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Average inflation targeting and economic volatility

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Abstract

The Federal Reserve announced that the interest rate targeting objective is to maintain an average inflation target (AIT) rate over time rather than an inflation target. What is the economic impact of moving from a constant inflation rate target to targeting an average inflation rate? A standard dynamic aggregate demand - aggregate supply (DAD-DAS) model is applied to run the simulations. Monetary policies are modeled by a DAD-DAS model using a monetary rate of growth targeting rule, and a classic Taylor rule in a baseline New Keynesian model. To model the AIT approach, a five-period moving average of inflation rate target (MAIT) is maintained as a short-run target, whereas, within the standard approach, a constant inflation target is maintained in the short- and long-run. As a robustness check, a canonical New Keynesian model is also used. Applying both supply and demand shocks to the simulation models, it is found that the MAIT approach increases economic volatility in both inflation and economic growth compared to the more standard objective constant inflation rate targeting.

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1 Introduction

For many years the Federal Reserve (Fed) has followed an inflation targeting approach to monetary policy. An inflation rate objective is chosen and inflationary gaps are closed by modifying interest rates, often mimicking targeting rules such as by the well-known Taylor (1993) rule. In August of 2020, the Federal Reserve announced a new monetary policy targeting strategy. In response to extended periods of low inflation, the Federal Reserve moved to an average inflation targeting approach, rather than continuing to pursue a fixed inflation rate target. Previously, if inflation went above or below the fixed inflation target, the Federal Reserve would alter interest rates until the same targeted value was again reached. Average Inflation Targeting (AIT) is fundamentally different.

There are two ways to implement AIT. One method is to pursue a constant price level inflation trend and respond to shocks in the short run by targeting a new constant inflation rate so that it catches up to the desired price level inflation trend in a set amount of time periods. This scenario results in short-run inflation rates that temporarily overshoot or undershoot the long-run inflation target and linearly converge over the prescribed number of periods until the target is reached. For example, given a 2% long-run inflation target, responding to an inflation drop to an undesirable low rate of 1%, the Fed might maintain a 2.5% inflation target for the next 5 periods and then resume the long-run 2% target. This process alters the inflationary gap by maintaining a constant inflation target while the inflation rate changes and, therefore, impacts interest rate rules that address that gap. This simple AIT method is not addressed here.

A second AIT method, and the subject of this paper, is to use a moving average inflation target (MAIT) for a set number of periods to determine the inflation rate target. Under MAIT, the inflation rate target changes every period until the long-run inflation rate target is reached. This method alters the inflationary gap in a substantially different way from the first method. Now, both the inflation target and actual inflation change every period, causing the interest rate target to differ from the simple AIT.

In this paper, simulations are run focused on a Dynamic Aggregate Demand – Aggregate Supply (DAD-DAS) model to obtain response functions for inflation and real GDP growth rates. In the cases to follow, both positive and negative aggregate demand (AD) and aggregate supply (AS) shocks are employed. Simulations are run first using 'standard' monetary policy and then again using MAIT. The MAIT response functions are considerably more volatile in the macroeconomic variables compared to the standard monetary policy. This result is consistent in both the DAD-DAS model and, as a robustness check, a canonical New Keynesian (NK) model.

The simulations are based on real-world aggregate data. Because the final simulation equations are determined in this way, they already implicitly contain expectations formed in the US economy. We do not make assumptions based on how expectations are formed, but recognize that the expectations of inflation, interest rates, GDP growth rates, etc. are already inherent in the coefficients that are solved for in the regression equations..

The differences between any AIT approach and the standard policy may depend on the economic environment. For example, Clarida (2019, 2020) suggests that the average inflation targeting policy may be more appropriate where demand shocks present the larger problem. When there is a supply shock, Federal Reserve AIT policies may be particularly destabilizing.

However, this paper shows that aggregate demand shocks also create high volatility under MAIT.

The body of literature regarding the efficacies of price level and/or inflation targeting is largely limited in specifically addresses average inflation targeting. One reason is that there are no clear and specific outlines in how average inflation targeting is to be achieved, however most research is limited to re-attaining a constant price level trend.

Nessen and Vestin (2005) showed that, under assumptions of inflation expectations augmented Phillips curves coupled with discretionary monetary policy, average inflation targeting led to loss function welfare improvement compared to the standard inflation or standard price level targeting. Their result, however, is dependent upon the calibrations of inflation expectations built into the Phillips curve. In their model, strong forward-looking inflation expectations are enhanced by an AIT approach in a feedback loop that tends to promote the AIT policy.

Reifschneider and Wilcox (2019) apply a Taylor-like rules-based approach to the Federal Reserve Bank's large econometric model of the economy in order to determine AIT's efficacy. They ultimately determine that AIT is a poor tool for recessionary regimes with low inflation. Their AIT simulation models all advocate for negative fed funds rates throughout the Great Recession, given various defined lengths of averaging, from one quarter up to 40 quarters. However, their main argument is not critical to the question of AIT efficacy because it is not pertinent to AIT only. All standard Taylor rules and even Friedman-augmented Taylor rules advocated for negative interest rates for several years during the Great Recession (Bias 2019).

Honkapohja and McClung (2022) use a canonical New Keynesian model to address AIT. At first they restrict the model to price stickiness and slow learning, which in the end, essentially mimics the same result as adaptive expectations. They find that expectations are vital to the robustness of AIT. The more transparent monetary policy targets and timings are, the more robust the stability achieved by the policy. This is an important result; however, it follows a long line of literature that promote policy-maker credibility and transparency. Their point was that the new AIT method begun in 2020 was unlikely to succeed due to failing to give the public a firm idea of how and when the new policy was to be conducted.

