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A Horse Race of Alternative Monetary Policy Regimes Under Bounded Rationality

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Abstract

We introduce bounded rationality, along the lines of Gabaix (2020), in a canonical New Keynesian model calibrated to match Canadian macroeconomic data since Canada's adoption of inflation targeting. We use the model to provide a quantitative assessment of the macroeconomic impact of flexible inflation targeting and some alternative m2netary policy regimes. These alternative monetary policy regimes are average-inflation targeting, price-level targeting and nominal gross domestic product level targeting. We consider these regimes' performance with and without an effective lower bound constraint. Our results suggest that the performance of history-dependent frameworks is sensitive to departures from rational expectations. The benefits of adopting history-dependent frameworks over flexible inflation targeting gradually diminish with a greater degree of bounded rationality. This finding is in line with laboratory experiments that show flexible inflation targeting remains a robust framework to stabilize macroeconomic fluctuations.

Topics: Central bank research; Economic models; Monetary policy framework Monetary policy transmission
JEL codes: E, E2, E27, E3, E4, E5, E52, E58

Résumé

Nous introduisons la rationalité limitée, à la façon de Gabaix (2020), dans un modèle néokeynésien canonique calibré pour reproduire les données macroéconomiques du Canada depuis l'adoption de son régime de ciblage de l'inflation. À partir de ce modèle, nous dégageons une évaluation quantitative de l'incidence macroéconomique du ciblage flexible de l'inflation et de quelques autres régimes de politique monétaire, à savoir : le ciblage de l'inflation moyenne, le ciblage du niveau des prix et le ciblage du produit intérieur brut nominal. Nous étudions la performance de ces régimes avec et sans la contrainte d'une valeur plancher. Nos résultats donnent à penser que la performance des cadres qui dépendent du passé est sensible aux écarts avec les anticipations rationnelles. En effet, les avantages de ces cadres par rapport au ciblage flexible de l'inflation diminuent progressivement quand le degré de rationalité limitée augmente. Ce constat va dans le sens des résultats d'expériences en laboratoire montrant que le ciblage flexible de l'inflation demeure un cadre robuste pour stabiliser les fluctuations macroéconomiques.

Topics: Recherches menées par les banques centrales; Modèles économiques; Cadre de la politique monétaire; Transmission de la politique monétaire

JEL codes: E, E2, E27, E3, E4, E5, E52, E58

1 Introduction

Canada adopted an inflation-targeting framework in 1991, with the target of 2% in place since 1995. Since its adoption, inflation as measured by the consumer price index has averaged close to 2% and has deviated narrowly around the target. Inflation expectations have also become firmly anchored around the target, giving the central bank more flexibility to account for output, employment or financial stability considerations while pursuing its inflation stabilization objective (flexible inflation targeting, or FIT).

While the success of FIT is undisputed, the decline in the neutral rate of interest—or the real interest rate consistent with output at potential—in Canada and elsewhere in recent years has raised questions about the suitability of FIT going forward.[1] The lower neutral rate limits the scope of conventional monetary policy to support the economy during downturns and increases the likelihood that the economy is constrained by the effective lower bound (ELB).

This new economic environment has prompted a willingness to explore alternative monetary policy frameworks, to resort to unconventional monetary policies and to rely on fiscal policy during exceptional times to provide more stimulus.[2] In this paper, we refrain from discussing extended monetary policies such as forward guidance or quantitative easing, and instead we examine the efficacy of alternative frameworks—average-inflation targeting (AIT), price-level targeting (PLT) and nominal gross domestic product–level (NGDPL) targeting—when the policy rate is subject to an occasionally binding ELB.

A large body of studies has investigated the efficacy of history-dependent monetary policy frameworks at the ELB.[3] History dependence considered in this paper takes the form of a commitment to make up for past deviations from the inflation target. If households and businesses in the private sector understand this commitment, it can shape their expectations and behaviour. This influence of monetary policy over private sector expectations can be crucially beneficial when the policy rate is constrained by the ELB. At the same time, the performance of history-dependent monetary policies relative to FIT depends critically on how the monetary policy framework conditions the expectations of market participants, businesses and the broader public. In rational expectations models, central banks successfully communicate these policies.

There is, however, growing survey data evidence that rational expectations models do not fully capture how market participants understand and act on the economic information they receive (Coibion, Gorodnichenko, and Kamdar 2018). This is also true

1. In Canada, the nominal neutral rate of interest has declined from around 5% in the early 2000s to a range of 1.75% to 2.75% recently (Brouillette et al. 2021). This downward trend has also been documented across developed countries (Eggertsson, Mehrotra, and Robbins 2019).

2. See Poloz (2020) lecture.

3. See Mertens and Williams (2019) for a discussion on PLT and AIT, Ambler (2020) for NGDPL targeting, and Dorich, Mendes, and Zhang (2021) for a comprehensive analysis in the Canadian context.

in laboratory studies. For instance, Kostyshyna, Petersen, and Yang (forthcoming) use laboratory experiments with university students in an artificial economy setting to evaluate the performance of alternative monetary policy rules. They show that in learning-to-forecast experiments with stronger trend-chasing expectations, history-dependent frameworks such as AIT, PLT and NGDPL targeting perform poorly relative to FIT following a large shock that leads to a binding ELB. In particular, under PLT and NGDPL targeting, the economy may degenerate into deflationary spirals when the ELB binds for an extended period.

With this background in mind, our paper builds on Gabaix (2020) to examine the robustness of these different monetary policy frameworks when agents exhibit bounded rationality. In this otherwise standard New Keynesian model, we assume that agents are myopic toward future information in the sense that they discount macroeconomic changes more than a rational agent would. This approach offers a tractable way for us to quantify the impact when economic agents operate under the assumption of bounded rationality. Myopic behaviour effectively reduces the weights agents place on events further in the future when making decisions today.[4]

The behavioural macroeconomic literature considers a variety of alternative forms of boundedly rational expectations, including level-k thinking and limited foresight. With level-k thinking, such as in Farhi and Werning (2019), agents are rational with respect to a partial equilibrium outcome but are unable to understand the general equilibrium effects of their decisions on the macroeconomy. The benefits of our approach of modelling inattention over level-k thinking is that ours is a parsimonious and easily tractable modification to the standard New Keynesian model. The general equilibrium effect is also maintained in models with limited foresight where agents have a finite planning horizon, as in Woodford and Xie (2020). In fact, Gust, Herbst, and Lopez-Salido (forthcoming) estimate that about 50% of households and firms have planning horizons that include the current quarter, and very few have horizons exceeding two years. To draw a parallel to the behavioural model used in our paper, which assumes a 0.85 myopia value, agents discount the one-year-ahead expectation by approximately 50% more than rational agents. The benefits of our approach following Gabaix (2020) over Woodford and Xie (2020) is that agents continuously discount expectations into the future rather than cutting off expectations at an exogenously determined point in the future.

We evaluate the performance of each monetary policy framework in stabilizing stochastic fluctuations in key macroeconomic variables such as the output gap, inflation and interest rates. For each framework, we consider a large set of possible policy rule coefficients and choose the optimal coefficient values based on a loss

4. Moreover, the model allows for different types of myopia that distinctly apply to households or firms. Specifically, in making consumption plans, households can discount the impact of future changes in income and interest rates to a greater extent than rational households. Similarly, myopic firms can further discount changes in expected inflation and future marginal costs when making pricing decisions.

function. We begin our analysis using an ad hoc loss function delegated to the monetary authority that comprises inflation and output gap variance (similar to the social welfare loss function) and explore the continuous space of relative weights on output gap variance. We further incorporate costly interest rate fluctuations into the ad hoc loss function. These alternative specifications of the loss function provide a comprehensive assessment of the frameworks and underpin the importance and great uncertainty around the central bank's objectives in setting monetary policy.

Our approach is, to the best of our knowledge, the first to consider a comprehensive assessment of a suite of history-dependent monetary policies in the presence of a binding ELB with bounded rationality. Our contribution is threefold. First, we examine the performance of optimized simple rules with respect to an extensive set of loss functions. Second, we consider results both at and away from a binding ELB within a stochastic environment. Finally, we provide an explicit quantitative assessment of the cost of the ELB under bounded rationality.

Our baseline result using an ad hoc loss function suggests that FIT yields a comparable unconditional macroeconomic outcome to AIT when considering the ELB and bounded rationality. Both of these frameworks outperform the strictly history-dependent ones such as PLT and NGDPL targeting. Underlying this result is the presence of important trade-offs in PLT and NGDPL that stabilize inflation at the expense of greater output gap volatility. With myopic agents, the probability of the policy rate hitting the ELB is assessed to be the highest under PLT—with longer duration of the ELB episodes—suggesting some consideration for financial stability.

However, history-dependent policies are shown to provide some benefits during periods when the policy rate remains constrained at the ELB. In addition to yielding mean inflation that is closer to the target, history-dependent policies also generate lower volatility in inflation. This confirms that the well-documented benefits of history dependence continue to be relevant even with a moderate amount of departure from rational expectations as assumed in the baseline calibration.

We also conduct a sensitivity analysis of the relative performance of history-dependent frameworks to varying values of myopia. Our sensitivity analysis suggests a superior performance of FIT over PLT when the myopia parameter is 0.95, with a slight departure from rational expectation (with a myopia parameter of 1). In contrast, AIT delivers a better macroeconomic outcome relative to FIT even when there is a nontrivial amount of departure from rational expectations (with a myopia parameter of about 0.5). This suggests that policy frameworks with shorter memory could be beneficial when agents form expectations under bounded rationality.

Overall, our work suggests that the relative performance of alternative regimes hinges crucially on how market participants form their expectations. The incentive of a central bank to switch from FIT to either AIT or PLT diminishes rapidly when the effective weights agents place on events further into the future decline even within a numerically small range. How to effectively harness the benefit of history-dependent policies at the ELB remains an increasingly challenging task when monetary policy communication takes place under exceptional economic situations.

This paper contributes to the literature ranking alternative monetary policy frameworks when agents are boundedly rational. Benchimol and Bounader (2021) use simple policy rules to determine the rankings under deterministic supply shocks and find that a form of inflation targeting is optimal when agents do not form correct *inflation* expectations—our paper nests this analysis since we additionally use an ELB environment. While our evidence confirms that FIT and AIT are welfare improving over history-dependent frameworks in most cases, we show that the latter frameworks can still be welfare improving in binding-ELB periods. Similarly, this conditionality on ELB episodes is an extension of the analysis provided in Budianto, Nakata, and Schmidt (2020), who find relatively better performance of AIT at the ELB for a certain level of myopia. Moreover, our analysis further considers the NGDPL targeting framework and makes use of a larger space of loss functions to ascertain this fact.

The remainder of the document is organized as follows: Sections 2 and 3 describe the New Keynesian model with bounded rationality and the main calibrations. Section 4 illustrates the key transmission channels under demand and cost-push shocks. Section 5 reports the main results with and without an occasionally binding ELB. It also includes some sensitivity analysis to our underlying assumption regarding myopia. Section 6 concludes.

2 The model

We conduct our comparison of alternative monetary policy regimes in a standard New Keynesian model with Calvo pricing, following Woodford (2003, Ch. 6) or Gali (2015, Ch. 3). The model is enriched with features of bounded rationality following Gabaix (2020).

Section 2.1 describes our Gabaix-style model in detail, with attention to how myopia on the part of households and firms is modelled, and how it alters household and firm behaviour (through the investment savings (IS) curve and the New Keynesian Phillips curve relative to the canonical New Keynesian models with rational expectations. Section 2.2 details each of the suite of policy rules under consideration.

2.1 A behavioural New Keynesian model with bounded rationality

2.1.1 Households

There is a continuum [0,1] of households in the economy indexed by j. Households derive utility from consuming c_t^j and disutility from providing labour. Each household j supplies N_t^j labour, which references the number of hours worked by household j. Each household maximizes its lifetime utility of

$$\mathbb{E}_0^{BR} \sum_{t=0}^{\infty} \beta U(c_t^j, N_t^j), \tag{1}$$

where $\mathbb{E}^{BR}$ is the expectations operator under bounded rationality and β is the discount factor. The period utility function for household j is given as

$$U(c_t^j, N_t^j) = \frac{c_t^{j\,1-\sigma} - 1}{1-\sigma} - \frac{N_t^{j\,1+\psi}}{1+\psi}, \tag{2}$$

where ψ is the elasticity of labour supply and σ is the risk aversion parameter.

In this paper, bounded rationality, on the part of both households and firms, takes two alternative forms:

1. cognitive discounting (i.e., agents have limited foresight)
2. cognitive inattention (i.e., agents have limited information about how variables respond within the model than they would otherwise under rational expectations)

Below, we provide more details on how these are modelled in the context of households.

