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Abstract

We study the welfare implication of average inflation targeting as a simple interest-rate rule, in which the monetary authority adjusts its short-term policy rate in response to the output gap as well as average inflation deviation from its target instead of reacting to the contemporaneous inflation rate as in a Taylor-type rule. We find that the welfare improvement achieved by switching to average inflation targeting from a standard Taylor rule is modest with a high degree of interest-rate smoothing, whereas it is significant without interest-rate smoothing. We show that average inflation targeting is welfare-improving in the same way as interest-rate smoothing by making the conduct of monetary policy history-dependent. Thus, the high degree of monetary policy inertia in the estimated interest-rate rules in many advanced economies implies that the welfare gain from adopting the average inflation targeting rule would be modest.

Keywords: New Keynesian model; History-dependent policy; Welfare analysis; Ramsey policy; Interest-rate rule; Monetary policy inertia;

JEL classification: E12; E32; E58; E61;

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1 Introduction

The U.S. and other advanced economies have recently undergone several structural changes that appear to matter for the conduct of monetary policy. For example, the neutral rates of interest seem to have fallen (Kiley and Roberts (2017)), which increases the risk of the short-term policy rates hitting the effective lower bound (ELB) and complicates the stabilization policy during an economic downturn. The flattening of the Phillips curve (Kuttner and Robinson (2010), Blanchard (2016)) also makes the task of an inflation-targeting central bank harder, as inflation becomes less responsive to output fluctuations.

In response to these changes, there has been an increased interest in alternative monetary policy frameworks. An attractive alternative framework is *average inflation targeting* (AIT).¹ Under this framework, instead of stabilizing a one-period (yearly) inflation rate around the target, the central bank aims to stabilize the average inflation rate over several periods. This implies that AIT is a *history-dependent* policy, in which economic agents understand that future policy actions depend on past economic conditions, in addition to current and expected future conditions.

Several studies have shown that AIT has appealing properties that could potentially mitigate the complications arising from these changes. Nessén and Vestin (2005) show that AIT influences public expectations of future policy actions and improves the short-run trade-off between inflation and output stabilization. This implies that monetary policy can still be effective even under the flattening of the Phillips curve. Mertens and Williams (2019) and Svensson (2019) show that when the ELB is binding, AIT can better anchor inflation expectations, which helps reduce the effect of ELB on the economy and improves welfare. And because AIT implies that a period of below-target inflation would be followed by a period where the central bank aims for above-target inflation, AIT can be a solution to the current persistently low-inflation environment in the U.S. economy.²

These studies on AIT in the literature, however, assume that the central bank does not engage in interest-rate smoothing. As discussed in Woodford (2003a,b), interest-rate smoothing is an example of history-dependent policy, which is a hallmark of optimal policy under commitment in the presence of forward-looking agents with rational expectations. This implies that any welfare benefit potentially arising from AIT may be minimal when interest-rate smoothing is present.

In this paper, we find that the welfare improvement from the history-dependent property of AIT almost wholly disappears once we introduce a high degree of interest-rate smoothing in central bank's behavior. We show this in the context of a small-scale New Keynesian model calibrated to the U.S. economy, where AIT is implemented through a simple interest-rate rule. (See McCallum

¹As part of its 2019 review of monetary policy strategy, tools, and communications, the Federal Reserve for example is interested in the question of whether to best meet its objectives there needs to be a change in its strategy that involves “[reversing] past misses of the inflation objective” (Clarida (2019)), which is a property of average inflation targeting.

²The U.S. headline and core PCE inflation rates have been persistently below its 2% target since the issuance of the statement about the 2% target in January 2012, whereas the unemployment rate has been below the FOMC's long-run projection since the early 2016. This low inflation environment in the U.S. raises a question of whether the current framework for monetary policy is consistent with achieving the dual mandate.

and Nelson (2005) for a discussion on instrument rules and actual central bank practice.) It has been empirically well-documented that central banks in U.S. and other advanced economies tend to adjust their policy rates gradually in response to changes in economic conditions. Our finding thus implies that the welfare gain from adopting average inflation targeting is minimal, at least in normal times when the ELB is not binding.

