsilon_t$.[11] The diagnostic distribution is then:

$$f_t^{\theta}(z_{t+1}) = f\left(z_{t+1}|z_t = \check{z}_t\right)\left[\frac{f\left(z_{t+1}|z_t = \check{z}_t\right)}{f\left(z_{t+1}|z_t = \rho\check{z}_{t-1}\right)}\right]^{\theta} C$$

where $\check{z}_t$ denotes the realization of z_t, c is a constant ensuring the distribution integrates to unity, and $\theta \geqslant 0$ is the "diagnosticity" parameter.[12] When $\theta = 0$ we have RE, whereas when $\theta > 0$, RE is distorted by the likelihood ratio governed by the diagnosticity parameter. Importantly, the distribution is conditional on two elements: First, it is conditional on the current realization of z_t (written as $\check{z}_t$ since it enters the true distribution of z_{t+1}). Second, it is conditional on the reference event, $z_t = \rho\check{z}_{t-1}$, which depends on the realization at $t-1$, $\check{z}_{t-1}$. Importantly, and central to the paper, as shown in Bordalo et al. (2018), the following tractable formula can be obtained:

[11] Where $\varepsilon_t \sim N\left(0,\sigma^2\right)$, $\rho \in [0,1)$, $f\left(z_{t+1}|z_t\right) \propto \varphi\left(\frac{(\rho z_{t-1}+\varepsilon_t)}{\sigma}\right)$, where $\varphi(.)$ is the density of a standard normal distribution. Here we also assume J=1, that is the lagged RE reference group gets revised after one period. Later, in line with Bianchi et al. (2023), we relax this assumption.

[12] Following Bordalo et al. (2018), we also assume that the reference event carries no news. That is, beliefs about z_{t+1} are formed conditional on the even that the random variable z_t, conditional on the past realization $\check{z}_{t-1}$ is what it was expected to be, which is equivalent to $z_t = \rho\check{z}_{t-1}$ $(\varepsilon_t = E\left[\varepsilon_t\right] = 0)$.

$$\mathbb{E}_t^{\theta}\left[z_{t+1}\right] = \mathbb{E}_t\left[z_{t+1}\right] + \theta\left(\mathbb{E}_t\left[z_{t+1}\right] - \mathbb{E}_{t-1}\left[z_{t+1}\right]\right)$$

Again, with $\theta = 0$, RE holds. Note that, occasionally, the term on the right, $\left(\xi_{t+1}^{z} = \mathbb{E}_t\left[z_{t+1}\right] - \mathbb{E}_{t-1}\left[z_{t+1}\right]\right)$, will be called the surprise (the deviation between the RE term and the reference expectation, $\mathbb{E}_{t-1}\left[z_{t+1}\right]$). Importantly, the surprise is the outcome of the time needed (initially set to one period) for the revision of the reference expectations (which therefore responds to shocks with a one-period lag). After a shock, diagnostic beliefs will overreact by a factor $\theta > 0$ to this surprise term, but then dissipate once the reference expectation is revised.[13] Mechanically, the transmission of shocks under RE will be augmented by surprise terms. In turn, these surprises will themselves interact dynamically with the rest of the model and thereby generate additional endogenous shock propagation resulting in greater business cycle fluctuations.

3 Model Overview

The modeling framework follows the tradition of Kiyotaki and Moore (1997) and Bernanke et al. (1999). In particular, we build upon the New Keynesian financial accelerator model popularized by Iacoviello (2005) in several dimensions, most notably through the introduction of diagnostic beliefs as a departure from rational expectations.[14]

Given the model is well-known, we only provide an overview which is complemented by further details in the appendix. The discrete time, infinite horizon economy consists of four key types of agents: (1) patient households, (2) (impatient) entrepreneurs (with lower discount rates relative to the households), (3) retailers, and (4) a central bank. The en-

[13] Consider an analogous AR(1) process w_t note the following (and see appendix for details): $\mathbb{E}_t^{\theta}\left[z_{t+r} + w_{t+s}\right] = \mathbb{E}_t^{\theta}\left[z_{t+r}\right] + \mathbb{E}_t^{\theta}\left[w_{t+s}\right] for, s \geqslant 0$. While $\mathbb{E}_t^{\theta}\left[z_{t+1} + w_{t-1}\right] = \mathbb{E}_t^{\theta}\left[z_{t+1}\right] + w_{t-1}$, note the following: $\mathbb{E}_t^{\theta}\left[z_{t+1} + w_t\right] \neq \mathbb{E}_t^{\theta}\left[z_{t+1}\right] + w_t$. The intuition is the DE introduces behavioral inattention whereby predetermined variables are observed with a lag (in this case, one lag). The implies that predetermined variables cannot be treated as constants. Likewise, while $\mathbb{E}_t^{\theta}\left[Z_{t+1} W_{t-1}\right] = \mathbb{E}_t^{\theta}\left[Z_{t+1}\right] W_{t-1}$, again note that $\mathbb{E}_t^{\theta}\left[Z_{t+1} W_t\right] \neq \mathbb{E}_t^{\theta}\left[Z_{t+1}\right] W_t$.

[14] Importantly, recall that DE nests RE, that is, under $\theta = 0$, RE prevails. Initially we consider the case where $J = 1$ (a one-period revision lag), for ease of exposition. The sensitivity analysis conducted below considers the implications of alternative parameterizations.

trepreneurs produce a homogenous good by hiring labor and combining it with collateralized real estate which underpins the model's financial accelerator mechanism.

3.1 Patient Households

Patient households (denoted with superscript "P") choose consumption, housing, (labor) hours, and lending ($C_t^P, H_t^P, L_t^P, B_t^P$) to maximize utility:

$$U_t^P = log(C_t^P) + \phi_t^P log(H_t^P) - \frac{(L_t^P)^\eta}{\eta}$$

subject to the following (nominal) budget constraint:

$$P_t C_t^P + Q_t H_t^P + R_{t-1} B_{t-1}^P \leqslant B_t^P + W_t L_t^P + Q_t H_{t-1}^P + P_t F_t - P_t T_t^P$$

where $P_t, Q_t, R_t, W_t, F_t, T_t^P$ denote the price level, the price of housing, nominal interest rate, wages, profits (from retailers), and transfers; ϕ_t^P is a housing preference parameter. Because the labor supply condition is standard (see Appendix A), here we focus on the other two first-order conditions (FOCs). Consider first the FOC with respect to consumption:

$$\frac{1}{\pi_t}\frac{1}{C_t^P} = \beta \mathbb{E}_t^\theta \left[\frac{1}{C_{t+1}^P} \frac{R_t}{\pi_{t+1}} \frac{1}{\pi_t} \right]$$

Under DE, this consumption Euler equations differs from a more standard presentation in two related ways. First, via the DE operator, $\mathbb{E}_t^\theta[.]$, and second through the inclusion of the inflation terms, $\pi_t = \frac{P_t}{P_{t-1}}$. Regarding the former, under DE, the expected consumption and inflation terms will be accompanied by surprise terms (as discussed in greater detail below). As for the second difference, recall that under DE, the reference distribution depends on variables being observed with a lag (and therefore, in this case, previously held beliefs at date $t-1$ constitute a state variable). Hence, and in contrast to RE, one cannot multiply by P_t on both sides of the equation and introduce P_t within the DE operator (as emphasized by Bianchi et al. (2023), and L'Huillier et al. (2023)).[15] As will be discussed

[15]Note the following, where both sides are multiplied by P_{t-1} (which can be introduced within the DE operator):

below, these π_t terms will influence the real interest rate and generate an additional mechanism that further augments model dynamics.

Regarding the FOC for housing, note the incorporation of DE operator:

$$\frac{q_t}{C_t^P} = \frac{\phi^P}{H_t^P} + \beta \mathbb{E}_t^\theta \left[\frac{q_{t+1}}{C_{t+1}^P} \right]$$

where $q_t = \frac{Q_t}{P_t}$. The marginal utility cost of purchasing more housing is equated with the marginal utility of having more housing and the expected extra future utility from having purchased housing earlier (which is valued by β / C_{t+1}^P). Note that, under DE, the expected real house price will be accompanied with a surprise term.

3.2 Entrepreneurs

Entrepreneurs produce an intermediate good, Y_t^w, using their stock of real estate and labor:

$$Y_t^w = A_t (H_{t-1}^E)^\nu (L_t^E)^{1-\nu}$$

Intermediate output is sold to retailers at price, P_t^w, before being available for consumption at price P_t, where, $X_t = \frac{P_t}{P_t^w}$, is the markup; A_t denotes total factor productivity (TFP).

Entrepreneurs choose $C_t^E, H_t^E, L_t^E, B_t^E$ to maximize utility with discount factor, $\gamma < \beta$:

$$U_t^E = log(C_t^E)$$

Subject to the following (nominal) budget constraint:

$$P_t^w Y_t^w - W_t L_t^E + B_t^E + Q_t H_{t-1}^E \leqslant P_t C_t^E + Q_t H_t^E + R_{t-1} B_{t-1}^E$$

And the collateral constraint:[16]

$$\frac{P_{t-1}}{P_t} \frac{1}{C_t^P} = \beta \mathbb{E}_t^\theta \left[\frac{R_t}{C_{t+1}^P} \frac{P_t}{P_{t+1}} \frac{P_{t-1}}{P_t} \right]$$

[16] Note that the collateral constraint applies to nominal asset holdings (versus those that are indexed).

$$B_t^E \leqslant m\mathbb{E}_t^\theta \left[\frac{Q_{t+1}H_t^E}{R_t}\right]$$

Again, because the labor supply condition is standard, we focus on the two other FOCs and the collateral constraint:

$$\frac{1}{\pi_t}\frac{1}{C_t^E} = \gamma\mathbb{E}_t^\theta \left[\frac{1}{C_{t+1}^E}\frac{R_t}{\pi_{t+1}}\frac{1}{\pi_t}\right] + \lambda_t$$

$$\frac{q_t}{C_t^E} = \gamma\mathbb{E}_t^\theta \left[\frac{1}{C_{t+1}^E}\left(\frac{\nu Y_{t+1}}{X_{t+1}H_t^E} + q_{t+1}\right)\right] + m\lambda_t\mathbb{E}_t^\theta \left[q_{t+1}\frac{\pi_{t+1}}{R_t}\pi_t\right]$$

$$\pi_t b_t^E = m\mathbb{E}_t^\theta \left[q_{t+1}H_t^E\frac{\pi_{t+1}}{R_t}\pi_t\right]$$

The entrepreneur's consumption Euler equation is similar to that of the patient households, but now includes the Lagrange multiplier (λ_t) associated with the borrowing constraint (which indicates how much more could be borrowed and consumed by marginally relaxing the constraint). The entrepreneur's asset pricing equation for housing differs in that the price of housing is equated with the expected (discounted) marginal product of housing ($\nu Y_{t+1}/X_{t+1}H_t^E$) and its continuation value; the final term denotes the amount by which more housing relaxes the collateral constraint.

The borrowing constraint stipulates that the entrepreneur cannot borrow more than the discounted expected value of future housing (where $q_{t+1}H_t^E$ serves as collateral). Importantly, notice that the fluctuations in house prices and interest rates will affect the maximum amount the entrepreneur can borrow (and thereby consume). The parameter, m, could be interpreted as a loan-to-value (LTV) ratio. As in the Euler equations, under DE, the borrowing constraint also includes additional inflation terms. Importantly, under DE, in the Euler equations and the borrowing constraints, the expected consumption, inflation, and the (real) house price will be accompanied by surprise terms, which will generate additional endogenous shock propagation.