Myopia type 1: Cognitive discounting

Following Gabaix (2020), we assume that households have limited foresight and form expectations $\mathbb{E}^{BR}(X_t)$ for any variable X_t according to

$$\mathbb{E}^{BR}(X_t) = \bar{m}\mathbb{E}(X_t) \quad \textit{and} \quad \mathbb{E}^{BR}(X_{t+k}) = \bar{m}^k \mathbb{E}(X_{t+k}), \tag{3}$$

which enters into the household's optimization problem through the expectations operator $\mathbb{E}^{BR}(X_t)$ in equation (1).

The cognitive discounting parameter, $\bar{m} \in [0, 1]$, measures to what extent households discount expectations about future events toward the steady state. Changes in $\bar{m}$ will vary the household's perception of future changes in consumption and hours worked. Rational expectations are the special case where $\bar{m} = 1$.

Each period, households' real income y_t consists of real wages $w_t N_t$ and dividends paid out of firm profits y_t^f. Given this income, the household can either consume or purchase a one-period bond k_t, with a real gross interest rate R_t, where $R_t = 1 + r_t$. The household's budget constraint is therefore

$$k_{t+1} = (1 + r_t)(k_t - c_t + y_t). \tag{4}$$

Myopia type 2: Cognitive inattention

Behavioural households also perceive changes in income and interest rates with some degree of myopia.

We can decompose household income y_t into two components, namely its steady state $\bar{y}$ and its deviation from steady state $\hat{y}_t(S_t, N_t)$ for a given state vector S_t. We assume a household perceives only a fraction $m_y \in [0,1]$ of the deviation of its income away from its steady state. With myopia, the household's perceived change in income is $\hat{y}_t^{BR}(S_t, N_t) = m_y \hat{y}_t(S_t, N_t)$.

Likewise, households will be myopic with respect to deviations of interest rates from steady state, with $\hat{r}_t^{BR}(S_t) = m_r \hat{r}_t(S_t)$, where $m_r \in [0,1]$. This implies that households are myopic to changes in current and future interest rates in their consumption-saving decision.

We assume that households are perfectly aware of the current wage rate and that working an additional hour increases their income by w_t, implying that the rate of change of boundedly rational expectations of income with respect to employment $\frac{\partial}{\partial N} y^{BR}(N_t, X_t) = w_t$. When we combine the equations for $\hat{y}^{BR}$ and $\hat{r}^{BR}$ with equation (3), the household's myopia and cognitive discounting imply

$$\mathbb{E}_t^{BR}[\hat{r}_{t+k}^{BR}] = m_r \bar{m}^k \mathbb{E}_t[\hat{r}_{t+k}] \quad and \quad \mathbb{E}_t^{BR}[\hat{y}_{t+k}^{BR}] = m_y \bar{m}^k \mathbb{E}_t[\hat{y}_{t+k}]. \tag{5}$$

Households' optimization problem

The household's total lifetime wealth is $(k_0 + \sum_{t=0}^{\infty} q_t(y_t - c_t))$, where $q_t = 1/\Pi_{\tau=0}^{t-1}(1 + r_t)$. Hence, the household seeks to maximize lifetime utility given its expected lifetime wealth, maximizing

$$\mathbb{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{j^{1-\sigma}} - 1}{1-\sigma} - \frac{N_t^{j^{1+\psi}}}{1+\psi} \right) + \lambda(k_0 + \sum_{t=0}^{\infty} q_t(y_t - c_t)), \tag{6}$$

where λ is the Lagrange multiplier with respect to lifetime wealth, taking the (boundedly rational) expected future paths for income y_t and interest rates r_t as given. We can derive first-order conditions for consumption and hours worked by optimizing $\mathbb{L}$ over c_t and N_t, respectively. We get

$$[c_t] \qquad (\beta)^t c_t^{-\sigma} = \lambda q_t, \tag{7}$$

$$[N_t] \quad (\beta)^t N_t{}^{\psi} - \lambda w_t q_t = 0, \tag{8}$$

where since all households are identical, we have dropped the household identifier j. Combining the two conditions yields a standard labour supply equation

$$w_t = \sigma c_t + \phi n_t. \tag{9}$$

Since the household's saving decision relies on expectations with myopia, its derivation will be more involved than the simple New Keynesian model. We will derive the household saving decision as a function of the household's propensity to consume out of perceived income and interest rates.

The household's first-order condition for consumption (7) implies that $c_t = c_0 \left(\frac{\beta^t}{q_t}\right)^{1/\sigma}$, for a given starting value of consumption $c_0 = \lambda^{-1/\sigma}$. Letting the total perceived income equal $\Omega = k_0 + \sum_{t=0}^{\infty} q_t y_t$, the total perceived budget constraint is $\Omega = \sum_{t=0}^{\infty} q_t c_t = c_0 \sum_{t=0}^{\infty} (\beta^t)^{1/\sigma} q_t^{1-1/\sigma}$.

Therefore, consumption at time $t = 0$ is

$$c_0 = \Omega\mu = \frac{k_0 + \sum_{t=0}^{\infty} q_t y_t}{\sum_{t=0}^{\infty} (\beta^t)^{1/\sigma} q_t^{(1-1/\sigma)}}, \tag{10}$$

where $\mu = \frac{1}{\sum_{t=0}^{\infty} (\beta^t)^{1/\sigma} q_t^{(1-1/\sigma)}}$ and equation (10) is a function of current and future income and interest rates.

To determine the marginal propensity to consume out of income, b_y, we consider a one-time change in income in period τ, dy_τ. First note that when linearized around the steady state, $q_t = \beta^t$ and $1 = \beta R = \beta(1 + r)$, where R is the steady-state gross interest rate and r is the steady-state net interest rate. This implies that in steady state $\mu = \sum_{t=0}^{\infty} (\beta^t)^{1/\sigma} q_t^{(1-1/\sigma)} = 1/(1 - \beta)$ and

$$c_0 = (1 - \beta)(k_0 + \sum_{t=0}^{\infty} q_t y_t), \tag{11}$$

and the marginal propensity to consume out of income is $b_y = 1 - \beta = r/R$ and a steady state $\mu = b_y$. Therefore, the impact of a change in dy_τ on consumption is

$$dc_0 = \mu d\Omega = b_y \frac{dy_\tau}{R^\tau} \tag{12}$$

and

$$\frac{\partial c_0}{\partial y_\tau} = b_y \frac{1}{R^\tau}. \tag{13}$$

For the household's propensity to consume out of interest rates b_r, consider a one-time change in interest rates in period τ, dr_τ. This implies a change in bond prices $dq_t = \frac{-1}{R^{t+1}} dr_\tau 1_{t>\tau}$.

$$\sum_{t\geq 0} dq_t = \sum_{t\geq 0} \frac{-1}{R^{t+1}} dr_\tau 1_{t>\tau} = \sum_{t\geq \tau+1} \frac{-1}{R^{t+1}} dr_\tau = \frac{-1}{rR^{\tau+1}} dr_\tau \tag{14}$$

Therefore,

$$\begin{aligned} \frac{d\mu}{\mu} &= -\mu(1 - 1/\sigma) \sum_{t\geq 0} \beta^{t1/\sigma} q_t^{-1/\sigma} dq_t = -\frac{r}{R}(1 - 1/\sigma) \sum_{t\geq 0} dq_t \\ &= (1 - 1/\sigma)\frac{r}{R}\frac{1}{rR^{\tau+1}} dr_\tau = (1 - 1/\sigma)\frac{dr_\tau}{R^{\tau+2}} \end{aligned} \tag{15}$$

In addition,

$$d\Omega = \bar{y}\sum_{t\geq 0} dq_t = \frac{-\bar{y}}{rR^{\tau+1}} dr_\tau \tag{16}$$

$$\begin{aligned} dc_0 = \mu\Omega\frac{d\mu}{\mu} + \mu d\Omega = c_0(1-1/\sigma)\frac{dr_\tau}{R^{\tau+2}} + \frac{r}{R}\frac{-\bar{y}}{rR^{\tau+1}}dr_\tau \\ = \left(-\frac{1}{\sigma}c_0 + c_0 - \bar{y}\right)\frac{dr_\tau}{R^{\tau+2}} = \left(-\frac{1}{\sigma}c_0 + \frac{rk_0}{R}\right)\frac{r_\tau}{R^{\tau+2}} \\ = \frac{b_r}{R^\tau}dr_\tau. \end{aligned} \tag{17}$$

where $b_r = \frac{\frac{r}{R}k_0 - 1/\sigma c_0}{R^2}$. We linearize around $c_0 = \bar{c} = 1, k_0 = 0$, implying that $b_r = \frac{-1}{\sigma R^2}$.

Therefore, with cognitive discounting

$$\hat{c}_t \;=\; E_t^{BR}\left[\sum_{\tau\geq t}\frac{1}{R^{\tau-t}}\left(b_r\hat{r}_\tau^{BR} + \frac{r}{R}\hat{y}_\tau^{BR}\right)\right] \;=\; E_t\left[\sum_{\tau\geq t}\frac{\bar{m}^{\tau-1}}{R^{\tau-t}}\left(b_r m_r\hat{r}_\tau + \frac{r}{R}m_y\hat{y}_\tau\right)\right]. \tag{18}$$

Since there is no investment in this model, the resource constraint implies that consumption equals total output $\hat{c}_\tau = \hat{y}_\tau$. Letting $\tilde{b}_y := r/Rm_y$ and $\tilde{b}_r m_r = -\frac{m_r}{\sigma R^2}$, we can rewrite equation (18) as

$$\hat{c}_t = E_t\left[\sum_{\tau\geq t}\frac{\bar{m}^{\tau-1}}{R^{\tau-t}}\left(\tilde{b}_r\hat{r}_\tau + \tilde{b}_y\hat{y}_\tau\right)\right]. \tag{19}$$

Taking the first term out of the summation yields

$$\hat{c}_t = \tilde{b}_y\hat{c}_t + \tilde{b}_r\hat{r}_t + E_t\left[\sum_{\tau\geq t+1}\frac{\bar{m}^{\tau-1}}{R^{\tau-t}}\left(\tilde{b}_r\hat{r}_\tau + \tilde{b}_y\hat{y}_\tau\right)\right]. \tag{20}$$

Gathering like terms, we can write

$$\hat{c}_t = \frac{\bar{m}}{R - rm_y}E_t\hat{c}_{t+1} - \frac{m_r}{\sigma R(R - rm_y)}\hat{r}_t. \tag{21}$$

2.1.2 Firms

There is a continuum of unit mass firms, with each firm denoted by i producing a differentiable product $Y_t(i)$ according to the following Cobb-Douglas production function:

$$Y_t(i) = N_t(i)^{(1-\alpha)}, \tag{22}$$

where $\alpha > 0$, implying diminishing returns to scale. Labour is the only input used in production (we do not consider technology shocks in our analysis).

We assume that only a fraction $(1-\theta)$ of firms are able to adjust their price each quarter. Therefore, the aggregate price level is equal to

$$P_t = P_{t-1}^{\theta}P_t^{*(1-\theta)}, \tag{23}$$

where P_t^* is the reset price, determined by all firms who adjust their price in that period. The optimization problem for the behavioural firm is to choose a price ${P_t}^*$ that maximizes its profit

$$\max_{P_t^*} \sum_{k=0}^{\infty} \theta^k (E_t^{BR} \left(\Lambda_{t,t+k} \left(\frac{1}{P_{t+k}} \right) \left((1+\tau) P_t^* Y_{t+k|t} - \mathcal{C}_{t+k}(Y_{t+k|t}) \right) \right), \tag{24}$$

given the conditional demand

$$Y_{t+k|t} = \left(\frac{P_t^*}{P_{t+k}} \right)^{-\epsilon} C_{t+k}. \tag{25}$$

The stochastic discount factor is $\Lambda_{t,t+k} = \beta^k U_{c,t+k}/U_{c,t}$ and $\mathcal{C}_t(\cdot)$ refers to the nominal cost function. An efficient equilibrium is introduced by setting a tax on production τ equal to $(\epsilon-1)^{-1}$ that is returned back to the firm as a lump sum. Firms who are able to adjust their price choose their optimal price P_t^* according to the following first-order condition:

$$\sum_{k=0}^{\infty} \theta^k \left(E_t^{BR} \Lambda_{t,t+k} Y_{t+k|t} \left(\frac{1}{P_{t+k}} \right) \left((1+\tau) P_t^* - \mathcal{M} \phi_{t+k|t} \right) \right) = 0, \tag{26}$$

where $\phi_{t+k|t} \equiv \mathcal{C}'_{t+k}(Y_{t+k|t})$ is the nominal marginal cost and $\mathcal{M} \equiv \frac{\epsilon}{\epsilon-1}$.