2 Illustration with a simple policy rule

We first illustrate the history-dependent property of interest-rate smoothing and AIT using a simple interest-rate rule where the central bank only responds to inflation deviations. In the contemporaneous one-period inflation targeting (CIT), the rule is given by

$$\hat{R}_t = \phi_R \hat{R}_{t-1} + (1 - \phi_R) \phi_\pi \hat{\pi}_t \quad (1)$$

where $\hat{R}_t = \log(R_t/\bar{R})$ is the nominal interest rate deviation, $\hat{\pi}_t = \log(\Pi_t/\bar{\Pi})$ is the inflation deviation from its target, $\phi_R \in [0, 1)$ is the degree of interest-rate smoothing, and ϕ_π is the inflation-feedback coefficient. Iterating backward, we have

$$\hat{R}_t = \phi_R^\ell \hat{R}_{t-\ell} + (1 - \phi_R) \phi_\pi \sum_{j=1}^{\ell} \phi_R^{j-1} \hat{\pi}_{t-j+1} \quad (2)$$

for any $\ell \geq 1$. Observing (2), interest-rate smoothing ($0 < \phi_R < 1$) imposes history-dependence on central bank's behavior: the current policy rate depends on the weighted average of past inflation deviations. This property allows the central bank to influence the public's expectations regarding future policy actions, improving the short-run stabilization trade-off.

Next, we posit under AIT, the central bank follows the rule

$$\hat{R}_t = \phi_R \hat{R}_{t-1} + (1 - \phi_R) \phi_\pi \bar{\pi}_{t,t-\ell+1} \quad (3)$$

where $\bar{\pi}_{t,t-\ell+1} = \frac{1}{\ell} \sum_{j=1}^{\ell} \hat{\pi}_{t-j+1}$ is the average inflation deviation with a target window $\ell \geq 1$. The target window $\ell = 1$ corresponds to CIT, while $\ell = 8$, for example, corresponds to an AIT rule that aims to stabilize a 2-year (8-quarter) average inflation rate.

Consider AIT when there is no smoothing, $\phi_R = 0$. From (3), we have

$$\hat{R}_t = \phi_\pi \bar{\pi}_{t,t-\ell+1} = \phi_\pi \frac{1}{\ell} \sum_{j=1}^{\ell} \hat{\pi}_{t-j+1}. \quad (4)$$

Comparing this to (2), AIT without interest-rate smoothing produces the same kind of history-dependent property as CIT with smoothing, and could thus produce a comparable welfare gain.

Assume instead the central bank follows (3) with $0 < \phi_R < 1$. As ϕ_R increases, the significance

of the average-inflation term becomes less pronounced for any given ϕ_π . Hence, the benefit arising from the history-dependent property of AIT is potentially small when there is already a heavy dose of history-dependence arising from interest-rate smoothing. Below, we further investigate the welfare implication of AIT using a New Keynesian model calibrated to the U.S. economy.

3 Welfare gain of AIT in a New Keynesian model

3.1 The model

We consider a standard New Keynesian model along the lines of [Rotemberg and Woodford \(1997\)](#) and [Steinsson \(2003\)](#), used in [Eo and Lie \(2019\)](#). The model consists of optimizing households, monopolistically-competitive firms, and a central bank that conducts monetary policy using a policy rule. The economy is subject to productivity, government spending, and cost-push shocks.

Households maximize

$$E_t \sum_{s=0}^{\infty} \beta^s \frac{[C_{t+s}(1 - N_{t+s})^\gamma]^{1-\sigma} - 1}{1 - \sigma}, \quad (5)$$

subject to

$$\int_0^1 P_t(i) C_t(i) di + B_t \leq R_{t-1} B_{t-1} + W_t N_t + \Pi_t^{prof} + T_t, \quad (6)$$

where $\beta \in (0, 1)$ is the discount factor, N_t denotes labor hours, W_t is the nominal wage, B_t represents one-period nominal government bonds, R_t is the nominal interest rate, Π_t^{prof} denotes the proceed from firms' profits, T_t represents lump-sum taxes, $P_t(i)$ denotes the price of variety i , and the consumption index C_t is a CES aggregator of differentiated varieties $C_t(i)$ with

$$C_t = \left[\int_0^1 C_t(i)^{1/(1+\theta_t)} di \right]^{1+\theta_t}. \quad (7)$$

Firms' average markup θ_t follows

$$\log(\theta_t) = (1 - \rho_\theta) \log(\bar{\theta}) + \rho_\theta \log(\theta_{t-1}) + \varepsilon_{\theta,t}, \quad (8)$$

with $\varepsilon_{\theta,t} \sim i.i.d.N(0, \sigma_\theta^2)$.