Financial acceleration versus deceleration

The borrowing constraint is convenient in terms of conveying the intuition of the financial accelerator. Consider, for example, a monetary policy shock, which will be discussed further below. Along with the rise in (real) interest rates, inflation, output, and house prices will all decline, and together, will tighten the collateral constraint and thereby suppress entrepreneurial borrowing and activity. The economic slowdown will in turn further push down house prices and reinforce the economic contraction resulting in a vicious cycle. This is the well-known financial accelerator mechanism. This accelerator effect, which generates greater endogenous shock propagation, is prevalent in the case of demand shocks where output and prices are positively correlated. In contrast, the dynamic differs in the case of supply shocks where output and prices move in opposite directions. When subjected to supply shocks, despite the tightening of the borrowing constraint associated with lower output and house prices, the spike in inflation will reduce the real stock of debt and help cushion the impact of the shock on the economy. In this case the debt deflation channel, by dampening the shock, is associated financial deceleration.

3.3 Final goods and retailers

The final goods producers and retailers are included to motivate sticky prices. Following Bianchi et al. (2023), as well as L'Huillier et al. (2023), we assume that retailers are subject to adjustment cost as in Rotemberg (1982).[17] This results in a familiar (log-linearized) New Keynesian Phillips curve, but with DE:

$$\hat{\pi}_t = \beta \mathbb{E}_t^{\theta} \left[\hat{\pi}_{t+1} \right] - \frac{(\epsilon - 1)}{\psi} \hat{x}_t + \varepsilon_t^{\pi}$$

where the "hats" denote deviations from the steady state, and, ε_t^{π}, is a cost push shock. Under DE, expected inflation will be associated with a surprise, which will endogenously increase the variability of this term.

[17] It is well known that the log-linearized Phillips Curve are observationally equivalent under Calvo (1983) vs Rotemberg (1982) models, see, for example, Lombardo and Vestin (2008)

3.4 Central Bank

The central bank implements the following (linearized) interest rate rule to meet its stabilization objectives:

$$\hat{R}_t = \rho_R \hat{R}_{t-1} + (1-\rho_R)\left(\omega_\pi \hat{\pi}_t + \omega_Y \hat{Y}_t\right) + \varepsilon_t^R$$

As will be discussed below, this baseline rule will be modified to accommodate additional policy considerations, such as house prices dynamics.

3.5 Model Dynamics Under Diagnostic Expectations

We now investigate the implications of introducing diagnostic expectations (DE) into the modeling framework. It will be useful to discuss the log-linearized consumption Euler equation under DE (where we consider the more familiar variant for the patient households):

$$\mathbb{E}_t^\theta\left[\hat{C}_{t+1}^P\right] - \hat{C}_t^P = \mathbb{E}_t^\theta\left[\hat{R}_t - \hat{\pi}_{t+1} - \hat{\pi}_t\right] - \hat{\pi}_t$$

We consider each side of the Euler equation in turn. On the left, recalling the properties of the DE operator, $\mathbb{E}_t^\theta\left[\hat{C}_{t+1}^P\right]$, can be recast as follows: $\mathbb{E}_t^\theta\left[\hat{C}_{t+1}^P\right] = \mathbb{E}_t\left[\hat{C}_{t+1}^P\right] + \theta\left(\mathbb{E}_t\left[\hat{C}_{t+1}^P\right] - \mathbb{E}_{t-1}\left[\hat{C}_{t+1}^P\right]\right)$, where the surprise in expected consumption is $\mathbb{E}_t\left[\hat{C}_{t+1}^P\right] - \mathbb{E}_{t-1}\left[\hat{C}_{t+1}^P\right]$. To help simplify exposition, define the surprise term as follows: $\xi_{t+1}^{C^P} = \mathbb{E}_t\left[\hat{C}_{t+1}^P\right] - \mathbb{E}_{t-1}\left[\hat{C}_{t+1}^P\right]$. Note that the reference expectation, $\mathbb{E}_{t-1}\left[\hat{C}_{t+1}^P\right]$, takes one period to be revised—that is, under the case where J=1 (where J is the time lag over which the RE revision is defined), it will respond with a one-period lag to shocks. The difference between the rational expectation and the reference expectation is equivalent to the surprise in expected consumption and underpins the overreaction of consumption to shocks.

Turning to the right side of the equation note that, $\mathbb{E}_t^\theta\left[\hat{\pi}_{t+1}\right]$, can be reformulated as $\mathbb{E}_t^\theta\left[\hat{\pi}_{t+1}\right] = \mathbb{E}_t\left[\hat{\pi}_{t+1}\right] + \theta\xi_{t+1}^\pi$, where $\xi_{t+1}^\pi = \mathbb{E}_t\left[\hat{\pi}_{t+1}\right] - \mathbb{E}_{t-1}\left[\hat{\pi}_{t+1}\right]$ denotes the surprise in expected inflation. At the same time, under DE, log-linearization introduces the right-most term, $\theta\left(\mathbb{E}_t\left[\hat{\pi}_t\right] - \mathbb{E}_{t-1}\left[\hat{\pi}_t\right]\right) = \theta\xi_t^\pi$, which is the surprise in current inflation (scaled by factor θ) which introduces additional dynamics to the model. Using this reformulation results in the following:

$$\underbrace{\mathbb{E}_t^{\theta}\left[\hat{C}_{t+1}^{P}\right]-\hat{C}_t^{P}}_{\mathbb{E}_t\left[\Delta\hat{C}_{t+1}^{P}\right]+\xi_t^{C_{t+1}^{P}}}=\underbrace{\mathbb{E}_t^{\theta}\left[\hat{R}_t-\hat{\pi}_{t+1}\right]-\theta\xi_t^{\pi}}_{\mathbb{E}_t\left[\hat{RR}_{t+1}\right]+\theta\xi_t^{R_t}-\theta\xi_t^{\pi_{t+1}}-\theta\xi_t^{\pi_t}}$$

where $\hat{RR}_{t+1}=\hat{R}_t-\hat{\pi}_{t+1}$.

Therefore, under DE, the left-hand side of the Euler equation, entails expected consumption growth augmented by the surprise in expected consumption ($\xi_{t+1}^{C^P}$). At the same time, on the right-hand side, the ex ante real interest rate is augmented by three surprise terms (ξ_t^{R}, ξ_{t+1}^{π}, and ξ_t^{π}). Therefore, although the Euler equation bears semblance to the standard formulation under RE, the inclusion of the surprise terms will generate additional endogenous model dynamics.

For instance, and as noted in Bianchi et al. (2023) under DE, the marginal propensity to consume is higher relative to RE. This is because any shock that boosts current income results in an overly optimistic view of future output leading to overconsumption (including because of the consumption surprise term). However, the initial bout of overconsumption is eventually followed by disappointment even in absence of bad news because the reference expectation is revised in line with outcomes. Again, there is an overreaction, but in the opposite direction as agents cuts consumption (more forcefully than under the RE case).

If this boost in current income was associated with higher inflation, as in the case of a demand shock, the real interest rate will be influenced by the surprise terms. For instance, the surprise in expected inflation would be an additional factor lowering the real interest rate. At the same time, the surprise in current inflation (ξ_t^{π}) would further reduce the real rate and functions as an additional expansionary channel. Taken together, and abstracting from monetary policy at the moment, the consumption and inflation surprise terms interact synergistically to generate larger swings in consumption growth. Importantly, the incorporation of the financial accelerator mechanism strengthens this dynamic and brings about even larger business cycles fluctuations.

The fact that DE can strengthen the dynamics of inflation will be particularly important in the case of supply shocks. This is because DE significantly strengthen the debt deflation channel owing to the surprises in expected and current inflation. In fact, in the model with the FA, the debt deflation channel can actually dampen shocks by reducing entrepreneurs' debt burden.

3.6 Model Parameterization

The parameterization of the model is based on Iacoviello (2005), but with some exceptions, as shown in **Table 1**. Because we use Rotemberg (1982) pricing instead of its Calvo (1983) counterpart, we need to pin down an elasticity of substitution for intermediate goods and a price adjustment parameter. The former is set to 11, resulting in a steady state markup of 10 percent which is in line with many studies, whereas the latter is set to 100 which is the same value used in other papers, including Bianchi et al. (2023). The two key parameters that underpin the strength of DE are J (which controls the time lag over which the RE revision is defined) and the diagnosticity parameter, θ. We initially choose conservative parameter values. Specifically, $J = 1$ and $\theta = 0.75$ in line with Bordalo et al. (2018) and L'Huillier et al. (2023). For the monetary policy rule, for our benchmark parameterization, we set the weight on inflation, output, and the interest rate smoothing terms to, 2, 0.12, and 0.73, respectively. The calibration of the shocks processes is also summarized at the end of the table. We consider an array of sensitivity tests that consider alternative parameterization that underpin the strength of DE, the source of exogenous variation, and, for instance, monetary policy rules.

Table 1: Model parameters

Description	Parameter	Value
Discount factors		
Patient household	β	0.99
Entrepreneurs	γ	0.98
Weight on housing (services)	ϕ	0.03
Labor supply aversion	η	1.01
Housing share	ν	0.1
Elasticity of substitution	ϵ	20
Price adjustment cost	ψ	140
Loan-to-value ratio	m	0.89
Diagnosticity parameter	θ	0.75
Monetary policy rule		
Weight on inflation	ω_π	1.5
Weight on output gap	ω_Y	0.12
Interest rate smoothing	ρ_R	0.73
Shocks		
Monetary policy		
Standard deviation	σ_R	0.25
Persistence	ρ_R	0.25
Cost push		
Standard deviation	σ_P	0.25
Persistence	ρ_P	0.9
Total factor productivity		
Standard deviation	σ_A	0.25
Persistence	ρ_A	0.9
Housing preference		
Standard deviation	σ_H	0.25
Persistence	ρ_H	0.9

4 Main Results

This section presents four key results. First, the New Keynesian model we developed which combines diagnostic expectations (DE) with the financial accelerator (FA) generates mutually reinforcing shock amplification. In particular, the model brings about in significant demand shock magnification. However, supply shocks can be dampened via a debt deflation channel which is strengthened amid DE. Second, and importantly, the model results in a worsening of the inflation-output volatility tradeoff confronting policymakers. Third, and in contrast to broadly accepted conventional wisdom—which argues against targeting the *level* of asset prices—our simulations suggest that targeting house price *growth* may result in notable welfare gains. Fourth, and finally, this finding appears robust to alternative parameter calibrations and sensitivity exercises.

4.1 Model Dynamics: The Financial Accelerator and Diagnostic Expectations

To understand the dynamic properties of the model, we focus on the monetary policy shock, but also consider the implications of the cost-push shock.[18] We start off with the presumption that rational expectations (RE) hold and compare a baseline model without the financial accelerator (FA) with a model with the FA. This comparison replicates the findings in earlier studies and showcases the role of the FA. We then contrast the baseline model with a version with diagnostic expectations (DE). The differences between these two models illustrates the role of DE. Lastly, we compare the baseline model with a version under DE and FA. This comparison highlights the dynamics associated with the combination of financial frictions together with a departure from rational expectations.[19]

Monetary Policy Shocks

Figure 1 depicts the reaction of key macroeconomic variables to a contractionary monetary policy shock. Assuming rational expectations, RE, we contrast models with and without the FA. Given sticky prices, the higher nominal interest rate raises the real interest rate and discourages current consumption and suppresses output (the interest rate channel).