Like the behavioural household, the behavioural firm has limited foresight and perceives the future with some degree of myopia. In addition, the firm is myopic to how inflation and its own cost structure may change in the future. Therefore, its perception of future changes in inflation and marginal costs are given as

$$\mathbb{E}_t^{BR}[\widehat{\pi}_{t+k}^{BR}] = m_\pi^f \bar{m}^k \mathbb{E}_t[\widehat{\pi}_{t+k}] \quad and \quad \mathbb{E}_t^{BR}[\widehat{\phi_{t+k|t}}^{BR}] = m_x^f \bar{m}^k \mathbb{E}_t[\widehat{\phi_{t+k|t}}], \tag{27}$$

where $m_\pi^f \in [0,1]$ and $m_x^f \in [0,1]$ measure the firm's myopia to changes in inflation and marginal costs, respectively. Defining the firm's discount rate for future profits under the current optimal price as $\rho = \beta\theta\bar{m}$, we can define its expectation of future inflation as

$$\begin{aligned} H_t &:= \sum_{k\geq 1} \rho^k \left(m_\pi^f \pi_{t+1} + \ldots + m_\pi^f \pi_{t+k} \right) \\ &= \sum_{i\geq 1} m_\pi^f \pi_{t+i} \sum_{k\geq i} \rho^k = \sum_{i\geq 1} \pi_{t+i} \frac{\rho^i}{1-\rho} = \frac{m_\pi^f}{1-\rho} \sum_{i\geq 0} \pi_{t+i} \rho^i 1_{i>0}. \end{aligned} \tag{28}$$

Utilizing equations (26) and (28), we can rewrite the optimal price-setting decision for a firm that can adjust its price as

$$\begin{aligned} p_t^* &= p_t + (1-\beta\theta) \sum_{k=0}^{\infty} \rho^k \mathbb{E}_t \left[m_\pi^f (\pi_{t+1} + \ldots + \pi_{t+k}) - m_x^f \phi_{t+k|t} \right] \\ &= p_t + (1-\beta\theta) \mathbb{E}_t \left[H_t - \sum_{k=0}^{\infty} \rho^k m_x^f \phi_{t+k|t} \right] \\ &= p_t + (1-\beta\theta) \sum_{k\geq 0} \rho^k \mathbb{E}_t \left[\frac{m_\pi^f}{1-\rho} \pi_{t+k} 1_{k>0} - m_x^f \phi_{t+k|t} \right]. \end{aligned} \tag{29}$$

With $\alpha > 0$, the firm's marginal cost can be computed as

$$\phi_{t+k|t} = \phi_{t+k} + \frac{\alpha\epsilon}{1-\alpha}(p_t^* - p_{t+k}). \tag{30}$$

This would allow us to rewrite the optimal price in equation (29) as

$$p_t^* = p_t + (1-\beta\theta)\sum_{k\geq 0}\rho^k \mathbb{E}_t\left[\frac{m_\pi^f}{1-\rho}\pi_{t+k}1_{k>0} - m_x^f\left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon}\right)\phi_{t+k}\right]. \tag{31}$$

2.1.3 Equilibrium

Clearing in the labour market implies

$$N_t = \int_0^1 N_t(i)di, \tag{32}$$

where aggregate employment across all i firms is given as N_t.

Clearing in the goods market implies

$$y_t = c_t. \tag{33}$$

2.1.4 The behavioural IS and Phillips curves

This section outlines the derivation of the behavioural IS curve and the Phillips curve based on the household and firm optimization problems laid out in Sections 2.1.1 and 2.1.2.

The behavioural IS curve

The behavioural IS curve can be derived from the household Euler equation (21) and the resource constraint in equation (33). Defining $\tilde{y}_t = y_t - y_t^n$ as the deviation of output y_t from its natural level under flexible prices y_t^n, and taking the deviation of the interest rates from its neutral level to be $\hat{r}_t = i_t - E\pi_{t+1} - r_t^n$, yields

$$\tilde{y}_t = ME_t\tilde{y}_{t+1} - \Gamma\left[i_t - E\pi_{t+1} - r_t^n\right], \tag{34}$$

$$\text{where} \quad M = \frac{\bar{m}}{R - rm_y}, \quad \Gamma = \frac{m_r}{\sigma R(R - rm_y)} \tag{35}$$

and r_t^n is the natural interest rate.

Demand shocks are introduced by allowing the natural rate to be time-varying. Specifically,

$$r_t^n = (1-\rho^{r^n})r + \rho^{r^n} r_{t-1}^n + \epsilon_t^{rn}, \tag{36}$$

where ρ^{r^n} is the persistence of the natural rate shock and ϵ_t^{rn} is an unanticipated innovation to this shock sequence, with a mean 0 and a standard deviation of σ^{rn}.

The rational expectations IS curve can be derived assuming $\bar{m} = m_r = m_y = 1$. In this scenario, the IS equation (37) reduces to the canonical IS curve

$$\tilde{y}_t = E_t\tilde{y}_{t+1} - \frac{1}{\sigma R}\left[i_t - E\pi_{t+1} - r_t^n\right]. \tag{37}$$

The behavioural Phillips curve

The derivation of the behavioural Phillips curve starts with the optimal price-setting decision for a firm in equation (26). Given that $\pi_t = \frac{1-\theta}{\theta}(p_t^* - p_t)$, we can write equation (31) as

$$\pi_t = \frac{1-\theta}{\theta} \sum_{k\geq 0} \rho^k \mathbb{E}_t \left[\frac{1-\beta\theta}{1-\rho} m_\pi^f \pi_{t+k} 1_{k>0} - m_x^f (1-\beta\theta) \left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon} \right) \widehat{\mu_{t+k}} \right], \tag{38}$$

where $\mu_t \equiv p_t - \phi_t$ is the average markup and $\widehat{\mu}_t \equiv \mu_t - \mu^n$ measures the gap between desired and average markups. In order to derive the behavioural New Keynesian Phillips curve, equation (38) can be written recursively as

$$\pi_t = \beta M^f \mathbb{E}_t [\pi_{t+1}] - \bar{\lambda} \hat{\mu}_t, \tag{39}$$

where

$$M^f = \bar{m} \left(\theta + \frac{1-\beta\theta}{1-\beta\theta\bar{m}} m_\pi^f (1-\theta) \right), \quad \bar{\lambda} = m_x^f \left(\frac{1-\theta}{\theta} \right) (1-\beta\theta) \left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon} \right). \tag{40}$$

Utilizing the household labour supply equation (9), the resource constraint in equation (33) and the relationship between aggregate employment and output in equation (22), the average markup μ_t can be derived as

$$\begin{aligned} \mu_t &= p_t - \phi_t \\ &= -(w_t - p_t) - \alpha n_t + log(1-\alpha) \\ &= -(\sigma y_t - \psi n_t) - \alpha n_t + log(1-\alpha) \\ &= -\left(\sigma - \frac{\psi+\alpha}{1-\alpha} \right) y_t + log(1-\alpha). \end{aligned} \tag{41}$$

Under flexible prices where $y_t = y_t^n$, we can derive the flexible-price markup μ^n as

$$\mu^n = -\left(\sigma - \frac{\psi+\alpha}{1-\alpha} \right) y_t^n + log(1-\alpha). \tag{42}$$

The deviation between average and desired markups $\hat{\mu}_t$ can therefore be computed by subtracting equation (42) from (41) to get

$$\widehat{\mu}_t = -\left(\sigma + \frac{\psi+\alpha}{1-\alpha} \right) (y_t - y_t^n). \tag{43}$$

Substituting this into equation (44) yields the behavioural New Keynesian Phillips curve

$$\pi_t = \beta M^f \mathbb{E}_t [\pi_{t+1}] + \bar{\kappa} \tilde{y}_t + u_t, \tag{44}$$

where

$$\begin{aligned} M^f &= \bar{m} \left(\theta + \frac{1-\beta\theta}{1-\beta\theta\bar{m}} m_\pi^f (1-\theta) \right), \\ \bar{\kappa} = m_x^f \kappa &= m_x^f \frac{(1-\theta)(1-\beta\theta)}{\theta} \left(\sigma + \frac{\psi+\alpha}{1-\alpha} \right) \left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon} \right). \end{aligned}$$

An exogenous cost-push shock u_t is included and evolves according to the following process:

$$u_t = \rho^u u_{t-1} + \epsilon^u_t, \tag{45}$$

where ρ^u is the persistence and σ^u is the standard deviation of the innovation ϵ^u_t.

The canonical New Keynesian Phillips curve under rational expectations can be derived from equation (44) by removing all forms of myopia with $\bar{m} = m^f_\pi = m^f_x = 1$. Under this condition $M^f = 1$ and $\bar{\kappa} = \kappa$, yielding the canonical New Keynesian Phillips curve under rational expectations

$$\pi_t = \beta \mathbb{E}_t \left[\pi_{t+1}\right] + \kappa \tilde{y}_t + u_t. \tag{46}$$

Together, equations (37) and (44) constitute the non-policy block of the behavioural New Keynesian model.

Monetary policy frameworks

With the inclusion of nominal frictions there is room for monetary policy to affect the real economy. Therefore, the final component necessary to close the model is a description of the monetary policy rule used to determine the nominal interest rate i_t. The FIT regime is the baseline monetary policy, with the associated policy rule taking the following form:

$$i_t = \theta_i i_{t-1} + (1-\theta_i)\left(r + \bar{\pi} + \theta_\pi \, \mathbb{E}_t \left(\left[\frac{1}{4}\sum_{j=1}^{4} \pi_{t+j}\right] - \bar{\pi}\right) + \theta_y \tilde{y}_t\right), \tag{47}$$

where θ_π and θ_y are all non-negative and denote the sensitivity of the policy rate to inflation and output gap respectively. θ_i references the rate of interest rate smoothing.

2.2 A suite of alternative monetary policy frameworks

We conduct the comparison of policy regimes including the baseline FIT and three alternative monetary policy frameworks. These include PLT, AIT and NGDP-level targeting.

Flexible inflation targeting (FIT)

Under the baseline setting, a central bank sets the interest rate i_t reacting to both the current output gap $\tilde{y}_t$ and the deviation of year-over-year inflation from the inflation target $\bar{\pi}$, allowing for some degree of smoothing. More concretely,

$$i_t = \Theta_i i_{t-1} + (1-\Theta_i)\left(r + \bar{\pi} + \Theta^{FIT}_\pi \, \mathbb{E}_t \left(\left[\frac{1}{4}\sum_{j=1}^{4} \pi_{t+j}\right] - \bar{\pi}\right) + \Theta_y \tilde{y}_t\right), \tag{48}$$

where Θ_i is the interest rate smoothing parameter, Θ^{FIT}_π is the sensitivity of the policy rate to inflation and Θ_y is the sensitivity of the policy rate to the output gap.

Price-level targeting (PLT)

We also include PLT, motivated by a number of studies on the merits of price-level targeting in dealing with an effective lower bound. Under PLT, changes in the price level that lead to a shortfall in inflation will be made up later by a period of inflation overshoot. This is characterized in the literature as history dependence. The expectation of higher prices in the future causes inflation to rise today through the expectations channel in the Phillips curve. As such, PLT provides an automatic buffer against a period of prolonged deflation. The success of PLT depends largely on the assumption that monetary policy is conducted with full commitment to the rule as well as the degree of rational expectations. In a model economy with a sufficient amount of bounded rationality, the expectation channel is weakened as a result of myopia toward future states. This leads to a potentially important quantitative impact on the efficacy of PLT in normal times, and particularly during the ELB.

The policy rule under PLT is defined as

$$i_t = \Theta_i i_{t-1} + (1 - \Theta_i) \left(r + \bar{\pi} + \Theta_p \, \mathbb{E}_t \left(p_{t+4} - \overline{p}_{t+4} \right) + \Theta_y \tilde{y}_t \right), \tag{49}$$

where $\overline{p}_{t+4}$ denotes the target price path. This value is set to zero since steady-state inflation is zero. The sensitivity of the policy rate to the price level's deviation from the target price path is determined by Θ_p.

Average inflation targeting (AIT)

AIT represents an intermediate framework between flexible inflation and price-level targeting and has the following form:

$$i_t = \Theta_i i_{t-1} + (1 - \Theta_i) \left(r + \bar{\pi} + \Theta_\pi^{AIT} \, \mathbb{E}_t \left(\left[\frac{1}{12} \sum_{j=0}^{11} \pi_{t+4-j} \right] - \bar{\pi} \right) + \Theta_y \tilde{y}_t \right), \tag{50}$$

where $\frac{1}{12} \sum_{j=0}^{11} \pi_{t-j}$ denotes the average year-over-year inflation rate over the last three years. The responsiveness of the policy rate to the average inflation measure is determined by Θ_π^{AIT}.