Each firm uses labor to produce variety i using

$$Y_t(i) = z_t N_t(i), \quad (9)$$

where aggregate productivity z_t follows

$$\log(z_t) = \rho_z \log(z_{t-1}) + \varepsilon_{z,t}, \quad (10)$$

with $\varepsilon_{z,t} \sim i.i.d.N(0, \sigma_z^2)$.

Following [Calvo \(1983\)](#) and [Yun \(1996\)](#), a fraction $\alpha \in [0, 1)$ of firms are not allowed to optimally

Table 1: Calibration: baseline model

	Value	Description		Value	Description
σ	2.00	preference parameter	ϕ_R	0.80	interest-rate smoothing
γ	3.86	preference parameter	ρ_z	0.95	persistence: productivity
β	$1.04^{-1/4}$	quarterly discount rate	ρ_θ	0.64	persistence: cost-push shock
$\bar{\theta}$	0.25	steady-state price markup	ρ_g	0.56	persistence: government spending
α	0.80	price stickiness	σ_z	0.007	standard deviation: productivity
ϕ_π	1.50	inflation reaction	σ_θ	0.115	standard deviation: cost-push
ϕ_x	0.50	output gap reaction	σ_g	0.224	standard deviation: government spending

adjust their prices at time t , and index their prices to the time-invariant long-run inflation target $\bar{\Pi}$. Each optimizing firm i chooses an identical price to maximize

$$\sum_{s=0}^{\infty} \alpha^s Q_{t,t+s} \left[\tilde{P}_t(i) \bar{\Pi}^s Y_{t+s}(i) - W_{t+s}(i) N_{t+s}(i) \right], \quad (11)$$

where $Q_{t,t+s}$ is the stochastic discount factor.

The policy rule is given by

$$\hat{R}_t = \phi_R \hat{R}_{t-1} + (1 - \phi_R) [\phi_\pi \bar{\pi}_{t,t-\ell+1} + \phi_x \hat{x}_t], \quad (12)$$

where $\hat{x}_t$ denotes the output gap defined by $\log(Y_t/Y_t^*)$ and Y_t^* is the flexible-price level of output with a constant markup. The central bank fully and credibly commits to the policy rule (12). The assumption that the central bank implements AIT through the commitment to (12) is similar to the approach in [Giannoni \(2014\)](#) in the context of price-level stabilization. When $\ell = 1$ the rule collapses to a standard Taylor-type rule that responds to the contemporaneous inflation deviation (i.e., CIT).

Aggregate demand is given by

$$Y_t = C_t + G_t, \quad (13)$$

where the exogenous government spending G_t follows

$$\log(G_t/\bar{G}) = \rho_g \log(G_{t-1}/\bar{G}) + \varepsilon_{g,t}, \quad (14)$$

with $\varepsilon_{g,t} \sim i.i.d.N(0, \sigma_g^2)$.

Table 1 presents the model's calibration based on the postwar U.S. economy. The calibrated values of structural parameters are consistent with those in [Schmitt-Grohé and Uribe \(2007\)](#). We assume the standard Taylor-rule coefficients of $\phi_\pi = 1.5$ and $\phi_x = 0.5$, with $\phi_R = 0.8$ for the baseline model. This value of ϕ_R is consistent with the estimate in [Smets and Wouters \(2007\)](#). The driving forces for z_t , G_t , and θ_t are parameterized as in [Eo and Lie \(2019\)](#), resulting in the

standard deviations of inflation, the output gap, and the nominal interest rate of 3.24%, 2.37%, and 3.15%, respectively, under CIT. These numbers match the actual moments for the U.S. economy quite well.³