[18] Appendix B discussed TFP and housing preferences shocks.

[19] In summary, at this stage, we are contrasting four models: (i) baseline: RE without the FA (RE NFA), (ii) the FA model under RE (RE FA), (iii) the DE model without the FA (DE NFA), and (iv) the FA under DE (DE FA).

In the FA model, the contraction in economic activity is reinforced by a decline in house prices (the asset price channel). At the same time, lower inflation raises the real cost of debt service, further depressing entrepreneurial consumption (the debt deflation channel). Importantly, in the FA model, all three channels work in the same direction and tighten the entrepreneurial collateral constraint. In turn, the tighter constraint further reduces output, inflation, and house prices, thereby setting in motion an adverse feedback loop (the financial accelerator, FA, mechanism).

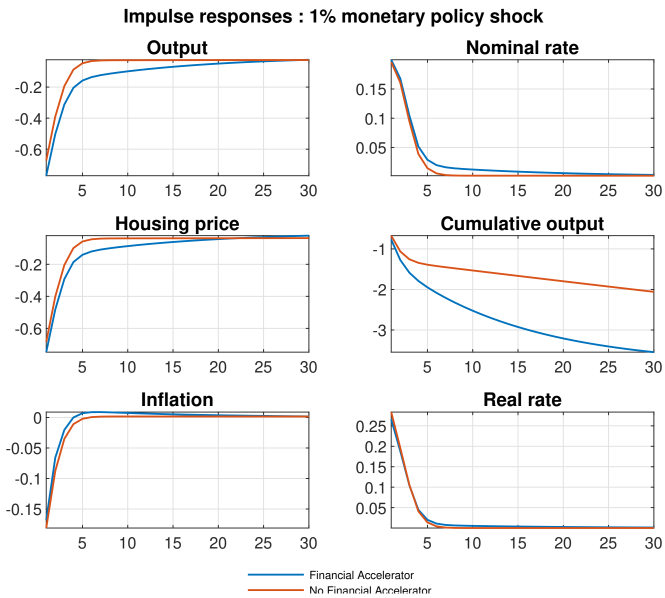

Figure 1: Impulse Responses of a Monetary Policy Shock under Rational Expectations: Financial Accelerator vs. No Financial Accelerator

Quantitatively, the one percent (annualized) monetary policy shock brings about a -0.7 percent decline in output upon impact in the baseline model. The output response in the model with the FA is -0.8 percent. Although the cumulative output responses show starker differences (-2 percent decline in output under the baseline versus -3.5 after 30 quarters), the inclusion of the FA does not amplify the shock materially. This result echoes the insight of Christiano et al. (2018) who note that the addition of financial frictions alone has only modest quantitative effects on model dynamics.[20] In fact, Kocherlakota (2000) argues that models with credit constraints of the type in Kiyotaki and Moore (1997) have only negligible

[20]Similar points have been made by Brzoza-Brzezina and Kolasa (2013), as well as

effects on dynamic responses to shocks. This critique is a reason motivating the inclusion of diagnostic expectations (DE) as a way to generate greater shock amplification.

Figure 2 also considers a monetary tightening, but contrasts the baseline RE model with a version with DE. Recall that in this comparison, the FA mechanism is not operational. The additional amplification resulting from the introduction of DE is clear. While output declines by about -0.7 percent in the baseline model, under DE, the ensuing recession is deeper with output declining almost twice as much (-1.2 percent).

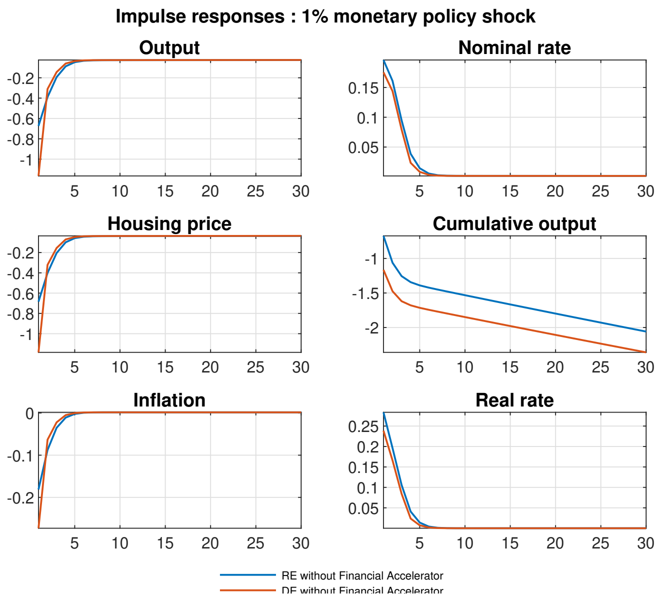

Figure 2: Impulse Responses of a Monetary Policy Shock: Rational Expectations without Financial Accelerator vs. Diagnostic Expectations without Financial Accelerator

In the DE model, there are several mechanisms at play that generate shock amplification. First, the rise in real interest rates discourages current consumption to a greater extent as agents overreact to the incoming news. In line with the intuition associated with DE, the negative surprise makes agents overly pessimistic about their future economic prospects.

Linde et al. (2016). Reasons for this result have been well documented, and include, for example, the use of linearized models and collateral constraints that are always binding. The literature has considered models that relax these assumptions, and have also resorted to models with a greater array of real and nominal frictions to better match empirical business cycle fluctuations.

At the same time, the overreaction associated with inflation (expected and current inflation surprises) brings about a deflation that results in an unfavorable wealth effect that further discourages consumption).[21] In summary, under DE, the effective marginal propensity to consume is larger relative to the RE case.

Figure 3 contrasts the baseline RE model with a version that combines the FA and DE. It should not be surprising that the combination of the FA mechanism under DE yields even greater shock amplification. As shown in the figure, in response to the monetary tightening, the FA model with DE generates a significant economic contraction of -1.3 percent upon impact (versus -0.7 under the baseline model RE model without the FA). The differences in cumulative output are also appreciable. There are two related mechanisms at work: First, DE strengthens the asset price channel. Second, the shock amplification properties of the FA bring about larger surprises which then lead to even greater overreaction. In turn, this overreaction yields an even a sharper decline in house prices for example, which then further compounds the FA dynamic. Taken together, the DE and FA generate mutually reinforcing feedback dynamic that results in monetary policy shock amplification and heightened macroeconomic volatility.

[21] In the current case with J=1, the bout of pessimism lasts for one period after which expectations are revised, resulting in a faster economic rebound.

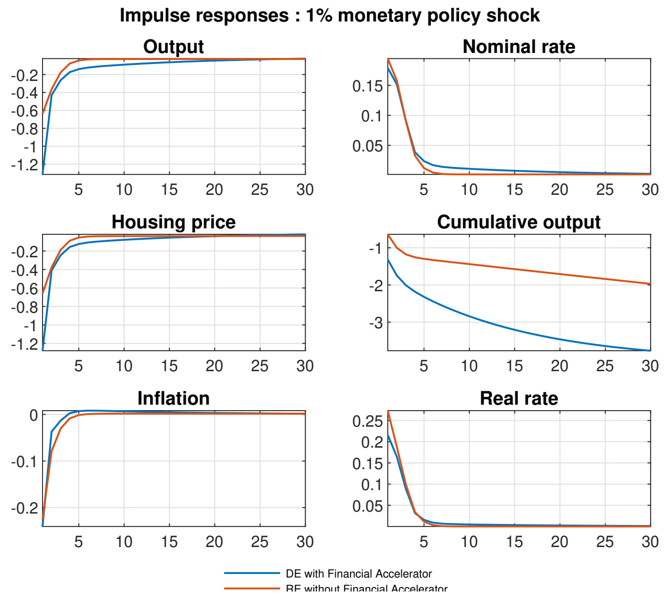

Figure 3: Impulse Responses of a Monetary Policy Shock: Rational Expectations without Financial Accelerator vs. Diagnostic Expectations with Financial Accelerator

Impulse Responses of a Cost-Push Shock

Figure 4 displays a cost-push shock—a canonical supply shock. Under the baseline RE model, amid rising prices, the monetary policy stance becomes increasingly restrictive. The ensuing rise in the real interest rate facilitates a decline in inflation by suppressing aggregate demand. The sharp rise in inflation transfers wealth—via the debt deflation channel—from lenders (patient households) to borrowers (entrepreneurs), who, all things equal, have a higher propensity to consume. This wealth effect is more pronounced amid financial frictions because higher inflation loosens the collateral constraint allowing the entrepreneurs greater flexibility to absorb the shock. More generally, whereas the model with the FA amplifies the effects of demand shocks (where inflation and output move in the same direction), it dampens the impact of supply shocks (where output and inflation move in opposite directions). That is, the financial frictions feature an accelerator of demand shocks and a decelerator of supply shocks as noted in Iacoviello (2005).

Under DE, the cost-push shock has a larger impact on output and inflation, and result in a more severe stagflationary scenario—note the sharper

Figure 4: Cost-Push Shock

rise in inflation combined with a deeper recession. As in the RE case, with DE, the differences between the models with and without the FA are hard to discern, again owing to the debt deflation channel. The initial spike in prices is associated with an overreaction in expected inflation and augmented by the surprise in current inflation which result in an even stronger debt deflation channel helping to further dampen the impact of the shock. The strength of the debt deflation channel amid DE is going to be a recurrent theme in this paper. In the case of cost-push shocks, although the model with DE results in greater overall shock amplification relative to the RE model, the effects of the FA can be harder to discern under our baseline calibration.

Diagnostic Expectations and the Financial Accelerator: Mutually Reinforcing Dynamics

To further understand the implications of diagnostic expectations (DE), including when combined with the financial accelerator (FA), we conduct an array of sensitivity tests. Note that our baseline calibration of the parameters that underpin DE was on the lower end of estimates used in other studies ($\theta = 0.75, J = 1$). Recall that θ is the factor that determines the degree of overreaction to surprises (that is, the extent to which DE deviate from RE). The parameter J pins down the time lag over which RE revisions occur, whereby values greater than unity denote more distant memory recall. We now consider alternative calibrations and investigate the implications on the response of output to monetary and cost push shocks.

Figure 5 summarizes multiple sensitivity tests.[22] In addition to the baseline calibration, it plots the troughs of the economic contractions associated with monetary policy and cost-push shocks across the four models (RE, DE, with and without the FA) under the following alternative parameterizations: $J \in \{1, 4\}$ and $\theta \in \{1, 2\}$. As would be expected, more distant memory and $\theta > 1$, result in more severe recessions.

Importantly, there is mutually reinforcing shock amplification. The inclusion of the FA results in greater monetary policy shock amplification as it synergistically interacts with DE, including by magnifying the strength of the asset price channel. Consider the case of $J = 4$ and $\theta = 2$, which is line with the empirical estimates provides by Bianchi et al. (2023).[23] The sum of the individual contributions from the FA and DE effects worsens the recession by an additional -1.9 percentage points relative to the baseline model. In contrast, the combined effects of the model with the FA and DE decreases output by an additional -2.5 percentage points. That is, the whole (the combination of DE and FA) is greater than the sum of its parts.[24] More distant memory and higher values of theta can have a disproportionate impact on output in the case of cost push shocks. The mutually reinforcing shock amplification in the case of these supply shocks is not as strong as in the case of demand shocks.