Nominal gross domestic product–level (NGDPL) targeting

The final framework considered is NGDPL targeting. The associated rule is defined as

$$i_t = \Theta_i i_{t-1} + (1 - \Theta_i) \left(r + \bar{\pi} + \Theta_{NGDPL} \, \mathbb{E}_t \left(NGDPL_{t+4} - \overline{NGDPL}_{t+4} \right) \right), \tag{51}$$

where $NGDPL_{t+4}$ is defined as the sum of both the price level p_{t+4} and the output gap $\tilde{y}_{t+4}$ with an assigned weight of Θ_{NGDPL} in the policy rule. The term $\overline{NGDPL}_{t+4}$

denotes the targeted path for NGDPL. This is value is set to zero since in steady state there is no NGDP growth, and inflation is zero in steady state.

3 Calibration

Table 1 summarizes the calibration of the baseline model with bounded rationality. First, note that all variables included in the model are of a quarterly frequency and that the calibration discussed will match this convention.

Starting with the household, we assume that a disutility of labour supplied, ψ, is 5 and a coefficient for the absolute risk aversion parameter, σ, is 1, implying logarithmic preference. The household's discount factor β will be set equal to 0.9944, implying a neutral interest rate of 2.25%. This matches the midpoint of the range reported by Brouillette et al. (2021) for the neutral rate in Canada for 2021. For the firms, we set the probability that a firm is unable to adjust prices each quarter, θ, to 0.9. This calibration implies a relatively flat slope for the Phillips curve under rational expectations, with $\kappa = 0.023$ in equation (46). While the slope coefficient in the Phillips curve is lower than convention, it is consistent with estimates of the Phillips curve by Corrigan et al. (2021) and Gervais and Gosselin (2014). The elasticity of substitution across goods, ϵ, is set equal to 9, implying a markup of 1.125. For the calibration of the baseline policy rule, we assume an interest rate inertia of 0.85, a weight on inflation of θ_π of 4.65 and a weight on output of θ_y of 0.4, matching the calibration used in ToTEM III.[5]

Both demand and cost-push shocks included follow an AR(1) process with a persistence of 0.8 and a standard deviation calibrated to generate a 16% ELB probability. This matches the ELB probability predicted by ToTEM III. Second, the size of the demand shock relative to the cost-push shock is calibrated such that under the baseline model calibration, cost-push shocks explain the majority of the movement in inflation, while demand shocks explain the majority of the movement in output, as observed in Canada.

For the cognitive discount and myopic parameters, we follow the convention established by Benchimol and Bounader (2021) and assume a 15% departure from rational expectations. The only notable exception is the household's income myopia, m^y. Since the household is perfectly aware of their wage rate, varying this parameter has little to no effect on the model and therefore m^y is set equal to 1 for the remainder of the analysis. In section 5, we vary the myopia and cognitive discount anywhere between a 0% and a 100% departure from rational expectations. This allows us to remain relatively agnostic to the specific calibration chosen for these parameter values.

5. The results presented in this paper are robust to the assumption of zero interest rate inertia.

Table 1: **Key structural parameters**

Parameter	Description	RE	Myopia	Functional form
$\overline{m}$	Cognitive discounting	1.00	0.85	
m_y	HH myopia to income	1.00	1.00	
m_r	HH myopia to interest rate	1.00	0.85	
m_π^f	Firm myopia to inflation	1.00	0.85	
m_x^f	Firm myopia to future MC	1.00	0.85	
β	Discount factor	0.9944	0.9944	
σ	Absolute risk aversion	1	1	
ψ	Labour disutility	5	5	
θ	Price survival rate	0.90	0.90	
ϵ	Demand elasticity	9	9	
α	Returns-to-scale parameter	0.25	0.25	
ρ^{r^n}	Demand shock persistence	0.8	0.8	
ρ^u	Cost-push shock persistence	0.8	0.8	
σ^{r^n}	Standard deviation: Demand shock	0.0345	0.0345	
σ^u	Standard deviation: Cost-push shock	0.00069	0.00069	
R	Gross interest rate	1.0056	1.0056	$\frac{1}{\beta}$
r	Net interest rate	0.0056	0.0056	$R-1$
θ_i	MP rule interest rate inertia	0.85	0.85	
θ_π	MP rule response to inflation	4.65	4.65	
θ_y	MP rule response to output	0.40	0.40	
$\bar{\kappa}$	Slope of the Phillips curve	0.023	0.0198	$\bar{\kappa} = m_x^f(\frac{1}{\theta}-1)(1-\beta\theta)\left(\sigma+\frac{\psi+\alpha}{1-\alpha}\right)\left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon}\right)$
M^f	Cognitive discounting term: Future inflation	1.00	0.7967	$M^f = \bar{m}\left(\theta+\frac{(1-\beta\theta)}{(1-\beta\theta\bar{m})}m_\pi^f(1-\theta)\right)$
M	Cognitive discounting term: Future output	1.00	0.85	$M = \frac{\bar{m}}{R-rm_y}$
Γ	Interest rate sensitivity	1.00	0.8452	$\Gamma = \frac{m_r}{\sigma R(R-rm_y)}$

Note: The RE column shows the calibration of the rational expectations model, while the Myopia column shows the main calibration of the bounded rationality model.

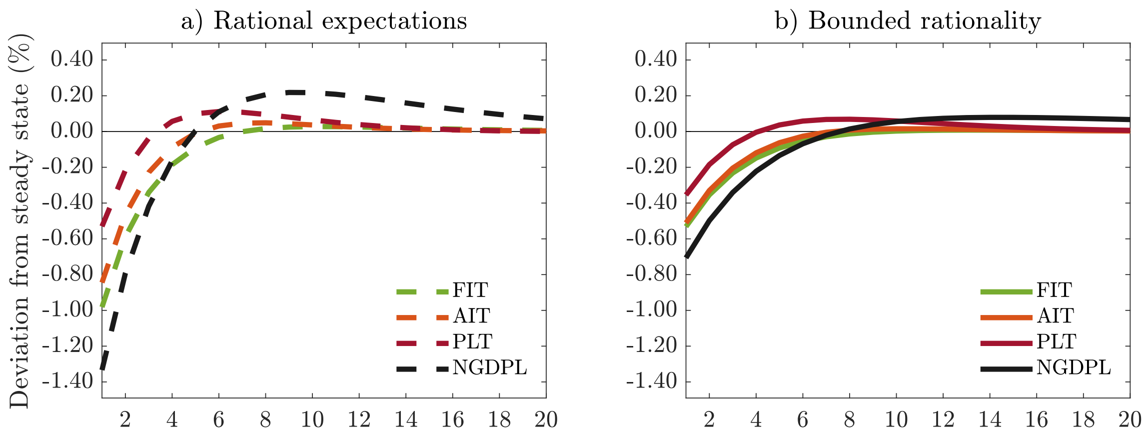
4 Transmission of shocks

In this section, we conduct an impulse response analysis in which we analyze the responses of inflation and the output gap to a transitory negative demand shock and a negative cost-push shock. Our focus is on understanding the key transmission mechanisms of the model with bounded rationality under the four monetary policy frameworks of choice: FIT, AIT, PLT and NGDPL targeting.

We use the same parameterization of the policy rules that was used in the calibration of the model with Canadian data. Specifically, we assume that the central bank adopts flexible targeting frameworks with interest rate smoothing. Thus, the policy rules take the form $i_t = 0.85 i_{t-1} + (1 - 0.85) \times 4.65 NV_t + (1 - 0.85) \times 0.4 \tilde{x}_t$, where NV_t corresponds to the targeted nominal variable and $\tilde{x}_t$ to the output gap. Given that under NGDPL the central bank can target only one variable, we assume that $i_t = 0.85 i_{t-1} + (1 - 0.85) \times 0.4 NGDPL_t$. Choosing this coefficient value makes the NGDPL rule comparable to the ones above since it matches the sensitivity of nominal interest rates to output gap movements.[6]

In Chart 1, we present the response of inflation to a negative demand shock under the assumption of rational expectations (panel a) and bounded rationality (panel b). In the rational expectations model, the initial drop in inflation is more attenuated under a PLT framework than under the FIT and AIT frameworks. This is an illustration of the conventional New Keynesian literature that emphasizes the importance of the expectation channel in a price-targeting regime: when firms and households fully anticipate higher future inflation and the central bank has perfect credibility, economic agents make optimal decisions that result in higher current inflation.

Chart 1: **Response of quarterly inflation to a negative demand shock**



Note: The graphs represent impulse response of quarterly inflation to a negative demand shock under different frameworks. FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting, and NGDPL is nominal gross domestic product-level targeting. The x-axis represents the number of quarters elapsed since the shock occurred.

6. Nominal GDP is the sum of price level and output gap in the standard New Keynesian model, which implies that there is an equal weight on the price level and the output gap.

AIT also benefits from the expectations channel since the central bank aims to correct for past inflation deviations within a moving window. This results in a faster rise in inflation in AIT relative to FIT.

Under the NGDPL regime, the expectations channel does not allow for a similar attenuation of inflation on impact, despite having a high level of history dependence. This is explained largely by the implicitly lower weight on price-level deviations in NGDPL targeting relative to PLT.

Introducing myopia does not affect this relative ranking of frameworks since PLT continues to best stabilize the initial decline in inflation, AIT remains an intermediary case between PLT and FIT, and NGDPL targeting notably yields the most volatile short- and long-term inflation profile (Chart 1, panel b). However, myopia has a noticeable effect on the absolute response of inflation and the output gap to the demand shock.

This attenuation effect occurs because myopic agents are subject to both cognitive discounting (agents discount the future at a higher rate than their discount factor) and cognitive inattention (agents pay less attention to future information).[7] As a result, future deviations in inflation have less bearing on current deviations in inflation given an identical initial shock.

Another important observation is that the "divine coincidence" (the positive correlation between inflation and the output gap under demand shocks) reinforces the effect of myopia on inflation. Indeed, agents' myopia to future negative output gap movements attenuates the drop in the current output gap (as observed in Chart 2, panel b), which helps limit the inflation decline in the short run via the Philips curve.[8]

We now begin a discussion of the cost-push shock. In light of the demand shock, we expect myopia to dampen volatility. As seen in Chart 3, panel b, we notice that myopia attenuates the initial response of inflation under all frameworks relative to the rational expectations model with the exception of PLT.

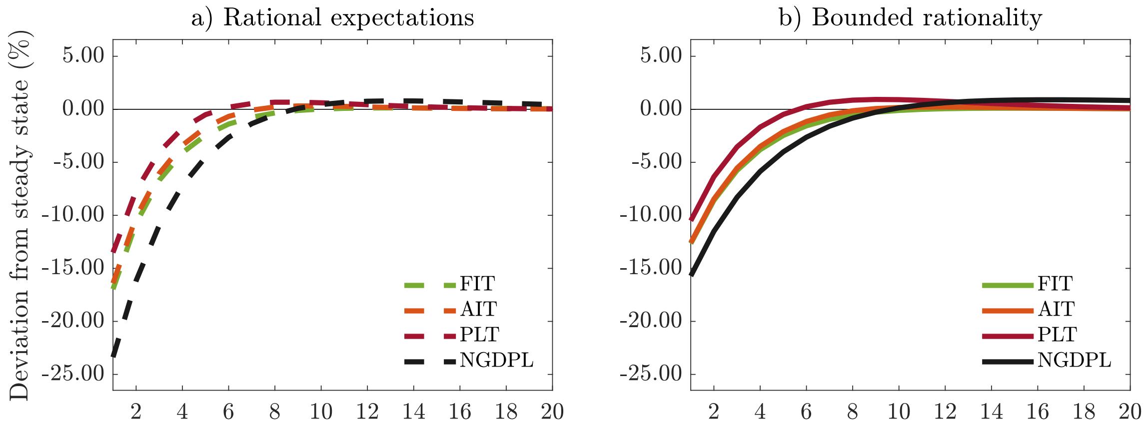
Under the PLT framework, myopic agents do not anticipate the future correction in prices, which implies that the expectations channel has a lesser effect in stimulating prices in the present. Given this slightly larger initial drop in prices, the central bank leaves interest rates lower for longer to achieve the medium-term overshoot required to reverse the price deviation from trend.