3.2 Welfare-cost measure

To evaluate and compare various policies, following [Schmitt-Grohé and Uribe \(2007\)](#), we calculate the unconditional welfare cost, λ , of a given policy as the fraction of consumption that households would be willing to give up under the Ramsey policy environment to be equally well off as under the alternative policy environment:

$$E \sum_{t=0}^{\infty} \beta^t U(C_t^a, N_t^a) = E \sum_{t=0}^{\infty} \beta^t U((1 - \lambda)C_t^r, N_t^r), \quad (15)$$

where E is the unconditional expectation operator, and $\{C_t^r, N_t^r\}$ and $\{C_t^a, N_t^a\}$ are the state-contingent plans for consumption and labor under the Ramsey policy and under the alternative policy, respectively. The Ramsey policymaker is benevolent and maximizes households' utility in (5), subject to private-sector equilibrium conditions. We solve the model up to a second-order approximation and calculate λ for any alternative policy.

3.3 Welfare analysis for the calibrated model

Figure 1 (a) plots the welfare costs of adopting the policy rule (12) as a function of the target window ℓ for different values of ϕ_R . When $\phi_R = 0.8$, the lowest welfare cost is achieved under $\ell = 12$ (3-year average inflation), with $\lambda = 0.27\%$. This policy is welfare-improving compared to CIT ($\lambda = 0.31\%$) because stabilizing the average inflation rate over several periods improves the trade-off between inflation and output stabilization, due to its effect on inflation expectations. However, the welfare gain from adopting AIT over CIT appears to be minimal.⁴ It is also notable that the welfare gain of using the AIT's optimal target window over a yearly inflation target (i.e., $\ell = 4$) is even more modest. The target window should not be too large, as a large enough ℓ may lead to larger fluctuations in the output gap $\hat{x}_t$, given the stabilization trade-off.⁵ Here, the welfare cost starts increasing for $\ell > 12$.

A different picture emerges when the monetary authority does not smooth its policy rate (i.e., $\phi_R = 0$). Here, the welfare gain of AIT relative to CIT is large: λ is reduced from 0.43% under

³The standard deviations of CPI inflation, the CBO output gap, and the federal funds rate for the sample period of 1949:Q1 to 2008:Q4 are 3.24%, 2.37%, and 3.40% respectively.

⁴Based on the 2018 U.S. per capita personal consumption expenditure figure of \$42,752, a 0.04% welfare gain translates to \$17 per capita per year. The gain is even smaller when we assume $\phi_R = 0.91$, which is the optimized degree of interest rate smoothing under $\phi_\pi = 1.5$ and $\phi_x = 0.5$. The welfare cost is only reduced from $\lambda = 0.3\%$ under CIT ($\ell = 1$) to $\lambda = 0.28\%$ under AIT with an optimized target window of $\ell = 10$.

⁵The utility-based welfare (loss) function in our model can be shown to depend on the fluctuations of one-period inflation deviation and the output gap. See, for example, [Benigno and Woodford \(2005\)](#), [Steinsson \(2003\)](#), and [Woodford \(2003a\)](#).

Figure 1: Welfare costs of average inflation targeting

Notes: Panel (a) plots the welfare cost λ across different target windows ℓ with/without interest smoothing. Panel (b) plots the welfare cost for two different inflation-feedback coefficient values in the same way as in Panel (a). For each of cases (a) and (b), all other parameter values are set to those in Table 1. The target window $\ell = 1$ corresponds to contemporaneous (one-period) inflation targeting.

CIT to 0.28% under AIT. This finding is consistent with our discussion in Section 2: AIT could lead to a large welfare improvement due to its history-dependent property. However, when there is already a significant degree of history-dependence in central bank's behavior by way of interest-rate smoothing, there is not much benefit from adopting AIT.

The extent of the history-dependent effect of both interest-rate smoothing and AIT also depends on the inflation-feedback coefficient ϕ_π (see policy rules (2) and (3)). In Figure 1 (b), we instead assume $\phi_\pi = 3$, while maintaining $\phi_R = 0.8$. Our finding about the modest welfare gain of AIT relative to CIT still holds true. If anything, the welfare gain appears to be even smaller for this higher value of ϕ_π .