4.2 How do Diagnostic expectations affect the output and inflation trade-off?

The previous section illustrated how diagnostic expectations (DE) amplify the impact of shocks on output and inflation. Shocks that result in a negative correlation between output and inflation force the central bank to confront a trade-off between output and inflation volatility. Assessing how DE affects this trade-off is therefore a natural question to ask. To address this question, we compute inflation-output volatility frontiers for alternative parameterizations of a central bank loss function which, initially, only

[22] The individual impulse response functions are available upon request.

[23] Bianchi et al. (2023) find $\theta \approx 2$ and have advocated for more distant memory ($J > 1$).

[24] As shown in the figure, FA results in an output decline of -0.8 percent versus -0.7 percent under the baseline model, a difference of 0.1 percentage points. DE (with $\theta = 2$, $J = 4$) results in a decline of -2.5, or a different of 1.8 percentage points. The sum is -1.9. However, the model with DE and FA results in an output decline of -3.1 percent. The difference versus the baseline model is -2.5 percentage points.

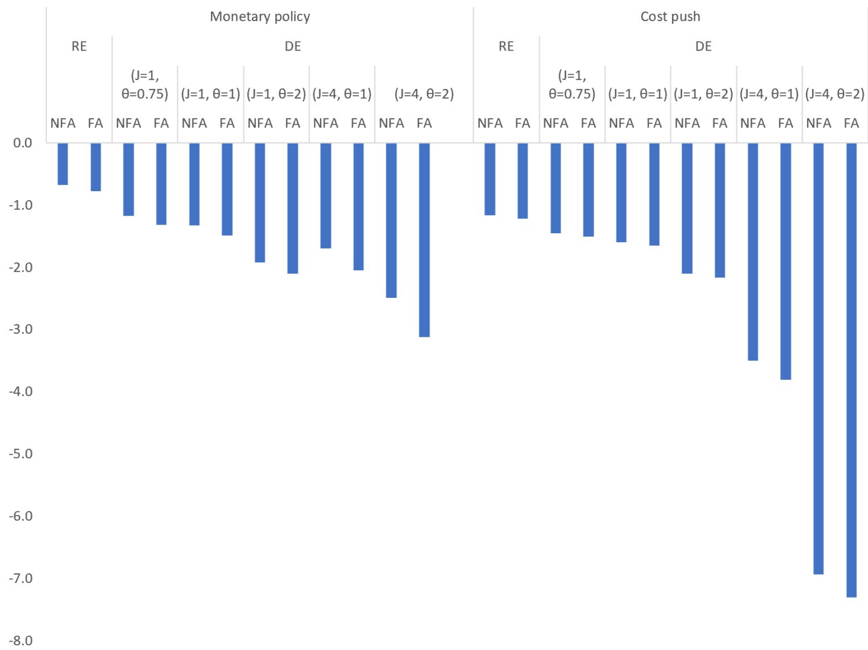

Figure 5: Summary results for various models and parameters

assumes that output and inflation volatility are the only two monetary policy objectives. These policy frontiers are computed for each of the four models.[25]

The policy frontier is constructed by positing a quadratic loss function, for example:

$$L = \Lambda Var(\hat{\pi}_t) + (1 - \Lambda)Var(\hat{Y}_t)$$

where Λ is a preference parameter. Given a value for this parameter, the solution corresponds to an optimal control problem in which the interest rate path is chosen to place the economy at the point on the variability frontier that minimizes the loss. Formally, we compute the policy reaction function that minimizes the loss, subject to the constraint that is imposed by the structure of the economy. The location of the efficiency frontier depends on the variability of aggregate supply shocks: the smaller such variability, the closer the frontier will be to the origin; while the slope of the frontier is determined by the structure of the economy.

Figure 6 plots two policy frontiers: the first is derived from the baseline

[25]Recall that these models were the: (i) baseline model under RE without the FA (RE NFA), (ii) the FA model under RE (RE FA), (iii) the DE model without the FA (DE NFA), and (iv) the FA under DE (DE FA).

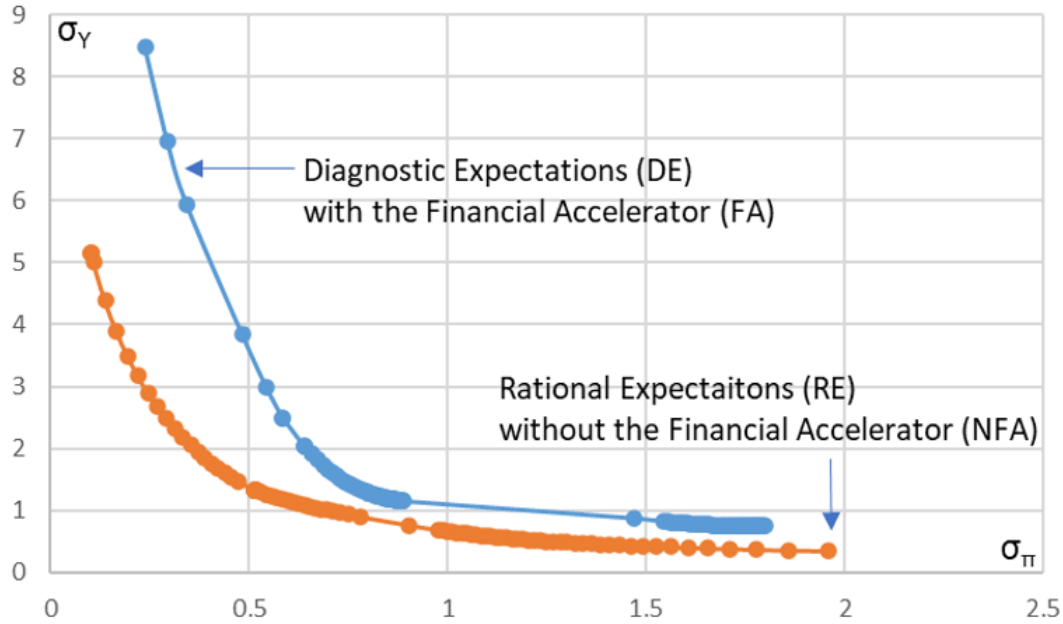

Figure 6: Policy Frontiers

model (RE, no FA), whereas the second is based on the DE model with FA. The vertical and horizontal axes correspond to output and inflation volatility, respectively. Both frontiers clearly illustrate the non-linear inverse relationship between output and inflation volatility. Importantly, the DE FA model presents a worse policy trade-off since the frontier is further away from the origin. For instance, at any given level of inflation volatility, the DE model with the FA is characterized with higher output volatility relative to the baseline model. At the same time, the DE FA frontier is steeper. This implies that the additional reduction in inflation volatility is accompanied by an increasingly greater rise in output volatility under the DE FA models. Hence, a worsening trade-off for policymakers.

Figure 7 displays four additional policy frontiers to reinforce model intuition. The top left and top right panels contrast the implications of DE on the models with and without the FA, respectively. The main takeaway is that, as noted previously, the presence of DE worsens the policy trade-off.[26] The lower two panels compare the role of the FA in models with the

[26]While not shown, note that a comparison of the frontiers contrasting the RE FA model with the DE without the FA also illustrates a deterioration in the policy trade-off owing to the introduction of DE.

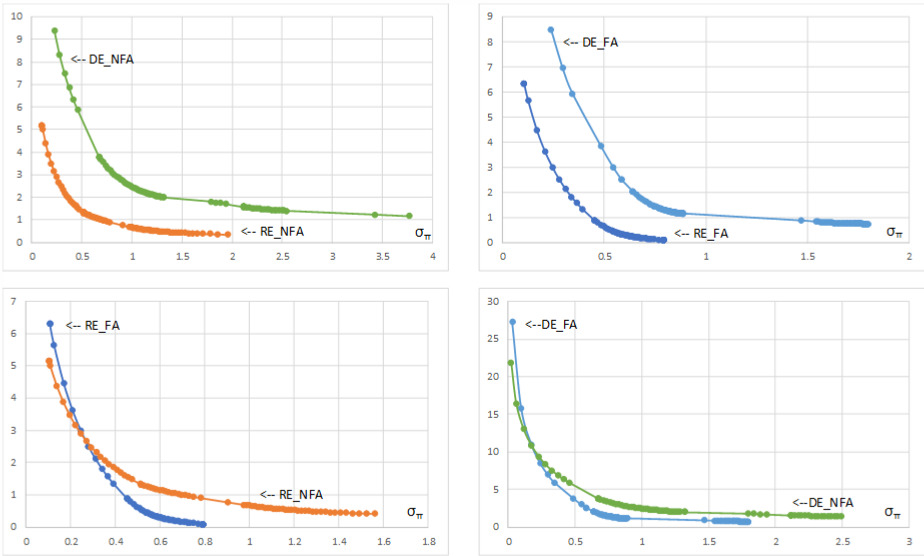

Figure 7: Frontiers and Debt Deflation Channel

same expectations assumption. Consider the bottom right panel which compares the model with and without the FA under DE. Note that the frontiers cross, and after a certain level of inflation volatility the FA model is associated with lower output volatility. We associate this result with the debt deflation channel, which strengthens as inflation variability increases, and thus, more effectively dampens supply shocks. Moreover, note that the frontiers intersect at a lower level of inflation volatility in the case of DE (relative to the RE models), which is intuitive because DE enhances the debt deflation channel.

4.3 Simple monetary policy rules

We now address the question of which policy rule the central bank should commit to in order to best achieve its stabilization objectives. Much of the literature has addressed this question by considering simple interest rate rules and parameterizing them to maximize the policymaker's objective function. Such function could be *ad hoc* (Billi, 2013) or micro founded (Woodford, 2003). In a model with two agents, it is not straightforward to derive a tractable loss function amenable to the policy experiments we consider. Nevertheless, following the lines of the lines of Adam and Woodford (2021), we assume the following objective function:

$$\mathbb{W} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \hat{\pi}_t^2 + \Lambda_y \hat{Y}_t^2 + \Lambda_h \hat{\pi}_{t,h}^2 \right\}$$

where Λ_y is the relative weight on output gap and Λ_h is relative wight on housing prices inflation.[27] We also consider the following generalized interest rate rule:

$$\hat{R}_t = \rho_R \hat{R}_{t-1} + (1-\rho_R)\left(\omega_\pi \hat{\pi}_t + \omega_Y \hat{Y}_{t-1} + \omega_q \hat{q}_t + \omega_{\Delta Q} \hat{\Delta Q}_t\right) + \varepsilon_t^R$$

Notice that this rule allows the central banker to target the level, $\hat{q}_t$, and growth rate of house prices, $\hat{\Delta Q}_t$, in addition to the standard inflation and output gaps.