Similarly, the representative firm's forecast of inflation underestimates the true future path under an NGDPL regime. For this reason, firms adjust prices much more slowly than in the rational expectations model, which prolongs the period over which prices decline and leads to an extended overshoot in inflation. Overall, myopia

7. The distinction between the two types of myopia is discussed in more detail in Section 2.

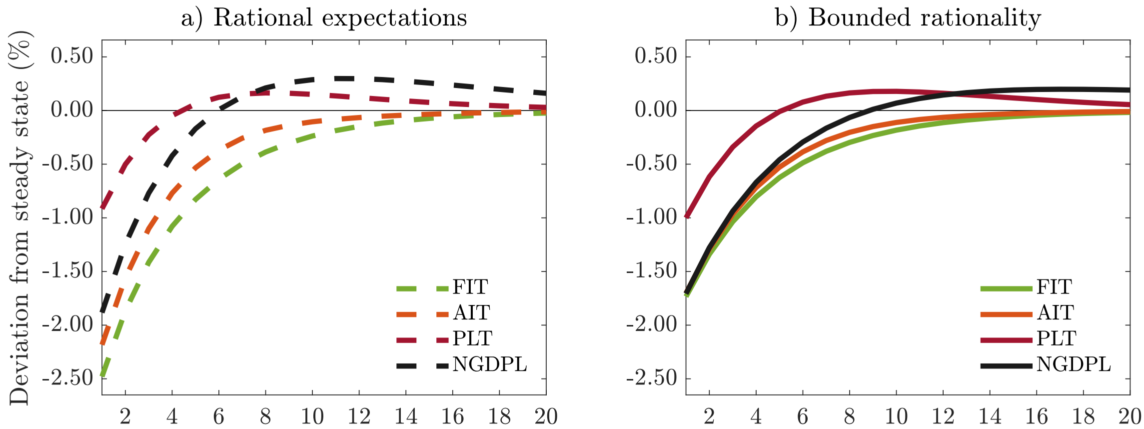
8. Another way myopia strengthens the "divine coincidence" effect is through the cognitive inattention to interest rates in the behavioural IS curve. The latter can be written as $x_t = -\sigma \Sigma_{k \geq 0} M^k E_t(\hat{r}_{t+k} - \hat{r}^n_{t+k})$, where M = 1 corresponds to the rational expectations case, and $\hat{r}_{t+k}$ is the real interest rate. When $M < 1$ and we model the demand shock as a lower natural real rate, deviations in the real rate are more discounted, which shrinks the output gap and, in turn, brings inflation closer to target than under the $M = 1$ case.

Chart 2: **Response of output gap to a negative demand shock**



Note: The graphs represent impulse response of the output gap to a negative demand shock under different frameworks. FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting; and NGDPL is nominal gross domestic product-level targeting. The x-axis represents the number of quarters elapsed since the shock occurred.

Chart 3: **Response of quarterly inflation to a negative cost-push shock**



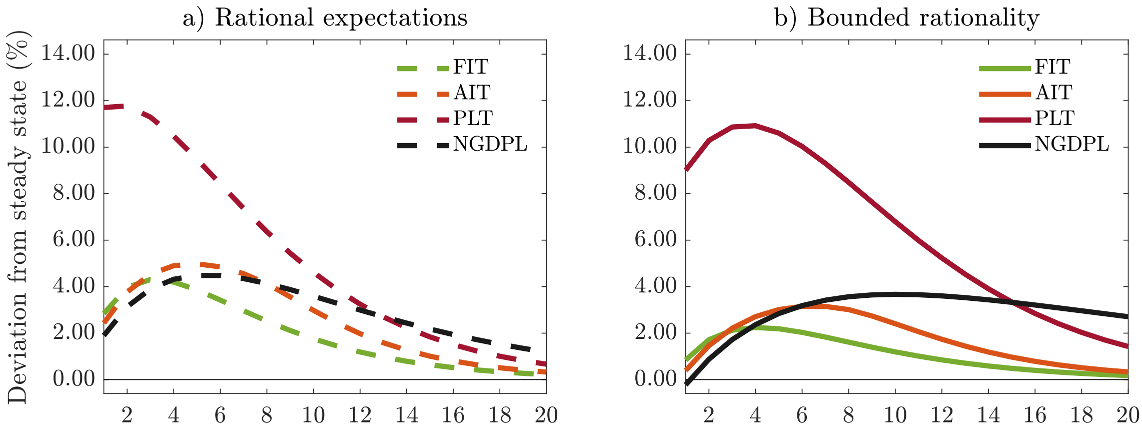
Note: The graphs represent impulse response of quarterly inflation to a negative cost-push shock under different frameworks. FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting; and NGDPL is nominal gross domestic product-level targeting. The x-axis represents the number of quarters elapsed since the shock occurred.

leads to higher volatility in inflation under the two level-targeting regimes, PLT and NGDPL. Meanwhile, the AIT and FIT frameworks see a reduction in volatility in both the short- and long-run because of the attenuating effects of myopia and the absence of a make-up strategy.

To illustrate what happens on the real side of the economy, we turn to Chart 4. Under the PLT and NGPDL frameworks, we notice that the output gap stays persistently higher, which confirms our earlier observation that nominal interest rates stay lower for longer as part of the make-up strategy. Hence, myopia amplifies *both* output gap volatility and inflation volatility, and thus turns history dependence from a desirable trait in rational expectations models into a disadvantage in a model with bounded rationality.

This is not the case for FIT, where introducing myopia attenuates the response

Chart 4: **Response of output gap to a negative cost-push shock**



Note: The graphs represent impulse response of the output gap to a negative cost-push shock under different frameworks. FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting; and NGDPL is nominal gross domestic product-level targeting. The x-axis represents the number of quarters elapsed since the shock occurred.

of the output gap throughout the simulation period. Similarly, the AIT framework yields a much less volatile output gap than PLT and continues to be an intermediary case between PLT and inflation targeting in the medium-to-long term largely because of the accommodative role of interest rates bringing the inflation average back to target. Hence, the lesser degree of history dependence allows AIT to keep its inflation-stabilizing properties without inducing too much volatility in the real economy. We will emphasize these findings in the simulation results in the next section.

5 Main results

In this section, we evaluate the ranking of monetary policy frameworks with and without a binding ELB. Following Dorich, Mendes, and Zhang (2021), we begin our analysis by ranking the FIT, AIT and PLT frameworks using ad hoc loss functions. Given that in practice the central bank may change its emphasis over time, our analysis varies the relative weight on output gap volatility. We further consider a positive weight on interest rate volatility to reflect the low volatility of policy rates in recent decades. Throughout the analysis, we contrast the model with bounded rationality to its rational expectations counterpart in order to better understand the relative shift in rankings when agents are myopic.

5.1 Ranking of inflation- and price-targeting frameworks

To rank these frameworks, we first run a grid search over a space of policy rule coefficients and, for each point, we record the moments of the series resulting from the stochastic simulation.[9] These coefficients lie in the range [0; 1333], where the upper bound is chosen to ensure that we obtain the true monetary policy frontier.[10] We do not optimize over the interest rate smoothing parameter but instead set it to 0.85, which is a value commonly used in inertial Taylor rules (Chung et al. 2019). The determination of optimal coefficients is based on the ad hoc loss function that minimizes a weighted sum of the variance of inflation and the output gap.

Policy frontiers without the effective lower bound

To construct the policy frontier, we vary the relative weight on the output gap variance and plot the associated moments. This is a slight departure from the social welfare loss function (which we will also discuss below), but we argue that this approach is a more robust consideration of the relative performance of frameworks. It allows for a wider range of values than the model-implied weight. Moreover, given that it is hard to estimate society's relative weight on the output gap, we do not take a stance on real-world beliefs and provide a ranking for a continuous space of plausible values.

The ad hoc loss function is

$$L^{adhoc} = Var(\pi_t^a) + \lambda_{\tilde{y}} Var(\tilde{y}_t), \tag{52}$$

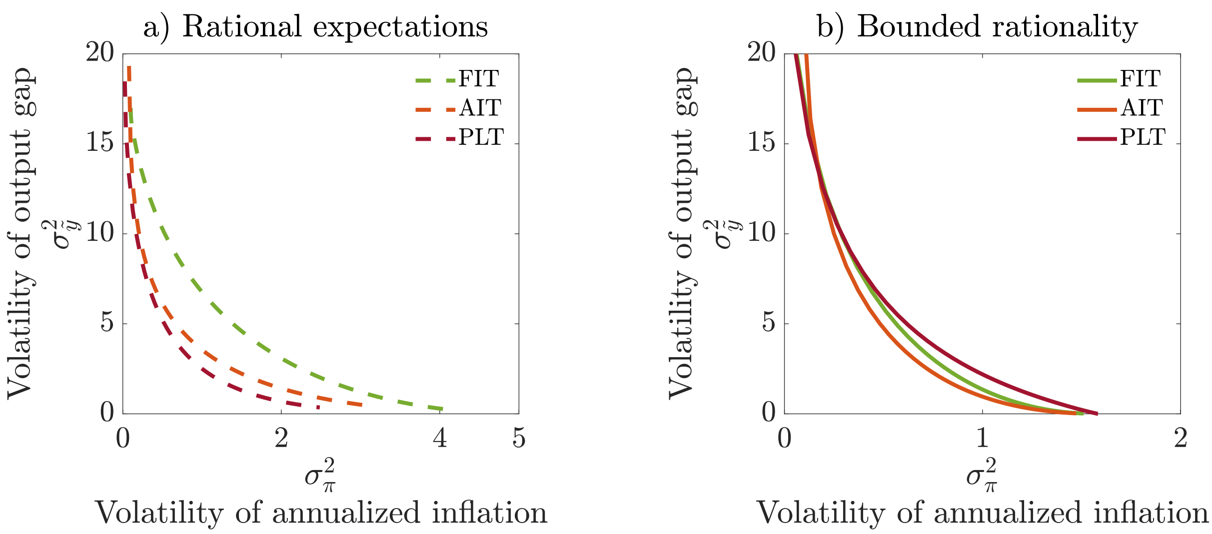
where $\lambda_{\tilde{y}} \in [0,2]$ is the weight on output gap variance and π_t^a is the annualized

9. For instance, in the case of the FIT rule, the grid point is $(\Theta_\pi^{FIT}, \Theta_{\tilde{y}})$.

10. While the upper bound is certainly an arbitrary choice, increasing the upper bound led to little to no movement in the policy frontier. This is largely because the more realistic coefficients are in the lower range. Hence, to ensure we are as accurate as possible in finding the optimal coefficients, we have a higher density of grid points in the lower range of coefficients.

inflation rate.[11] We plot the second moments associated with the coefficients that yield the minimal loss value given by equation (52). In doing so, we obtain the efficiency frontier plots in Chart 5.

Chart 5: **Efficient policy frontiers without a binding effective lower bound**



Note: The efficient policy frontiers plot the variances of the output gap and annualized inflation yielded by the optimal coefficients under the ad hoc loss function defined in equation (52). The values are scaled by 10^4 to simplify the notation on the axes. FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting.

While the relative weight on the output gap is not plotted on the graph itself, we can visually infer that points on the left side of the frontier line (i.e., low inflation and high output volatility) correspond to very low values of $\lambda_{\tilde{y}}$ since the social planner aims to stabilize inflation much more than the output gap. Conversely, very high values of $\lambda_{\tilde{y}}$ correspond to the right end of the frontier line. The frontier plots illustrate the trade-off between inflation and output gap stabilization.

Chart 5, panel a, confirms the intuition developed in Section 4. Under rational expectations, both AIT and PLT can yield lower inflation volatility compared with FIT given the same output gap volatility outcome. All else equal, the expectation channel under history-dependent rules plays a crucial role in dampening inflation fluctuations. Hence, the AIT and PLT frontiers are closer to the origin, which indicates that they strictly dominate FIT for a large range of $\lambda_{\tilde{y}}$ considered.

Myopia reverses the ranking, with AIT and FIT outperforming PLT (see Chart 5, panel b) for a large range of weights on the output gap variance. Since myopia reduces the role of inflation expectations in the Phillips curve, there is a marked reduction in the volatility of inflation and output for both inflation-targeting rules. Therefore, the AIT and FIT frontiers move inward. In contrast, myopia undermines the expectations channel for PLT, which worsens inflation volatility conditional on

11. Note that the social welfare function uses the quarterly level of inflation. This is annualized in the ad hoc loss function, as done in Swarbrick and Zhang (forthcoming) and Djeutem, Reza, and Zhang (forthcoming).