3.4 Alternative welfare measures

We next assess whether our finding is robust to alternative welfare measures. Instead of (15), we use the following quadratic welfare loss function:

$$L = \sigma(\hat{\pi}_t)^2 + \lambda_x \sigma(\hat{x}_t)^2 + \lambda_R \sigma(\hat{R}_t)^2 \quad (16)$$

where $\lambda_x \geq 0$ and $\lambda_R \geq 0$ represent the relative weight on the output-gap and the nominal interest rate stabilization, respectively; $\sigma(\hat{\pi}_t)$, $\sigma(\hat{x}_t)$, and $\sigma(\hat{R}_t)$ are the standard deviations of one-period inflation, the output gap, and the nominal rate, respectively. This loss function takes into account

Table 2: Welfare losses of various policies based on simple loss functions

	Welfare cost	Model standard deviations			Williams's (1999) loss function ($\lambda_x = 1$)			Woodford's (2003) loss function ($\lambda_x = 0.048$)		
		$\sigma(\hat{\pi}_t)$	$\sigma(\hat{x}_t)$	$\sigma(\hat{R}_t)$	$\lambda_R = 0$	$\lambda_R = 0.02$	$\lambda_R = 0.04$	$\lambda_R = 0$	$\lambda_R = 0.077$	$\lambda_R = 0.154$
(a) interest-rate smoothing: $\phi_R = 0.8$										
CIT	0.313	3.24	2.37	3.15	16.11	16.30	16.50	10.77	11.53	12.29
AIT ($\ell^* = 12$)	0.267	3.02	2.43	2.37	15.06	15.17	15.29	9.43	9.86	10.29
(b) no interest-rate smoothing: $\phi_R = 0$										
CIT	0.428	3.77	2.03	7.11	18.35	19.37	20.38	14.42	18.31	22.20
AIT ($\ell^* = 12$)	0.283	3.14	2.21	4.72	14.74	15.18	15.63	10.07	11.79	13.50

Notes: The welfare loss function has a general form of $L = \sigma(\hat{\pi}_t)^2 + \lambda_x \sigma(\hat{x}_t)^2 + \lambda_R \sigma(\hat{R}_t)^2$. The standard deviation $\sigma(\cdot)$ is expressed in percent (annualized for inflation and nominal interest rate). CIT and AIT refer to contemporaneous one-period inflation targeting (i.e., $\ell = 1$) and average inflation targeting, respectively. The target window for AIT ℓ^* is chosen to minimize the welfare loss for each case with/without interest-rate smoothing.

the possibility that variations in the nominal interest rate matter for households' welfare.

We consider different values of λ_x and λ_R , based on those used in Williams (1999) and Woodford (2003a): the former considers $\lambda_x = 1$ and $\lambda_R = 0.02$, while the latter uses $\lambda_x = 0.048$ and $\lambda_R = 0.077$, based on reasonable calibrations of a micro-founded model. We also consider a case in which the importance of nominal interest rate stabilization (λ_R) is doubled.

Table 2 reports the welfare losses of CIT and AIT with the optimized target window $\ell^* = 12$. Overall, our finding based on the measure in (15) is qualitatively robust across the two alternative welfare measures. The welfare gain, i.e., the reduction in the welfare loss, is much smaller when $\phi_R = 0.8$ than when $\phi_R = 0$. This is true for all three considered values of λ_R . The large reductions in $\sigma(\hat{\pi}_t)$ and $\sigma(\hat{R}_t)$ under $\phi_R = 0$ are mainly responsible for the largely-reduced welfare loss under AIT. In contrast, the reductions are much smaller when $\phi_R = 0.8$, highlighting again the minimal welfare gain from adopting AIT when there is already a large dose of history-dependent central bank's behavior arising from interest-rate smoothing.

4 Conclusion

We show in this paper that the welfare gain from adopting average inflation targeting over contemporaneous inflation targeting appears to be minimal when interest-rate smoothing is present. The high degree of monetary policy inertia in the estimated interest-rate rules in the U.S. and many other advanced economies implies that switching to an average inflation targeting rule would result in a modest welfare improvement.

Our analysis does not explicitly consider the possibility of a binding effective lower bound on the nominal interest rate, which may affect the welfare gain. It is also of interest to examine the robustness of our finding in a medium- or large-scale model with additional frictions in the economy. We leave them for future research.

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