We will again analyze four models: the RE and DE models, with and without FA. We will consider five policy rules. First, and serving as the benchmark rule, we explore the implications of flexible inflation targeting (FIT), where the central bank targets inflation and output ($\omega_\pi \geqslant 0, \omega_Y \geqslant 0, \omega_q = \omega_{\Delta Q} = 0$). Second, we consider strict inflation targeting (SIT) where the central bank only focuses on inflation stabilization ($\omega_\pi \geqslant 0, \omega_Y = \omega_q = \omega_{\Delta Q} = 0$). Third, and motivated by the analysis of optimal monetary policy, the merits of price-level targeting (PLT) is investigated (in this case, the central banks targets $\hat{P}_t$ instead of $\hat{\pi}_t$). Then, in the models with the FA, we also explore the benefits of targeting either the level of house prices (rule four) or house price growth (rule five)—that is, either $\omega_q \geqslant 0$ or $\omega_{\Delta Q} \geqslant 0$ (in addition to $\omega_\pi \geqslant 0, \omega_Y \geqslant 0$).

Table 2 summarizes the analysis on optimal simple interest rate rules. For each rule, it tabulates the welfare cost (which measures the percent of forgone steady state consumption), the coefficient values linked to each policy objective (for example, ω_Y), and the standard deviations (σ, in percent) of inflation, output, as well as the level and growth rate of house prices.[28]

[27] where $\Lambda_y > \Lambda_h$ and the welfare function is derived as a second order approximation of patient households' utility function. In Appendix C, we consider the case where $\Lambda_h > \Lambda_y$ for robustness check.

[28] Notice that ease of exposition, ω_π and ω_q, are used for the inflation or price targeting rules and the rules that target the level or growth rate of house prices, respectively.

	Rational expectations (RE)								Diagnostic expectations (DE)							
	No Financial Accelerator			*Financial Accelerator (FA)*					*No Financial Accelerator*			*Financial Accelerator (FA)*				
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
	FIT	*SIT*	*PLT*	*FIT*	*SIT*	*PLT*	*q*	*ΔQ*	*FIT*	*SIT*	*PLT*	*FIT*	*SIT*	*PLT*	*q*	*ΔQ*
Welfare	5.35	5.35	5.52	6.65	6.73	6.76	6.65	6.40	7.72	11.07	7.03	7.67	13.94	7.24	7.67	4.41
ω_{π}	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
ω_{Y}	0.00	–	0.01	0.11	–	0.13	0.11	0.00	0.52	–	0.61	0.66	–	0.71	0.66	0.00
ω_{Q}	–	–	–	–	–	–	0.00	0.64	–	–	–	–	–	–	0.00	2.18
σ_{π}	0.12	0.12	0.13	0.13	0.12	0.14	0.13	0.15	0.15	0.14	0.16	0.16	0.15	0.17	0.16	0.14
σ_{Y}	3.30	3.30	3.26	3.75	3.91	3.68	3.75	3.54	3.71	4.61	3.36	3.51	5.19	3.29	3.51	2.66
σ_{Q}	3.44	3.44	3.39	3.67	3.82	3.60	3.67	3.47	3.70	4.65	3.36	3.56	5.16	3.36	3.56	2.77
$\sigma_{\Delta Q}$	1.87	1.87	1.81	1.96	2.07	1.87	1.96	1.68	3.01	4.31	2.67	2.84	4.81	2.62	2.84	1.53

Table 2: Optimal Simple Rules. Note: Welfare in percent of forgone steady state consumption, standard deviations in percent.

To anchor the discussion, we start with the baseline model (RE without the FA). The results indicate that the optimal simple rule is FIT, which, in this case, coincides with SIT (Table 2, columns [1]-[2]). Notwithstanding the greater output stabilization conferred by PLT (note that $\phi_Y \neq 0$), the slightly higher inflation volatility increases welfare losses relative to FIT.

The introduction of the FA (Table 2, columns [4]-[8]) results in higher welfare losses across the board relative to the baseline model. There are several noteworthy observations: First, by taking output into account, FIT performs better relative to SIT and PLT. Importantly, note that under column [7], the weight on the level of the house price is zero ($\phi_q = 0$). That is the rules under columns [4] and [7] are equivalent. As in many studies, including, for instance, Iacoviello (2005), there seems to be no merit in targeting the *level* of asset prices. This result is in line with most studies investigating the role of asset prices within a monetary policy framework. Indeed, this finding corroborates studies that can be traced back to Bernanke and Gertler (1999), among others, who underscore that once movements in inflation are taken into account (possibly along with output fluctuations), there is no need for monetary policy to respond to asset prices.

By contrast, the rule that targets the *growth* rate of house prices yields the lowest welfare losses (Table 2, column [8]). Targeting house price growth—by taming the asset price channel—results in a sizable reduction in output volatility with only a slight increase inflation volatility. This finding echoes the results of Gilchrist and Saito (2008) who consider the value of targeting equity price growth under imperfect information. A key advantage of targeting asset price growth is that the policy maker does not need to infer the underlying value of the asset—a fundamental critique of targeting the level of asset prices. In this context, targeting the growth of the asset prices thereby renders such a policy more robust (including to information asymmetries) because it does not involve a judgment call on the degree of asset price misalignment.

With the introduction of DE, and initially abstracting from the FA, the welfare losses associated with the policy rules increase relative to the RE models. In the DE model without FA, PLT yields the most favorable welfare outcome (Table 2, columns [9]-[11]. The stabilization benefits conferred by this path dependent monetary strategy is associated with a stronger debt deflation channel which, combined with a greater sensitivity to output gap movements, results in lower business cycle fluctuations relative to the other rules, at the cost of a modest rise in inflation volatility.

We now compare the optimal simple rules in the DE model with the FA (Table 2, columns [12]-[16]). A couple of observations are worth noting. First, even in this model, in line with most of the existing research, there does not appear to be any value in targeting the level of house prices. Notice the overlap between the model under column [15] with FIT (under column [12]) and the unfavorable welfare scores. Second, PLT is superior to FIT and SIT. Third, and of most interest, the policy rule targeting the *growth* rate of house prices performs the best based on its welfare score (column [16]). By most aggressively responding to fluctuations in house price growth ($\phi_{\Delta Q} = 2.18$), this rule seems to strike the right balance by sufficiently suppressing the asset price channel (which dampens the impact of demand shocks) and, by accommodating some inflation volatility, harnesses the stabilization benefits of a stronger debt deflation channel (which is strengthened under DE and helps attenuate the effects of supply shocks). In summary, within this modeling framework, although we find that there is no case for targeting the level of house prices, there seems to be merit in considering the *growth* of asset prices when formulating a monetary policy strategy.[29]

[29]For further intuition, see Appendix C.

4.4 Sensitivity Exercises

To assess the robustness of this result, we consider several sensitivity tests which are summarized in **Appendices D and E**. The main takeaways are as follows: First, the benefits of targeting house price growth are even more pronounced when the amplification associated with DE are enhanced, including under more distant memory (J=4, and when theta =2). Second, to dampen the debt deflation channel, we introduce indexed debt and recompute the optimal simple rules for these four new models.[30] While indexed debt can negate the wealth effects and impact on the collateral constraint associated with inflation, it does not remove the current inflation surprises associated with DE, and so has a more limited effect, and does not alter the conclusions noted above. Third, we consider different shock combinations. For instance, we re-run the simulations such that they only include supply shocks, or consider only the cost-push shock. Again, the main findings hold. Fourth, and finally, we consider a lower loan-to-value ratio of 50 percent (on its own and along with the other sensitivity tests considered; see bottom row of Table 3). Overall, targeting house price *growth* results in the best welfare outcomes in this case as well.

5 Conclusion

We contribute to the literature on the macroeconomic implications of financial frictions by introducing Diagnostic Expectations into a well-known New Keynesian financial accelerator model. Diagnostic Expectations formation is a departure from the Rational Expectation (RE) hypothesis which allows for an overreaction of beliefs. Our financial accelerator (FA) model with DE generates mutually reinforcing shock amplification, especially in the case of demand shocks. However, supply shocks can be attenuated owing to a debt deflation channel which is strengthened under DE. Importantly, the model results in a worsening of the inflation-output volatility trade-off confronting policymakers. The analysis also indicates that targeting house price *growth* results in a lower welfare costs and is associated with desirable economic stabilization properties. Overall, our modeling framework suggests that although there is no case for targeting the *level*

[30]Note that in this way, this paper contrasts the results of eight models: with and without the FA, with DE or RE, and the corresponding versions with indexed debt.

of house prices, there seems to be merit in considering the *growth* of asset prices when formulating a monetary policy strategy.

Our findings point to two avenues for future research. First, it would be interesting to see whether the case for leaning against the wind by targeting house price growth holds when macroprudential tools exist and can be effectively implemented by a relevant authority. Second, an empirical evaluation of a model which brings together DE, financial frictions, and other empirically-relevant rigidities is a natural next step.

References

Adam, K., Woodford, M., 2021. Robustly optimal monetary policy in a new keynesian model with housing. Journal of Economic Theory 198, 105352.

Adrian, T., Shin, H.S., 2011. Financial intermediary balance sheet management. Annu. Rev. Financ. Econ. 3, 289–307.

Ajello, A., Laubach, T., Lopez-Salido, D., Nakata, T., 2016. Financial stability and optimal interest-rate policy .

Allen, F., Gale, D.M., 2007. An introduction to financial crises .

Barberis, N., Shleifer, A., Vishny, R., 1998. A model of investor sentiment. Journal of Financial Economics 49, 307–343.

Benchimol, J., Bounader, L., 2023. Optimal monetary policy under bounded rationality. Journal of Financial Stability 67, 101151.

Bernanke, B.S., Gertler, M., 1989. Agency costs, net worth, and business fluctuations. American Economic Review 79, 14–31.

Bernanke, B.S., Gertler, M., 1999. Monetary policy and asset price volatility. Economic Review QIV, 17–51.

Bernanke, B.S., Gertler, M., 2001. Should central banks respond to movements in asset prices? American Economic Review 91, 253–57.

Bernanke, B.S., Gertler, M., Gilchrist, S., 1999. The financial accelerator in a quantitative business cycle framework, in: Taylor, J.B., Woodford, M. (Eds.), Handbook of Macroeconomics. Elsevier Science, North–Holland. volume 1C, pp. 1341–93.

Bianchi, F., Ilut, C., Saijo, H., 2023. Diagnostic business cycles. The Review of Economic Studies .

Billi, R.M., 2013. Nominal gdp targeting and the zero lower bound: Should we abandon inflation targeting? Riksbank Research Paper Series .

Bordalo, P., Coffman, K., Gennaioli, N., Shleifer, A., 2016. Stereotypes. Quarterly Journal of Economics 131, 1753–94.

Bordalo, P., Gennaioli, N., Kwon, S.Y., Shleifer, A., 2021. Diagnostic bubbles. Journal of Financial Economics 141, 1060–77.

Bordalo, P., Gennaioli, N., La Porta, R., Shleifer, A., 2019. Diagnostic expectations and stock returns. Journal of Finance 74, 2839–74.

Bordalo, P., Gennaioli, N., Ma, Y., Shleifer, A., 2020. Overreaction in macroeconomic expectations. American Economic Review 110, 2748–82.

Bordalo, P., Gennaioli, N., Shleifer, A., 2018. Diagnostic expectations and credit cycles. Journal of Finance 73, 199–227.

Bordalo, P., Gennaioli, N., Shleifer, A., 2022. Overreaction and diagnostic expectations in macroeconomics. Journal of Economic Perspectives 36, 223–44.

Brunnermeier, M.K., Eisenbach, T., Sannikov, Y., 2013. Macroeconomics with financial frictions: A survey, in: Acemoglu, D., Arellano, M., Dekel, E. (Eds.), Advances in Economics and Econometrics, Tenth World Congress of the Econometric Society. Cambridge University Press. volume II: Applied Economics, pp. 4–94.