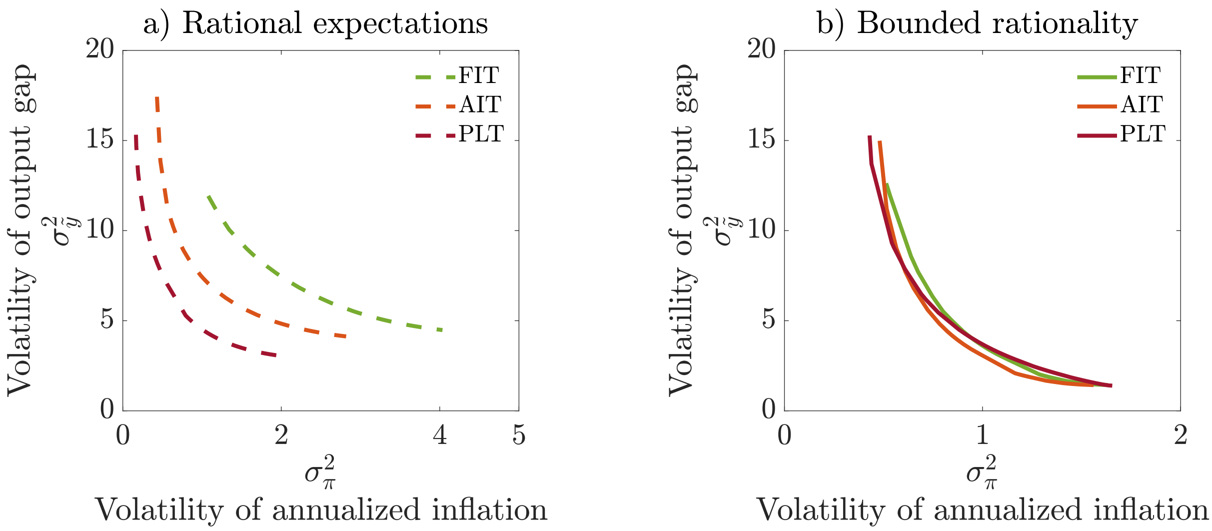
a recessionary shock. History dependence becomes a liability since it induces an inflation overshoot without the added benefit of attenuating the initial response in inflation. Hence, there is a marked shift outward of the frontier plots associated with PLT.

Policy frontiers with the effective lower bound

We proceed to review the results based on an occasionally binding ELB of 0.25% where the natural rate of interest is 2.25%. Both values were chosen based on Canadian data. The lower bound is the historical constraint on the target for the overnight rate, while the natural rate is the midpoint of the current estimated range by Brouillette et al. (2021).

The efficient policy frontier analysis in Chart 6 shows similar findings to the analysis done without an ELB constraint. Under the rational expectations model, PLT is the preferred framework for the range of relative weights on output gap variance.

Chart 6: **Efficient policy frontiers with a binding effective lower bound**



Note: The efficient policy frontiers plot the mean squared deviation of output gap and annualized inflation yielded by the optimal coefficients under the ad hoc loss function defined in equation (52). The values are scaled by 10^4 to simplify the notation on the axes. FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting.

The frontier plots in Chart 6, panel a, demonstrate the long-standing conclusion that PLT strictly dominates all other rules when there is a binding ELB. During ELB episodes, PLT keeps interest rates lower for longer, which helps bolster current inflation through the expectations channel in the Phillips curve. Bounded rationality challenges the strict dominance of PLT, with AIT now outperforming PLT for a majority of the frontier space in Chart 6, panel b. This is due to the fact that myopia weakens this expectations channel, forcing the PLT frontier outward. Beyond the Phillips curve, cognitive discounting also dampens the effect future changes in consumption have on the households' current consumption-saving decision. This helps reduce volatility in output and improve the performance of all rules across the board.

However, the effect is largest for FIT and AIT, moving their frontiers inward. Visually, this chart confirms the conclusions made by Budianto, Nakata, and Schmidt (2020), who conclude that the marginal gains between PLT, AIT and FIT are relatively small with bounded rationality. This result is driven entirely by the presence of cost-push shocks, which, as shown in the Appendix, reduce the performance of PLT when expectations are boundedly rational.

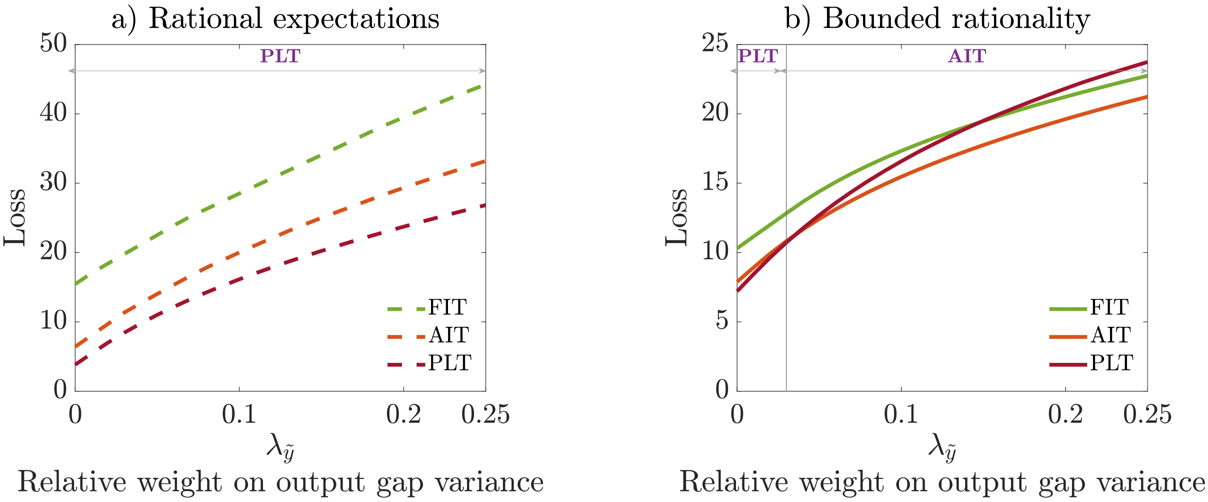
Introducing a penalty for large interest rate changes

This result is also robust to a loss function specification that incorporates interest rate volatility.[12] In equation (53), we assign a fixed relative weight on the change in annualized interest rates:

$$L^{adhoc} = (\pi_t^{yy} - \bar{\pi}^a)^2 + (\tilde{y}_t)^2 + 0.5(\Delta i_t)^2 \tag{53}$$

This ad hoc loss function is used to produce Chart 7, which shows the minimal loss yielded by the loss function in equation (53) conditional on the relative weight on output gap variance $\lambda_{\tilde{y}}$. Given a certain value of $\lambda_{\tilde{y}}$, the framework with the lowest loss outperforms the others. The loss plot captures all three dimensions of volatility in a two-dimensional plot and provides an explicit mapping between the assumed weight on the real economy and the ranking associated with it. It also complements the intuition obtained from the efficient policy frontier.

Chart 7: **Ad hoc loss with occasionally binding effective lower bound**



Note: The loss plots illustrate the minimized loss value conditional on the ad hoc loss function defined by equation (53) and the relative weight on output gap variance. The values are unitless and they are scaled by 10^5 to simplify the notation on the axes. The headlines in purple indicate the preferred framework, which yields the smallest loss value over a range of weight on output gap variance. FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting.

12. Here we follow the methodology adopted in Murchison (2010). This additional term may reflect the central bank's consideration for the adverse effect of excessive movements in the short-term risk-free rate on financial markets.

Under rational expectations in Chart 7, panel a, we notice that the history-dependent PLT continues to outperform AIT and FIT for the full range of values considered. Hence, the ranking is robust to the addition of interest rate volatility. This is understandable given that fluctuations in the output gap are determined by movements in real rates, and a loss function with a higher weight on output gap variance implicitly penalizes nominal interest rate movements. Hence, this relative weight has a qualitatively similar effect to an explicit weight on interest rate volatility.

An important contribution of this paper is to show that myopia reverses the dominance of PLT for a wide range of relative weights on the output gap. This result is equally robust to the introduction of a positive weight on the volatility of interest rate changes. With bounded rationality, Chart 7, panel b, demonstrates that history-dependent rules do progressively worse as the central bank puts more weight on output gap volatility. PLT dominates only for a relatively small weight on output gap stabilization, while AIT dominates for larger values. Recall that myopia requires higher volatility of interest rates for PLT in the longer term in order to compensate for the large initial decline in inflation. Absent this stimulus, inflation is less stable under PLT and contributes to the greater rise in loss. Although there is a degree of history dependence under AIT as well, less movement in the output gap is required to stabilize average inflation.

5.2 Incorporating NGDPL targeting in the analytical framework

So far, we have abstained from integrating the NGDPL framework in our analysis to ensure a comparable ranking. Under NGDPL, there is a single weight on the target variable, which implies that it cannot yield an efficient policy frontier where there exists a trade-off between the output gap and inflation variance. These features would put it at a disadvantage in the ad hoc loss analysis above. We shift to the micro-founded loss function to assess the model-implied ranking, and then continue with the regime-specific loss function, which we hold to be a more appropriate objective of a central bank.

Welfare loss results

First, we follow the standard approach in characterizing the ranking of monetary policy frameworks by employing the social welfare function. This welfare criterion is based on the households' expected lifetime utility derived from consumption and leisure. While households have boundedly rational expectations and use heuristics to inform decisions, they still continue to experience utility as they would under rational expectations. Therefore, the welfare criterion is based on objective expectations.

Following Woodford (2003, Ch. 6), we measure the welfare criterion as

$$\mathbb{W} = \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{\epsilon}{\lambda} \pi_t^2 + \left(\sigma + \frac{\phi + \alpha}{1 - \alpha} \right) \tilde{y}_t^2 \right], \tag{54}$$

$$\text{where} \quad \lambda = (\frac{1}{\theta} - 1)(1 - \beta\theta)\frac{(1-\alpha)}{(1-\alpha+\alpha\epsilon)}. \tag{55}$$

It follows that the expected social welfare loss (SWF) function is

$$L^{SWF} = var(\pi_t) + \left(\frac{1-\theta}{\theta}\right)\left(\frac{1-\beta\theta}{\epsilon}\right)\left(\sigma + \frac{\psi+\alpha}{1-\alpha}\right)\left(\frac{1-\alpha}{1-\alpha+\alpha\epsilon}\right) Var(\tilde{y}_t). \tag{56}$$

In Table 2, we report the moments and ELB statistics associated with the coefficients that minimize equation (56). We focus on the components of the loss to emphasize the macro stabilization qualities of our candidate frameworks. It is also important to evaluate the performance of each of these rules *during* ELB episodes. Following Dorich et al. (2018), we report moments of inflation and the output gap conditional on nominal interest rates being at the ELB under FIT. In addition, we also report the unconditional probability of hitting the ELB for each framework and the mean duration of the ELB episodes conditional on FIT.

Table 2: **Performance of policy frameworks given the social welfare loss function**

	ELB statistics				**Annualized inflation**				**Output gap**				**Loss relative to FIT**	
	RE		**Myopia**		**RE**		**Myopia**		**RE**		**Myopia**		**RE**	**Myopia**
Frameworks	**Probability**	**Duration**	**Probability**	**Duration**	**Mean**	**RMSD**	**Mean**	**RMSD**	**Mean**	**RMSD**	**Mean**	**RMSD**	**Loss**	**Loss**
Unconditional														
FIT					-0.23	0.89	-0.19	0.68	-0.74	3.45	-0.9	2.93	1.00	1.00
AIT					-0.16	0.59	-0.16	0.64	-0.49	3.37	-0.64	2.78	0.66	0.95
PLT					0	0.38	0	0.61	-0.28	3.32	-0.26	3.01	0.46	0.95
NGDPL					0	0.88	0	0.86	-0.07	2.54	-0.02	2.36	0.96	1.30
Conditional on FIT at ELB														
FIT	26.4	4	33.1	4.4	-1.14	1.49	-0.81	1.04	-1.19	3.89	-0.08	2.55		
AIT	37.9	5.4	39.7	5.9	-0.74	1.03	-0.74	0.97	-0.37	3.78	0.02	2.56		
PLT	28	4	40.4	5.5	-0.28	0.49	-0.48	0.74	0.44	3.64	0.69	2.72		
NGDPL	12.5	1.7	18.8	2.3	-0.66	1.01	-0.71	0.98	-1.07	2.98	-0.25	2.4		

Note: The table reports the mean and root mean squared deviation (RMSD) associated with the policy rule coefficients optimized under the social welfare loss function. We report these statistics based on the full series, which we call the unconditional sample, as well as the series conditional on the ELB episodes under the FIT regime. We record only the unconditional probability and the mean duration of ELB episodes conditional on the episode intersecting the FIT ELB episode. The loss values are not reported conditional on the ELB since the welfare criterion is applicable unconditionally. RE is rational expectations; FIT is flexible inflation targeting; AIT is average-inflation targeting; PLT is price-level targeting; and NGDPL is nominal gross domestic product-level targeting.