Brzoza-Brzezina, M., Kolasa, M., 2013. Bayesian evaluation of dsge models with financial frictions. Journal of Money, Credit, and Banking 45, 1451–76.

Calvo, G.A., 1983. Staggered prices in a utility-maximizing framework. Journal of Monetary Economics 12, 383–98.

Camous, A., Van der Ghote, A., 2022. Financial Cycles Under Diagnostic Expectations. Working Paper Series 2659. ECB.

Cardarelli, R., Elekdag, S., Lall, S., 2011. Financial stress and economic contractions. Journal of Financial Stability 7, 78–97.

Checchetti, S.G., Gensberg, H., Lipsky, J., Wadhwani, S., 2000. Asset Prices and Central Bank Policy. Technical Report 2. The Geneva Report on the World Economy.

Christiano, L.J., Eichenbaum, M.S., Trabandt, M., 2018. On dsge models. Journal of Economic Perspectives 32, 113–140.

Christiano, L.J., Motto, R., Rostagno, M., 2014. Risk shocks. American Economic Review 104, 27–65.

Coibion, O., Gorodnichenko, Y., 2015. Information rigidity and the expectations formation process: A simple framework and new facts. American Economic Review 105, 2644–78.

Curdia, V., 2007. Monetary Policy under Sudden Stops. Staff Report 278. Federal Reserve Bank of New York.

Curdia, V., Woodford, M., 2011. The central bank balance sheet as an instrument of monetary policy. Journal of Monetary Economics 58, 54–79.

Diamond, D.W., Rajan, R.G., 2006. Money in a theory of banking. American Economic Review 96, 30–53.

Dudley, W.C., 2015. Is the Active Use of Macroprudential Tools Institutionally Realistic? Technical Report. Remarks by William C. Dudley, the President and Chief Executive Officer of the Federal Reserve Bank of New York.

d'Arienzo, D., 2020. Maturity Increasing Overreaction and Bond Market Puzzles. Working Paper. Bocconi University.

Elekdag, S., Tchakarov, I., 2007. Balance sheets, exchange rate policy, and welfare. Journal of Economic Dynamics and Control 31, 3986–4015.

Farhi, E., Werning, I., 2016. A theory of macroprudential policies in the presence of nominal rigidities. Econometrica 84, 1645–1704.

Favero, C., Melone, A., Tamoni, A., 2023. Monetary policy and bond prices with drifting equilibrium rates. Journal of Financial and Quantitative Analysis , 1–26.

Filardo, A., Rungcharoenkitkul, P., 2016. A quantitative case for leaning against the wind. Working Papers 594. BIS.

Fisher, I., 1933. The debt-deflation theory of great depressions. Econometrica 1, 337–57.

Gennaioli, N., Shleifer, A., 2010. What comes to mind. Quarterly Journal of Economics 125, 1399–433.

Gennaioli, N., Shleifer, A., Vishny, R.W., 2012. Neglected risks, financial innovation, and financial fragility. Journal of Financial Economics 104, 452–68.

Gertler, M., Gilchrist, S., 2018. What happened: Financial factors in the great recession. Journal of Economic Perspectives 32, 3–30.

Gertler, M., Gilchrist, S., Natalucci, F., 2007. External constraints on monetary policy and the financial accelerator. Journal of Money, Credit and Banking 39, 295–330.

Gertler, M., Kiyotaki, N., 2015. Banking, liquidity, and bank runs in an infinite horizon economy. American Economic Review 105, 2011–43.

Gertler, M., Kiyotaki, N., Prestipino, A., 2020. Banking panics as endogenous disasters and the welfare gains from macroprudential policy. American Economic Review 110, 463–469.

Gilchrist, S., Leahy, J.V., 2002. Monetary policy and asset prices. Journal of Monetary Economics 49, 75–97.

Gilchrist, S., Saito, M., 2008. Expectations, asset prices, and monetary policy: The role of learning, in: Campbell, J.Y. (Ed.), Asset Prices and Monetary Policy. University of Chicago Press.

Gourio, F., Kashyap, A.K., Sim, J., 2018. The tradeoffs in leaning against the wind. IMF Economic Review 66, 70–115.

Greenwood, R., Hanson, S.G., Jin, L.J., 2019. Reflexivity in Credit Markets. Working Paper 25747. NBER.

He, Z., Krishnamurthy, A., 2013. Intermediary asset pricing. American Economic Review 103, 732–70.

Holmstrom, B., Tirole, J., 1997. Financial intermediation, loanable funds, and the real sector. Quarterly Journal of Economics 62, 663–91.

Iacoviello, M., 2005. House prices, borrowing constraints and monetary policy in the business cycle. American Economic Review 95, 739–764. URL: https://dx.doi.org/10.1257/0002828054201477, doi:10.1257/0002828054201477.

IMF, I.M.F., 2015. Monetary policy and financial stability. Discussion paper, International Monetary Fund .

Jeanne, O., Korinek, A., 2019. Managing credit booms and busts: A pigouvian taxation approach. Journal of Monetary Economics 107, 2–17.

Jermann, U., Quadrini, V., 2012. Macroeconomic effects of financial shocks. American Economic Review 102, 238–71.

Jin, L.J., 2015. A speculative asset pricing model of financial instability. Available at SSRN 2524762 .

Jorda, O., Schularick, M., Taylor, A.M., 2016. The great mortgaging: Housing finance, crises and business cycles. Economic Policy 31, 107–152.

Kahana, M.J., 2012. Foundations of Human Memory. Oxford University Press.

Kahneman, D., Tversky, A., 1972. Subjective probability: A judgment of representativeness. Cognitive Psychology 3, 430–54.

Keynes, J.M., 1936. The General Theory of Employment, Interest, and Money. Palgrave Macmillan.

Kindleberger, C.P., 1978. Manias, Panics and Crashes: A History of Financial Crisis. Basic Books.

Kiyotaki, N., Moore, J., 1997. Credit cycles. Journal of Political Economy 105, 211–48.

Kocherlakota, N.R., 2000. Creating business cycles through credit constraints. Quarterly Review, Federal Reserve Bank of Minneapolis 24, 2–10.

Korinek, A., Simsek, A., 2016. Liquidity trap and excessive leverage. American Economic Review 106, 699–738.

Linde, J., Smets, F., Wouters, R., 2016. Challenges for central bank models 2B, 2185–2256.

Lombardo, G., Vestin, D., 2008. Welfare implications of calvo vs. rotemberg-pricing assumption. Economic Letters 100, 275–279.

L'Huillier, J., Singh, S.R., Yoo, D., 2023. Incorporating diagnostic expectations into the new keynesian framework. The Review of Economic Studies .

Mankiw, N.G., Reis, R., 2002. Sticky information versus sticky prices: A proposal to replace the new keynesian phillips curve. Quarterly Journal of Economics 117, 1295–328.

Mankiw, N.G., Reis, R., Wolfers, J., 2003. Disagreement about inflation expectations. NBER Macroeconomics Annual 18, 209–48.

Maxted, P., 2023. A macro–finance model with sentiment. The Review of Economic Studies .

Minsky, H.P., 1977. The financial instability hypothesis: An interpretation of keynes and an alternative to 'standard' theory. Challenge 20, 20–7.

Monacelli, T., 2009. New keynesian models, durable goods, and collateral constraints. Journal of Monetary Economics 56, 242–254.

Pflueger, C., Siriwardane, E., Sunderam, A., 2020. Financial market risk perceptions and the macroeconomy. The Quarterly Journal of Economics 135, 1443–91.

Rotemberg, J.J., 1982. Monopolistic price adjustment and aggregate output. Review of Economic Studies 49, 517–531.

Shiller, R.J., 2016. Irrational Exuberance. Princeton University Press.

Sims, C.A., 2003. Implications of rational inattention. Journal of Monetary Economics 50, 665–90.

Sims, E., Wu, C., Zhang, J., 2021. The four equation new keynesian model. The Review of Economics and Statistics , 1–45.

Smets, F., 2014. Financial stability and monetary policy: How closely interlinked? International Journal of Central Banking 10, 263–300.

Souleles, N.S., 2004. Expectations, heterogeneous forecast errors, and consumption: Micro evidence from the michigan consumer sentiment surveys. Journal of Money, Credit and Banking 36, 39–72.

Stein, J.C., 2010. Monetary policy as financial stability regulation. The Quarterly Journal of Economics 127, 57–95.

Stein, J.C., 2013. Overheating in credit markets: Origins, measurement, and policy responses Speech by Jeremy C. Stein, the Governor of the Federal Reserve System At the ”Restoring Household Financial Stability after the Great Recession: Why Household Balance Sheets Matter”, research symposium sponsored by the Federal Reserve Bank of St. Louis, St. Louis, Missouri.

Vissing–Jorgensen, A., 2003. Perspectives on behavioral finance: Does ‘irrationality’ disappear with wealth? evidence from expectations and actions. NBER Macroeconomics Annual 18, 139–208.

Woodford, M., 2003. Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton University Press.

A Model Equations

The full set of equilibrium conditions for the financial accelerator model with Diagnostic expectations is tabulated below.

$$A1. \quad (L_t)^{\eta-1} C_t^P = w_t \tag{1}$$

$$A2. \quad \frac{1}{\pi_t}\frac{1}{C_t^P} = \beta E_t^\theta \left[\frac{1}{C_{t+1}^P} \frac{R_t}{\pi_{t+1}} \frac{1}{\pi_t} \right] \tag{2}$$

$$A3. \quad \frac{q_t}{C_t^P} = \frac{\phi_t^P}{H_t^P} + \beta E_t^\theta \left[\frac{q_{t+1}}{C_{t+1}^P} \right] \tag{3}$$

$$A4. \quad (1-\nu) A_t (H_{t-1}^E)^\nu (L_t)^{-\nu} = w_t X_t \tag{4}$$

$$A5. \quad \frac{1}{\pi_t}\frac{1}{C_t^E} = \gamma E_t^\theta \left[\frac{1}{C_{t+1}^E} \frac{R_t}{\pi_{t+1}} \frac{1}{\pi_t} \right] + \lambda_t \tag{5}$$

$$A6. \quad \frac{q_t}{C_t^E} = \gamma E_t^\theta \left[\frac{1}{C_{t+1}^E} \left(\frac{\nu A (H_t^E)^{\nu-1} (L_{t+1})^{1-\nu}}{X_{t+1}} + q_{t+1} \right) \right] + m\lambda_t E_t^\theta \left[q_{t+1} \frac{\pi_{t+1}}{R_t \pi_t} \right] \tag{6}$$

$$A7. \quad \pi_t b_t^E = m E_t^\theta \left[q_{t+1} H_t^E \frac{\pi_{t+1}}{R_t \pi_t} \right] \tag{7}$$

$$A8. \quad \pi_t \pi_{t-1} = \frac{\beta}{Y_t} E_t^\theta \left[\frac{C_t^P}{C_{t+1}^P} (\pi_{t+1} - 1)\pi_{t+1} Y_{t+1} \right] + \frac{(\epsilon - 1)}{\psi} - \frac{\epsilon}{\psi}\frac{1}{X_t} \tag{8}$$

$$A9. \quad R_t = R^{1-\rho_R} R_{t-1}^{\rho_R} \left(\pi_{t-1}^{\omega_\pi} \left(\frac{Y_{t-1}}{Y} \right)^{\omega_Y} \right)^{1-\rho_R} \exp(\epsilon_t^R) \tag{9}$$

$$A10. \quad Y_t = A (H_{t-1}^E)^\nu (L_t)^{1-\nu} \tag{10}$$

$$A11. \quad C_t^P + C_t^E = Y_t - \frac{\psi}{2}(\pi_t - 1)^2 Y_t \tag{11}$$

$$A12. \quad H_t^P + H_t^E = H \tag{12}$$

$$A13. \quad C_t^E + q_t H_t^E + \frac{R_{t-1} b_{t-1}^E}{\pi_t} = \frac{Y_t}{X_t} - w_t L_t + b_t^E + q_t H_{t-1}^E \tag{13}$$

Note that in the linearized model, $\theta = 0$ results in the Rational Expectations model. As in Iacoviello (2005), setting $b_t^E = \frac{B^E}{R}$, shuts off the asset price channel (and therefore the financial accelerator mechanism). Lastly, the model with indexed debt implies that that π_{t+1} terms in the consumption Euler equations drop out, for example, equation (A2) becomes: $\frac{1}{\pi_t}\frac{1}{C_t^P} = \beta \mathbb{E}_t^\theta \left[\frac{R_t}{C_{t+1}^P} \frac{1}{\pi_t} \right]$. Taken together, the analysis considers eight models that are nested in the system of equations presented above (DE or RE, with and without FA, nominal or indexed debt).

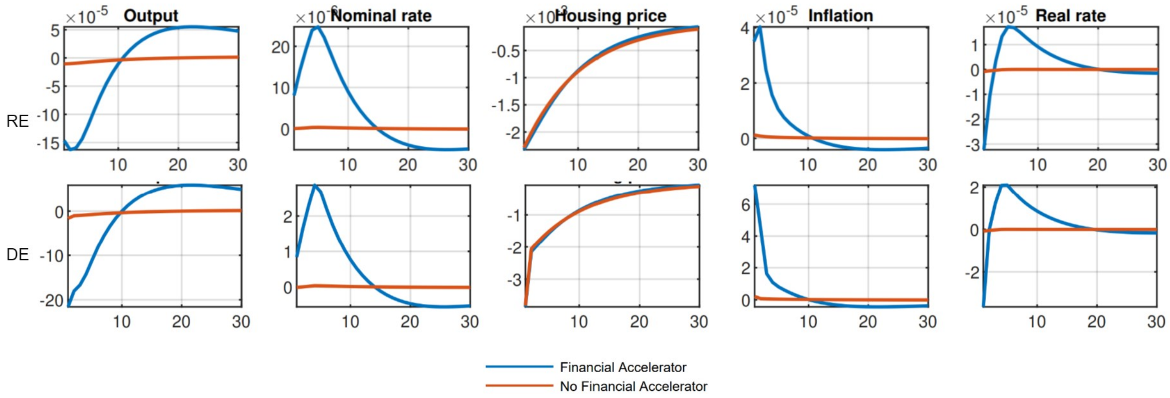

Figure 8: Housing Preference Shock

B TFP and Preference shocks

Figure 8 shows the impact of a housing preference shock, where patient households desire less housing.[31] Here the focus is on the FA model, including to draw attention to the asset price channel. The immediate impact is a sharp house price decline. Although, by decreasing an input cost, this would make housing more desirable for the entrepreneurs, the decrease also tightens the collateral constraint. This latter dynamic initially dominates, and depressed entrepreneurial activity acts like a drag on the economy. As house price recover from the temporary shock, the constraint loosens, and entrepreneurial activity recovers. As expected, the shock is more prevalent amid the FA models. Note, that since output and inflation move in opposite directions, as in the case of a supply shock, the debt deflation channel helps dampen the impact of the shock, especially under DE.

[31]Note that the shock is simulated by decreasing ϕ_t^P which alters the marginal rate of substitution between housing and consumption.

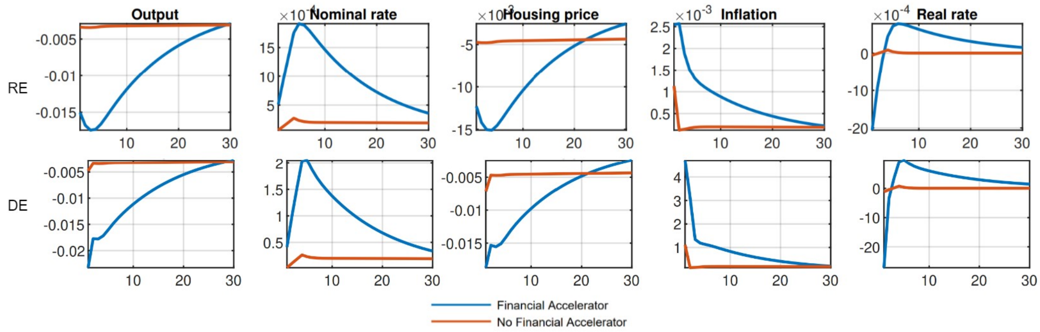

Figure 9: TFP Shock

Figure 9 illustrates the dynamics associated with a temporary decline in TFP. Because this is also an adverse supply shock, the broad contours of the impulse response functions in the FA model are similar to those associated with a cost-push shock. In this case, the decline in productivity leads to a decrease in housing, including as patient households demand less of it as their consumption decreases. Although the decline in house prices makes an input cheaper for the entrepreneurs, it results in a tighter collateral constraint (albeit somewhat offset owing to the increase in inflation). Overall, the main takeaway here is that DE results in larger macroeconomic responses.

C OSR Impulse response analysis

To enhance the intuition of the optimal simple rules discussed in Section 4.3, we now investigate the dynamic response of key macroeconomic variable to the two main shocks considered earlier: the monetary policy and cost-push shocks. In an attempt to further strike the right balance between brevity and insight, we display four macroeconomic aggregates (output, the inflation rate, the policy rate, and the level of real house prices) across three models only: (1) the baseline RE model without the FA, (2) the RE model with the FA, and (3) the DE model with the FA. We also consider a selected set of optimized simple rules. Specifically, in the baseline model, we plot FIT and PLT (including because SIT overlaps with FIT or because it is inferior in welfare terms relative to the other two rules). In the models with the FA, we consider the rule that also target the growth rate of house prices. Recall that the optimization analysis indicated that the rule that allowed for the inclusion of the level of house prices overlapped with FIT (that is, $\phi_q = 0$).

Consider first the monetary policy shock shown in Figure 10. Under the baseline model (Figure 12, top row), we see that FIT is associated with lower output and inflation fluctuations relative to PLT which underpins its lower welfare cost. The main policy result of the paper is highlighted with the inclusion of the FA (Figure 12, middle row). Notice the less aggressive policy tightening associated with the rule that targets house price growth. This milder policy response generates a less severe decline in house prices, and therefore attenuates the asset price channel, which, in turn, helps stabilize output and results in a less severe recession relative to FIT and PLT cases. A similar narrative holds in the context of the DE model with the FA, but with even starker differences (Figure 12, bottom row). In particular, in this case, targeting house price growth in the context of the monetary policy shock results in an endogenous response whereby the nominal interest rate initially declines. Naturally, this outcome underpins the less violent business cycle gyrations.

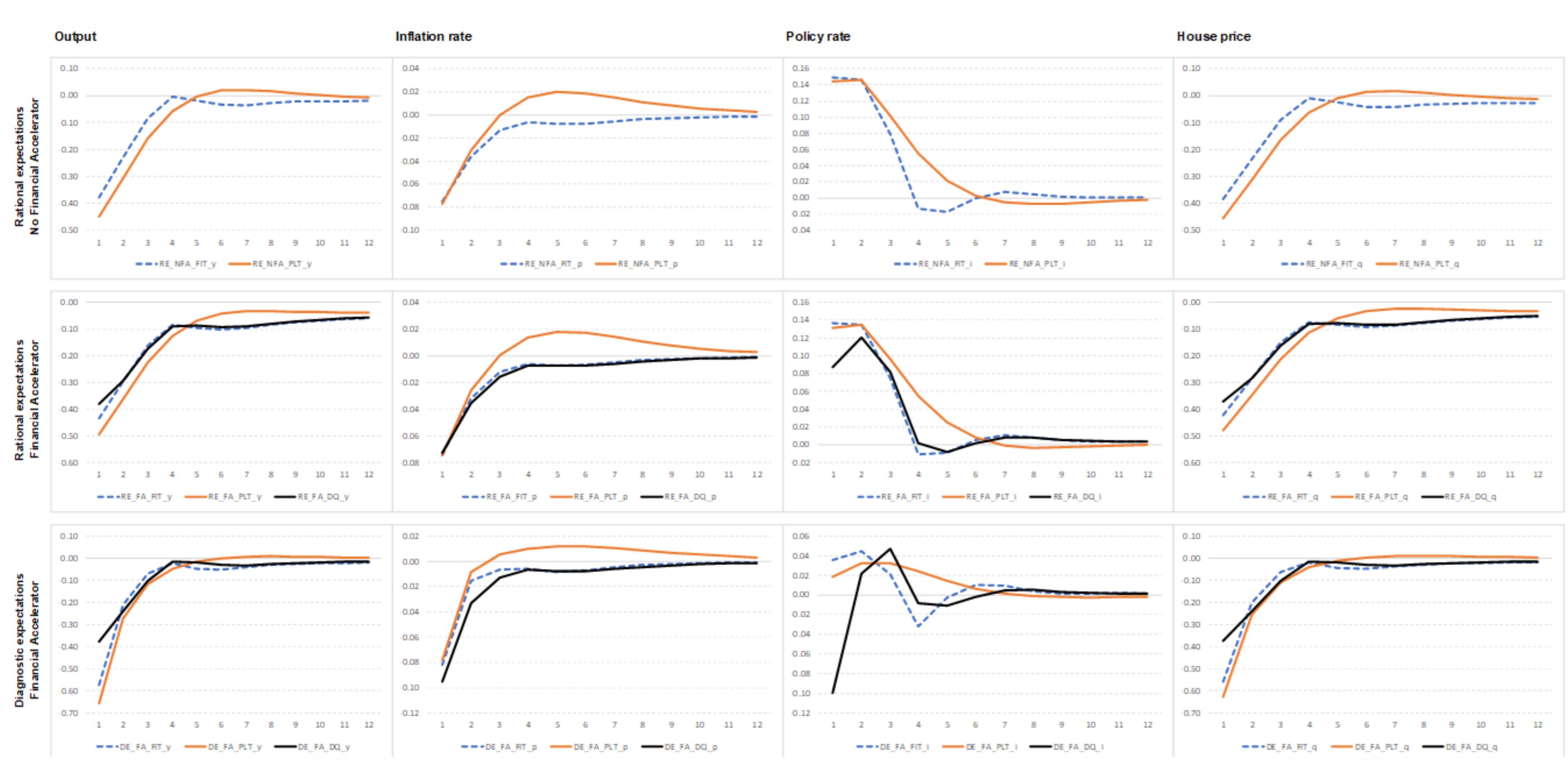

Figure 10: OSR Impulse Responses: Monetary Policy Shock

Figure 11 shows the implications of the cost-push shock. Under the baseline model (Figure 13, top row), PLT is associated with higher inflation volatility, owing to the historically-dependent nature of the policy regime, and therefore, is characterized by having higher welfare costs relative to FIT. Several key insights of the paper are revealed with the introduction of the FA. Notice that upon impact, the rule that targets house price growth prescribes a monetary loosening (Figure 12, middle row). This resembles the optimal policy response discussed earlier (recall Figure 11). Again, by tempering the asset price channel, this rule confers notable stabilization benefits and brings about a less severe initial economic contraction. Through the debt deflation channel, the slightly higher increase in the inflation rate also helps soften the impact of the shock. Under DE (Figure 12, bottom row), notice the monetary loosening across all optimized policy rules. However, the initial cut in the policy rate is much more pronounced in the rule that target house price growth. The shallower decline in house prices again mitigates the asset price channel, and yields a shallower recession. In summary, the rules that target the *growth* rate of house prices attenuate the asset price channel, and even without taking output directly into consideration, help reduce the amplitude of business cycle fluctuations.