The unconditional results corroborate our findings for rational expectations in Chart 6 with PLT as the preferred framework in stabilizing both inflation and output gap volatility. As expected, NGDPL targeting and PLT remove mean inflation deviations from target in the presence of a binding ELB. In particular, NGDPL targeting stands out for the stabilizing properties of its output gap. Unlike PLT, NGDPL targeting forces the coefficients to be the same across both nominal and real components. This often results in the optimized coefficient for NGDPL resting between the two optimized coefficients for PLT. The net result is greater output gap stabilization at the cost of higher inflation volatility. AIT serves as the middle ground between FIT and the strictly history-dependent rules, with an optimal price level drift between these two competing rules.

When agents are myopic, NGDPL targeting continues to excel in stabilizing the output gap but its inflation stabilization performance deteriorates relative to FIT and AIT. Further, PLT's relative performance deteriorates for both inflation and the output gap due to a weakening of the expectations channel in the Phillips curve. The AIT framework is relatively immune to the effect of myopia. This is due to the fact that by optimizing over the coefficients in this policy rule, we are able to deliver the optimal degree of price-level drift. For this reason, AIT yields comparable inflation volatility and lower output gap volatility relative to PLT. This rule also strictly dominates FIT in reducing volatility and deviations from target for both nominal and real variables. Notably, the volatility of output declines with bounded rationality, caused by the households' myopia toward future changes in consumption in the household Euler equation.

One of the novel contributions of this paper to the bounded rationality literature is its focus on the performance of monetary policy rules *during* ELB episodes. History-dependent monetary policy rules are often lauded for their ability to reduce the severity of ELB episodes. By looking exclusively at the moments during ELB episodes, this research helps us understand the advantage of using the frameworks in the current low interest rate economy in a model with bounded rationality. Restricting the sample of the simulation to these periods does not affect the superior performance of PLT in stabilizing inflation or the output gap relative to competing rules. However, PLT is the only framework that yields a positive output gap, pointing to the trade-off under supply shock when the central bank risks overheating the economy in an attempt to bring inflation back to target.

While myopia reduces the differences in inflation stabilization at the ELB between frameworks with and without strict history dependence, PLT still performs well during ELB episodes. This advantage comes at the cost of relatively greater output gap volatility compared with the case with rational expectations.

Even if PLT and NGDPL targeting obtain superior inflation stabilization measures, this is not what is observed in laboratory experiments (Kostyshyna, Petersen, and Yang, forthcoming), where a negative shock inducing an ELB leads to an unboundedly severe recession with a deflationary spiral. While we cannot recover this result in this model setup since myopia has an attenuating effect on macroeconomic outcomes, we can still show that with a high enough degree of myopia, history-dependent rules will perform poorly compared with FIT and AIT. We explore this result in the sensitivity section below.

Lastly, we notice that NGDPL obtains the lowest unconditional ELB probability and duration irrespective of the assumption about agents' rationality. This is due to the lower sensitivity of interest rates to the nominal component (i.e., prices) chosen under the social welfare loss function.

Introducing regime-specific loss functions

We now proceed to characterize the ranking of alternative monetary policy frameworks using a loss function that is specific to respective framework. We refer to this loss function as "regime-specific loss" hereafter. Table 3 presents the specification for each regime as a weighted sum of the volatility in the nominal variable, the real variable and the change in annualized interest rates. Effectively, the central bank uses an objective function that is consistent with the target of the policy regime. In this way, we choose the coefficients that best stabilize the macro variables targeted by each monetary policy regime, and then we observe whether we obtain a change in macroeconomic stabilization performance.

Table 3: **Regime-specific loss functions**

Frameworks	Loss function
Flexible-inflation targeting	$L^{FIT} = (\pi_t^{yy} - \bar{\pi}^a)^2 + (\tilde{y}_t)^2 + 0.5(\Delta i_t)^2$
Average- inflation targeting	$L^{AIT} = (\pi_t^{3y} - \bar{\pi}^a)^2 + (\tilde{y}_t)^2 + 0.5(\Delta i_t)^2$
Price-level targeting	$L^{PLT} = (p_t - \bar{p}_t)^2 + (\tilde{y}_t)^2 + 0.5(\Delta i_t)^2$
NGDP-level targeting	$L^{NGDPL} = \{(\tilde{y}_t + p_t) - (\bar{y}_t + \bar{p}_t)\}^2 + 0.5(\Delta i_t)^2$

In the unconditional sample, myopia continues to reduce the differences in inflation stabilization across the board, with the performance of each monetary policy rule becoming increasingly similar. However, history-dependent rules yield an output gap volatility almost twice as large as their counterparts when agents are myopic. Hence, the choice of history-dependent rules may be beneficial during a recessionary episode at the risk of higher volatility in normal times.

These findings are further illustrated in Chart 8, which illustrates the distribution of inflation for periods conditional on FIT being at the ELB.[13] Under rational expectations, we observe a distinct ranking dominated by the history-dependent rules when evaluating both their dispersion and their ability to achieve target inflation. The mean inflation under PLT and NGDPL is closest to the inflation target, while that for FIT and AIT are shifted to the left. Likewise, the dispersion of inflation under the PLT and NGDPL frameworks is reduced relative to FIT and AIT, which corroborates the values found in Table 4.

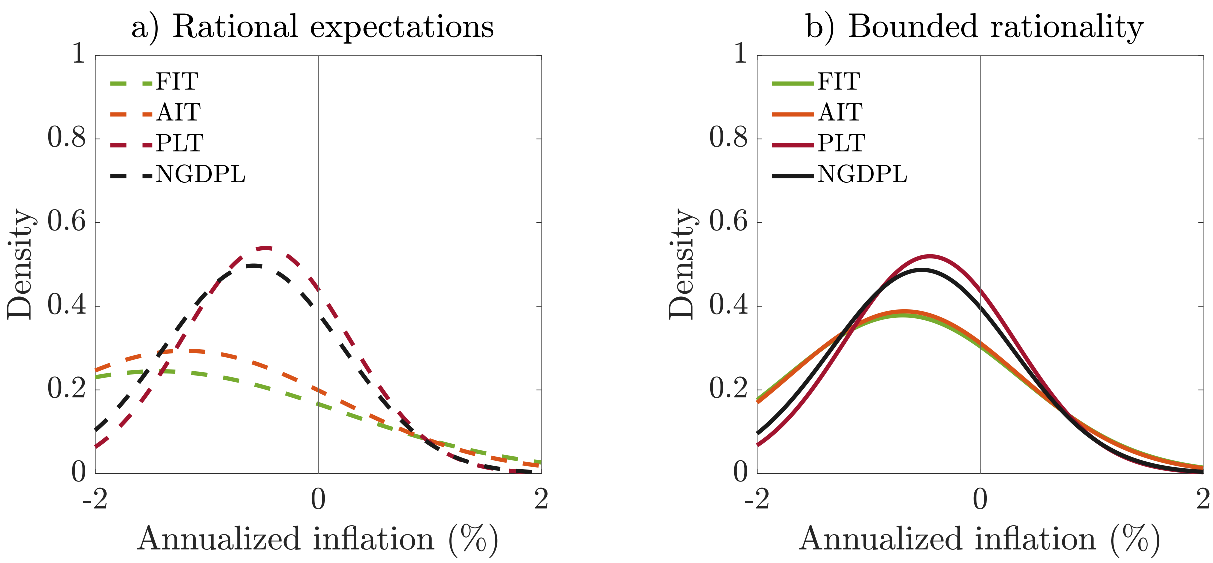
13. We fit the distribution with a normal distribution since it matches the kernel density very closely and improves the visibility of results.

Table 4: **Performance of policy frameworks given the regime-specific loss function**

	ELB Statistics				**Annualized Inflation**				**Output Gap**			
	RE		**Myopia**		**RE**		**Myopia**		**RE**		**Myopia**	
Frameworks	**Proba-bility**	**Dura-tion**	**Proba-bility**	**Dura-tion**	**Mean**	**RMSD**	**Mean**	**RMSD**	**Mean**	**RMSD**	**Mean**	**RMSD**
Unconditional												
FIT					-0.21	1.68	-0.09	1.09	-0.66	2.17	-0.35	1.33
AIT					-0.16	1.43	-0.08	1.07	-0.52	2.03	-0.34	1.33
PLT					0	0.78	0	0.76	-0.28	2.24	-0.14	2.36
NGDPL					0	0.88	0	0.86	-0.07	2.54	-0.02	2.36
Conditional on FIT at ELB												
FIT	25.6	3.9	23	3.9	-1.43	2.17	-0.7	1.26	-2.6	3.74	-1.96	2.47
AIT	24.7	3.4	23	3.7	-1.2	1.81	-0.68	1.23	-2.16	3.42	-1.91	2.44
PLT	23.5	3.1	28.6	4.5	-0.47	0.88	-0.45	0.89	-1.01	3.01	-1.36	2.37
NGDPL	12.5	1.8	18.8	3.1	-0.58	0.99	-0.52	0.97	-1.53	3.09	-1.62	2.55

Note: The table reports the mean and root mean squared deviation (RMSD) associated with the policy rule coefficients optimized under the regime-specific loss functions. With nominal interest rates bound by the ELB, we report these statistics based on the full unconditional series as well as the series conditional on periods where interest rates are at the ELB under the FIT regime. Note that we record only the unconditional probability and the conditional duration. See the text for more details.

Chart 8: **Distribution of inflation in simulations with optimized coefficients**



Note: The panels illustrate the distribution of inflation conditional on periods where FIT interest rates are at the effective lower bound. The policy rule coefficients were optimized under the regime-specific loss functions defined in Table (3). FIT is flexible inflation targeting, AIT is average-inflation targeting, PLT is price-level targeting, and NGDPL is nominal gross domestic product-level targeting

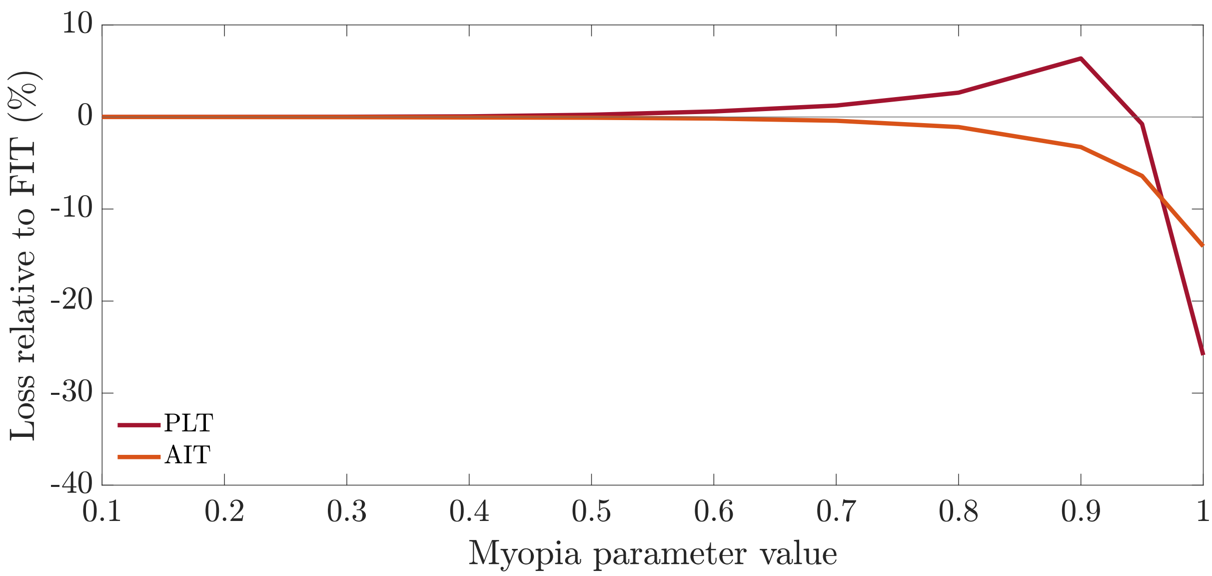
Under bounded rationality (Chart 8, panel b), we find that myopia reduces the performance of PLT and NGDPL rules in stabilizing mean inflation around its target. For FIT and AIT, we observe an improvement in both mean and dispersion inflation during ELB episodes. As we saw in Section 4, recessions are less severe when expectations are boundedly rational. This is due to the fact that future output gap movements have less of an effect on the current macroeconomy. Therefore, boundedly rational expectations help bolster the performance of AIT and FIT while diminishing the performance of PLT and NGDPL targeting.

5.3 Sensitivity of results to the degree of myopia

To assess the robustness of our results to the assumptions regarding myopia, we perform a sensitivity analysis of the ranking of monetary policy frameworks over the full range of possible myopia values. This exercise allows us to explore what degree of myopia is sufficient to change the ranking of alternative monetary policy frameworks under rational expectations.