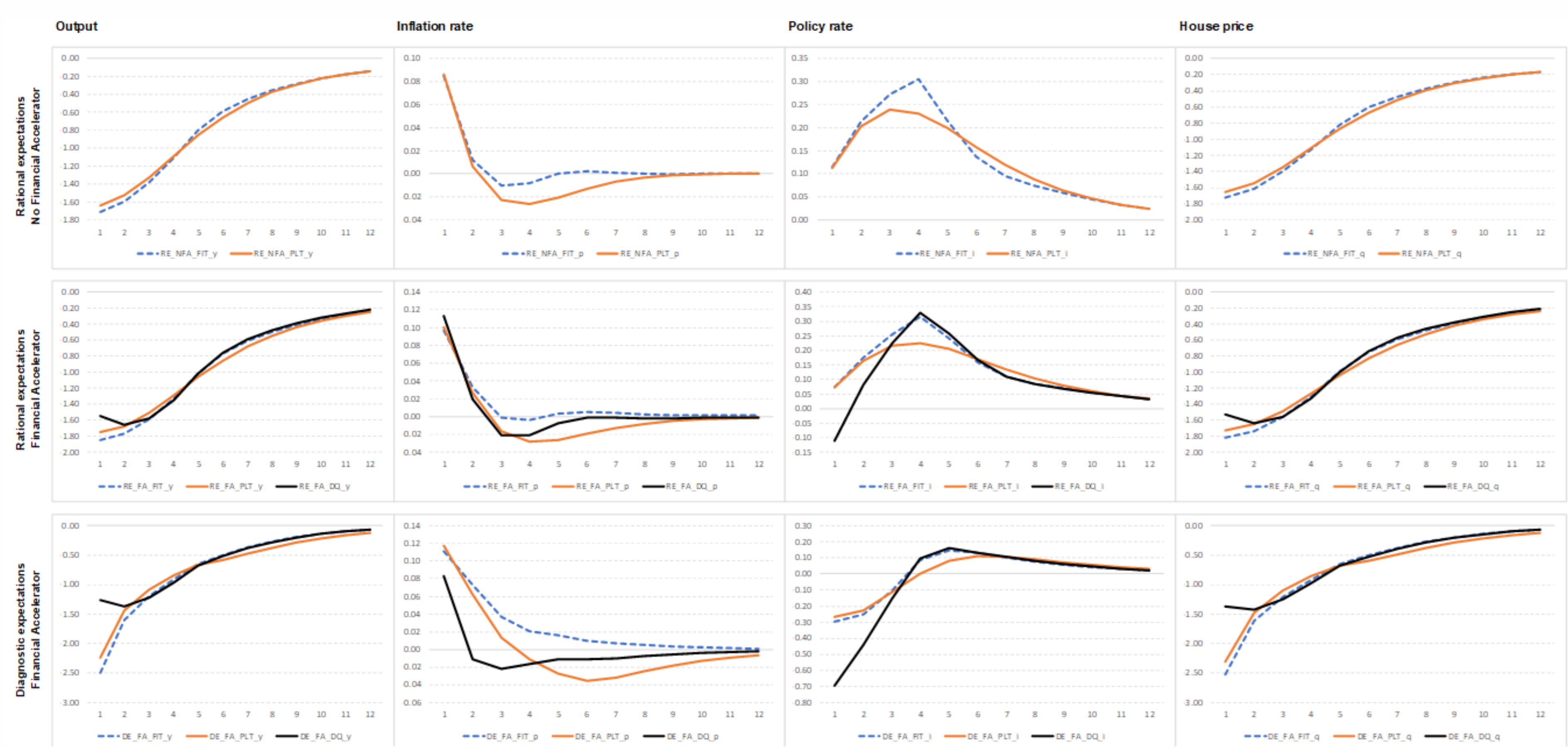

Figure 11: OSR Impulse Responses: Cost Push Shock

D OSR sensitivity analysis

Table 3: Sensitivity Exercises

							Indexed Debt			Indexed Debt			θ = ½, J = 1		
	RE			DE			RE			DE			DE		
	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*
Welfare	0.24	0.24	0.24	0.35	0.35	0.33	0.24	0.24	0.24	0.35	0.35	0.33	0.25	0.25	0.25
ω_π	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
ω_Y	0.24	0.24	0.24	0.49	0.49	0.41	0.24	0.24	0.24	0.49	0.49	0.41	0.31	0.31	0.30
ω_Q	–	0.00	0.00	–	0.00	1.13	–	0.00	0.00	–	0.00	1.11	–	0.00	0.20
σ_π	0.45	0.45	0.45	0.53	0.53	0.54	0.45	0.45	0.45	0.53	0.53	0.54	0.46	0.46	0.46
σ_Y	3.12	3.12	3.12	3.85	3.85	3.13	3.11	3.11	3.11	3.86	3.86	3.15	3.18	3.18	3.10
σ_Q	3.04	3.04	3.04	3.84	3.84	3.19	3.04	3.04	3.04	3.86	3.86	3.17	3.12	3.12	3.05
$\sigma_{\Delta Q}$	1.60	1.60	1.60	3.52	3.52	2.52	1.60	1.60	1.60	3.53	3.53	2.50	2.18	2.18	2.05
	m=0.5			**m=0.5**			**m=0.5**			**m=0.5**			**m=0.5**		
	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*
Welfare	0.24	0.24	0.24	0.39	0.39	0.37	0.24	0.24	0.24	0.39	0.39	0.37	0.25	0.25	0.25
ω_π	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
ω_Y	0.12	0.12	0.12	0.35	0.35	0.29	0.13	0.13	0.13	0.36	0.36	0.29	0.20	0.20	0.20
ω_Q	–	0.00	0.00	–	0.00	1.03	–	0.00	0.00	–	0.00	1.01	–	0.00	0.00
σ_π	0.46	0.46	0.46	0.56	0.56	0.57	0.46	0.46	0.46	0.56	0.56	0.57	0.47	0.47	0.47
σ_Y	2.84	2.84	2.84	4.14	4.14	3.45	2.84	2.84	2.84	4.13	4.13	3.46	3.00	3.00	3.00
σ_Q	2.81	2.81	2.81	4.15	4.15	3.50	2.80	2.80	2.80	4.15	4.15	3.50	2.97	2.97	2.97
$\sigma_{\Delta Q}$	1.55	1.55	1.55	3.85	3.85	2.82	1.55	1.55	1.55	3.84	3.84	2.82	2.16	2.16	2.16

	θ = 2, J = 1			θ = 2, J = 4			Only supply shocks			Only cost-push shock			Larger monetary policy shock		
	DE			DE			DE			DE			DE		
	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*
Welfare	0.28	0.28	0.27	0.46	0.46	0.40	0.12	0.12	0.05	0.12	0.12	0.05	1.65	1.65	1.65
ω_π	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
ω_Y	0.57	0.57	0.43	0.60	0.60	0.53	0.16	0.16	0.00	0.16	0.16	0.00	12.75	12.75	12.75
ω_Q	–	0.00	0.93	–	0.00	1.48	–	0.00	1.62	–	0.00	1.62	–	0.00	0.00
σ_π	0.48	0.48	0.48	0.60	0.60	0.60	0.18	0.18	0.13	0.18	0.18	0.13	1.28	1.28	1.28
σ_Y	3.18	3.18	2.89	4.57	4.57	3.17	4.40	4.40	3.04	4.40	4.40	3.04	1.56	1.56	1.56
σ_Q	3.14	3.14	2.87	4.69	4.69	3.43	4.39	4.39	3.14	4.39	4.39	3.14	1.57	1.57	1.57
$\sigma_{\Delta Q}$	3.07	3.07	2.43	4.95	4.95	3.07	4.02	4.02	2.19	4.01	4.01	2.19	1.31	1.31	1.31
	m=0.5			**m=0.5**			**m=0.5**			**m=0.5**			**m=0.5**		
	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*	FIT	*q*	*ΔQ*
Welfare	0.29	0.29	0.29	0.58	0.58	0.48	0.11	0.11	0.06	0.11	0.11	0.06	2.90	2.90	2.90
ω_π	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
ω_Y	0.44	0.44	0.35	0.43	0.43	0.34	0.12	0.11	0.00	0.12	0.11	0.00	11.82	11.82	11.82
ω_Q	–	0.00	0.71	–	0.00	1.84	–	0.00	1.54	–	0.00	1.54	–	0.00	0.00
σ_π	0.49	0.49	0.50	0.65	0.65	0.65	0.15	0.15	0.13	0.15	0.15	0.13	1.70	1.70	1.70
σ_Y	3.27	3.27	2.98	5.72	5.72	3.64	4.45	4.46	3.20	4.45	4.46	3.20	1.68	1.68	1.68
σ_Q	3.26	3.26	2.98	5.87	5.87	3.91	4.46	4.47	3.28	4.46	4.47	3.28	1.68	1.68	1.68
$\sigma_{\Delta Q}$	3.26	3.26	2.68	6.27	6.27	3.34	4.13	4.14	2.33	4.13	4.14	2.33	1.41	1.41	1.41

Source: Authors' calculations.
Note: Welfare in percent of forgone steady state consumption, standard deviations in percent.

OSR: Robustness checks

E OSR robustness check

Table 4: Optimal Simple Rules (Alternative welfare weights)

	Rational expectations (RE)								Diagnostic expectations (DE)							
	No Financial Accelerator			*Financial Accelerator (FA)*					*No Financial Accelerator*			*Financial Accelerator (FA)*				
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
	FIT	*SIT*	*PLT*	*FIT*	*SIT*	*PLT*	*q*	*ΔQ*	*FIT*	*SIT*	*PLT*	*FIT*	*SIT*	*PLT*	*q*	*ΔQ*
Welfare	4.39	4.38	4.55	5.26	5.27	5.39	5.26	5.08	7.23	13.88	6.82	7.24	11.07	6.58	7.22	4.11
ω_π	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
ω_Y	0.01	–	0.01	0.04	–	0.06	0.04	0.01	0.67	–	0.72	0.55	–	0.63	0.01	0.01
ω_Q	–	–	–	–	–	–	0.00	0.46	–	–	–	–	–	–	0.55	2.00

Source: Authors' calculations.
Note: Welfare in percent of forgone steady state consumption, standard deviations in percent.

OSR: Robustness checks

PUBLICATIONS

The Diagnostic Financial Accelerator
Working Paper No. WP/2024/132