In Chart 9, we vary the degree of myopia and observe the loss of PLT and AIT relative to FIT. For each level of myopia considered, we optimize the coefficients using the loss function in equation (53). A positive relative loss implies that the optimal FIT policy outperforms the competing rule, while a negative value implies that the alternative policy rule outperforms FIT. For instance, in the rational expectations model that corresponds to a parameter value of 1, both history-dependent rules perform relatively well, in line with the literature and our previous analysis.

Chart 9: **Sensitivity of ranking to degree of overall myopia**



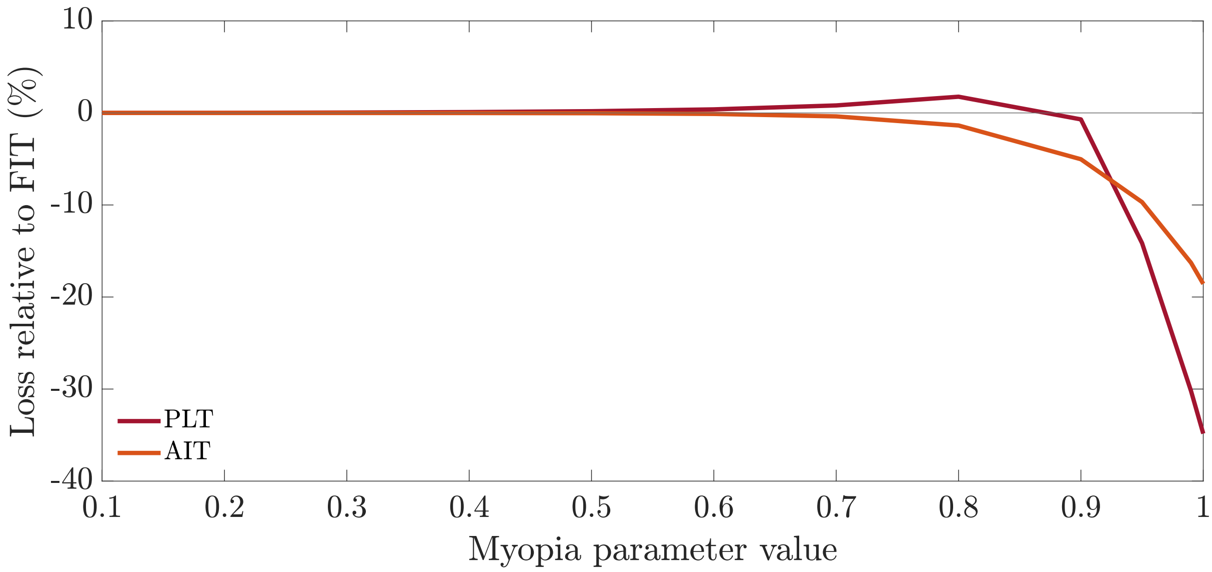
Note: The lines show the loss of PLT and AIT regimes relative to FIT for a range of myopia values. Specifically, all myopia parameters $\bar{m}, m_y, m_r, m_\pi^f, m_x^f$ are set to the value indicated on the x-axis. Given a set of myopia values, policy coefficients are optimized using the ad hoc loss function in equation (53) with equal weights on output gap and inflation variance. The effective lower bound is not binding in this set of results. FIT is flexible inflation targeting; AIT is average-inflation targeting; and PLT is price-level targeting.

Chart 9 illustrates that it is sufficient to assume a mild degree of myopia to undermine the expectations channel and reverse the ranking established under the rational expectations model. As we decrease the value of overall myopia, we progressively de-part from the rational expectations model. Given only a 5% departure from rational expectations, we can see that FIT outperforms PLT. In addition, this chart illustrates that, regardless of the level of myopia, the AIT rule always outperforms FIT.[14]

To help understand what drives these results, we perform the following two experiments. First, we vary each myopia parameter independently to assess which form of myopia is behind the results shown in Chart 9. Second, we perform a shock-specific analysis to understand how overall myopia interacts with the different types of shocks in the model. These charts are available in the Appendix. We note that the results reported in Chart 9 are driven primarily by the cognitive discounting term $\bar{m}$. In addition, the deterioration in the performance of PLT over AIT and FIT as we move away from rational expectations is entirely due to its inability to stabilize both interest rates and output when the economy is driven by supply shocks. Lastly PLT will always outperform AIT and FIT, regardless of the degree of myopia, in a demand-driven economy.

Next we vary the degree of myopia and observe the loss changes relative to FIT.

Chart 10: **Sensitivity of ranking to degree of overall myopia with binding effective lower bound**



Note: The lines show the loss of PLT and AIT regimes relative to FIT for a range of myopia values. Specifically, all myopia parameters $\bar{m}, m_y, m_r, m_x^f$ are set to the value indicated on the x-axis. Given a set of myopia values, policy coefficients are optimized using the adhoc loss function in equation (53) with equal weights on output gap and inflation variance. The ELB is binding in this set of results. FIT is flexible inflation targeting; AIT is average-inflation targeting; and PLT is price-level targeting.

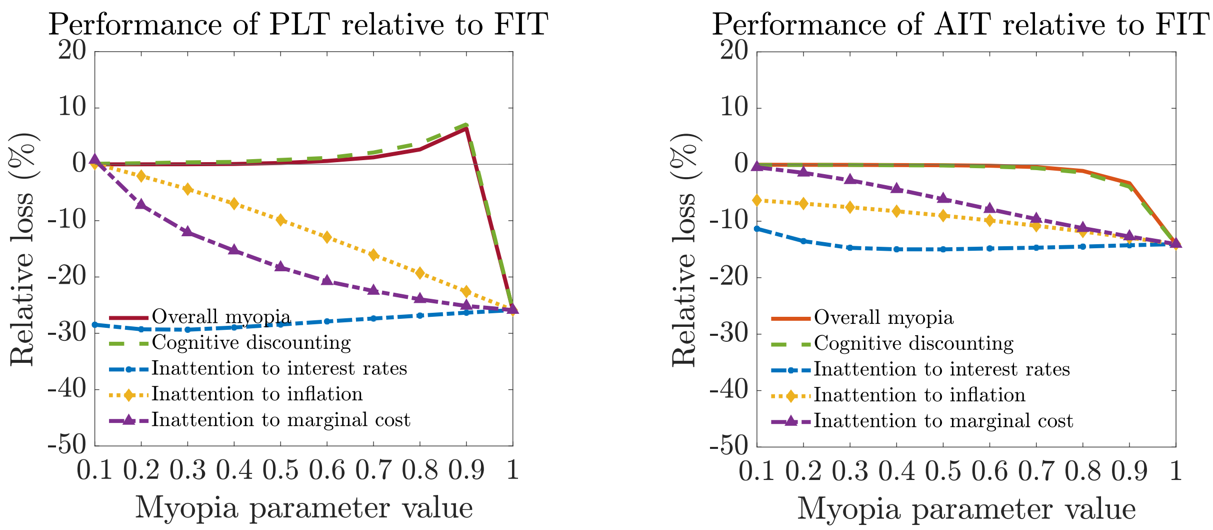
As seen in Chart 10, the presence of a binding ELB improves the performance of PLT relative to FIT. This is due to the relatively strong performance of PLT during ELB episodes. While PLT's performance has improved across all myopia values, it still takes only a small departure from rational expectations (10%) for FIT to outperform

14. Note that NGDPL targeting produces a dramatically larger loss relative to FIT for all myopia values.

PLT. AIT continues to outperform FIT across all myopia values, suggesting that this rule is robust to the assumption of myopia and a binding ELB.

To assess which form of myopia drives the ranking reported in Charts 9 and 10, we decompose the effect of each myopia parameter on the relative ranking of PLT and AIT with respect to FIT. In Chart 11, we demonstrate that the relative performance of both PLT and AIT rules relative to FIT are driven primarily by the cognitive discounting parameter $\bar{m}$. While the cognitive inattention parameters play less prominent roles in the ranking of the frameworks, they do affect the performance of these history-dependent rules. For instance, higher cognitive inattention to marginal costs and inflation leads to a worse relative performance of PLT and AIT. Since cognitive inattention to inflation implies that firms care less about future inflation, the expectations channel in the Phillips curve is weakened, thereby limiting the efficacy of history-dependent policies.

Chart 11: **Sensitivity of ranking to myopia type**



Note: FIT is flexible inflation targeting; AIT is average-inflation targeting; and PLT is price-level targeting.

6 Conclusion

In this paper, we compared the performance of a range of monetary policy frameworks in a standard New Keynesian model with bounded rationality following the cognitive discounting approach in Gabaix (2020). We conducted stochastic simulations to rank these regimes when accounting for the presence of the occasionally binding ELB in a low neutral rate environment.

Relying on dynamics generated by a distribution of shocks that reproduce key Canadian macroeconomic data since 1995, we found that a higher degree of myopia overall reverses the ranking of strongly history-dependent frameworks such as PLT and NGDPL for a class of loss functions. The relatively inferior performance of these frameworks can be attributed to a weakened expectations channel.

With myopic agents, the ELB probability is assessed to be the highest under PLT. These episodes also tend to have longer duration, suggesting some consideration for financial stability. Nevertheless, history-dependent policies provide some benefits during periods when the policy rate remains constrained at the ELB. In addition to yielding an inflation outcome that is closer to the target, history-dependent policies also generate lower volatility in inflation. This confirms that the well-documented benefits of history dependence continue to be relevant even with a moderate departure from rational expectations.

In a robustness test, we also captured the marginal effect of myopia on the ranking of frameworks when ELB is not binding. For instance, we found that FIT can outperform PLT even for a 5% departure from rational expectations. This suggests that a central bank's incentive to switch from FIT to PLT diminishes drastically even within a numerically small range of myopia. In contrast, for a moderate amount of myopia, AIT continues to outrank FIT. Nevertheless, we found that when the degree of departure from rational expectations is sufficiently large, there is very little difference in adopting history-dependent policy frameworks over FIT.

Our analysis can be improved by estimating the degree of bounded rationality in household and firm behaviour in Canada. We leave this for future research.

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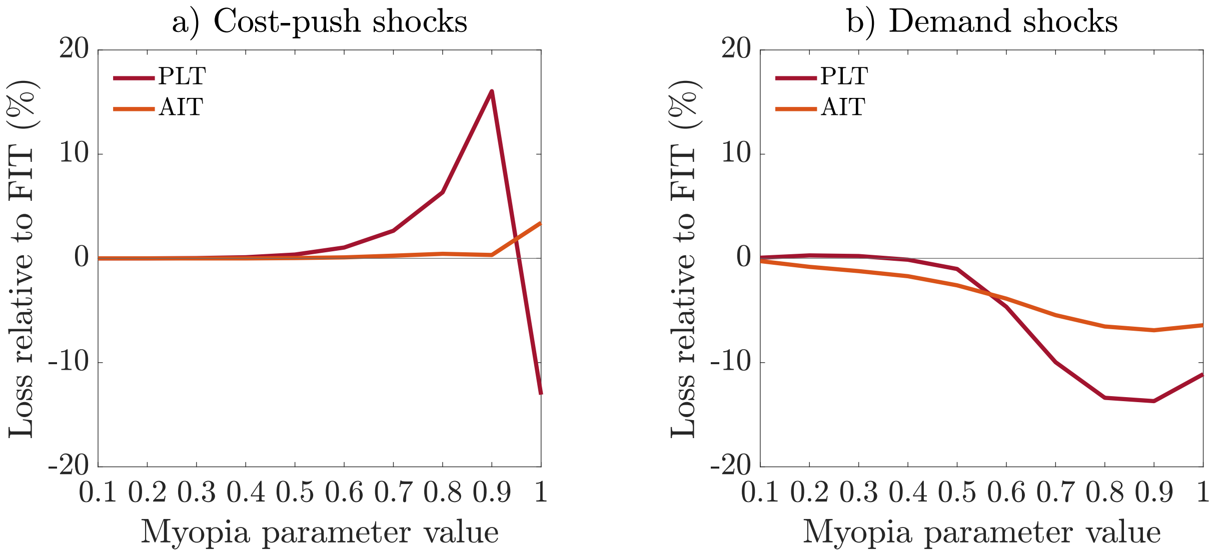
Appendix

Additional sensitivity analysis

To further explore what drives the results in the sensitivity analysis in Section 5, we perform a stochastic simulation in a single shock environment to understand how overall myopia interacts with the different types of shocks in the model.

Chart A.1 demonstrates that both PLT and AIT deliver inferior performance to FIT with a cost-push shock. PLT's superior performance in stabilizing macroeconomic fluctuations diminishes completely under a negligible degree of myopia. AIT is relatively immune to this problem, with only a mild increase in loss relative to FIT. In contrast, both history-dependent policies show better performance than FIT under demand shocks.

Chart A.1: **Sensitivity of ranking to shock type**



Note: FIT is flexible inflation targeting; AIT is average-inflation targeting; and PLT is price-level targeting.