In addition, Reifschneider and Williams (2000), Mertens and Williams (2019), Amano, Leduc and Wagner (2020), and Budianto, Nakata and Schmidt (2020) consider AIT in the context of the effective lower bound. Unlike Reifschneider and Wilcox (2019), these studies suggest that AIT may be a helpful tool to raise inflation rates when nominal interest rates are constrained. In general, all of these results are dependent upon how inflation expectations are modeled.

There are several contributions in this paper. First, the results directly address the question of MAIT to find there is greater economic volatility following shocks - and, specifically, induced damped oscillations. Second, the results are robust to two very different modeling simulations, the Dynamic Aggregate Demand - Aggregate Supply model and the New Keynesian model. Third, the results are robust to all shocks, both aggregate demand and supply, and both positive and negative. In particular, our results are among the first to question AIT efficacy under AD shocks.

Section 2 of the paper focuses on the Dynamic Aggregate Demand - Aggregate Supply model. The model is empirically estimated using quarterly US data between 2002 and 2019. Both aggregate demand and aggregate supply shocks are then applied displaying the transitional dynamics of both the standard and the MAIT policy approaches. Section 3 follows the same method using the New Keynesian model. Section 4 concludes.

2 Dynamic Aggregate Demand - Aggregate Supply Model

A dynamic aggregate demand and aggregate supply model allows for an illustration of the impact of the two different policies - inflation targeting and Moving Average Inflation Targeting (MAIT).

The supply side of the simulation model is based on three classic relationships. The first is that real GDP is positively related to the amount of labor; the second is that the labor wage supply curve is influenced by the amount of labor, the price level and the expected price level; and, third, the wage demand is affected by the amount of labor and the price level. The result is that the dynamic aggregate supply curve is a function of growth rate of wages, inflation and real GDP growth as summarized in equation (**??**).

$$\pi_t = \delta_0 + \delta_1 \pi_t^e + \delta_3 w_t + \delta_4 y_t \tag{1}$$

Based on dynamic aggregate supply summarized in equation (**??**), each variable is expected to have a positive effect on inflation, ie. $\delta_1 > 0$, $\delta_2 > 0$, and $\delta_3 > 0$.

The dynamic aggregate demand side of the model is derived from the equation of exchange $m + v = \pi + y$ where m is the growth rate of the money supply, v is the growth rate of the velocity of money, π is the inflation rate and y is the growth rate in real GDP. Equation (**??**) is determined from rearranging the dynamic aggregate demand curve to obtain a linear function for inflation.

$$\pi_t = \gamma_0 + \gamma_1 y_t + \gamma_2 m_t + \gamma_3 v_t \tag{2}$$

From equation (**??**), the GDP growth rate is expected to have a negative relationship with inflation, while both the growth rate in money supply and velocity are expected to have a positive impact on inflation, with $\gamma_1 < 0$, $\gamma_2 > 0$, and $\gamma_3 > 0$.

Equations (**??**) and (**??**) represent the baseline model for each simulation. The specific values used for the simulation are based on quarterly US data from 2002Q1 until 2019Q4. The timeframe utilizes recent data and ends before the significant impact of COVID-19 on the US macroeconomy, which may bias the long-run trends needed for the simulations. All data are from the FRED database provided by the Federal Reserve of St. Louis; namely inflation (*PCEPI-PC1*), real GDP per capita growth rates (*GDPPC1-PC1*), money growth rates (*M2SL-PC1*), velocity growth rates (*M2V-PC1*), wage growth rates (*LEU0252881500Q-PC1*), and inflation expectations (*MICH*).

Under equilibrium conditions, in a DAD-DAS, both inflation and GDP growth are jointly determined. A two stage least squares (2SLS) technique is used to empirically address the identification problem. Table (**??**) presents the results of regressions using both standard OLS and two-stage least squares regression techniques. Each of the variables in Table (**??**) are of the expected sign and are statistically significant.

Table **??**: Dynamic Aggregate Demand - Aggregate Supply
2002Q1 - 2019Q4

	Standard OLS		2-Stage Least Squares	
	Dynamic AD	Dynamic AS	Dynamic AD	Dynamic AS
Intercept	0.3052	-2.3842***	-0.1447	-2.5635***
	(0.4375)	(0.5033)	(0.4043)	(0.4514)
y_t	-0.8098***	0.2462***		
	(0.1536)	(0.0494)		
$y_{t,predicted}$			-2.3125***	0.3185***
			(0.3295)	(0.0463)
m_t	0.8078***		1.7439***	
	(0.1269)		(0.2186)	
v_t	0.9158***		2.0607***	
	(0.1266)		(0.2548)	
w_t		0.1659**		0.1797**
		(0.0682)		(0.0610)
π^e		1.1.26***		1.1012***
		(0.1529)		(0.1367)
R^2	0.5311	0.5554	0.6192	0.6445
$Adj.R^2$	0.5095	0.5348	0.6016	0.6281
Obs.	69	69	69	69

Table 1: ** $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard error is in parentheses. The dependent variable is the rate of inflation.*

2.1 Monetary Policy in the DAD-DAS Model

For the DAD-DAS model, monetary policy is manifest through a money rate of growth mechanism where the rate of growth is changed to close inflation and/or GDP growth rate gaps. Once again, a standard monetary regime is examined and compared to the MAIT approach. The standard monetary growth rule is modeled here as:

$$m_t^* = \bar{m} + \lambda_\pi (\pi^* - \pi_t) + \lambda_y (y^* - y_t) \tag{3}$$

where m_t^* is the monetary rate of growth target at time t, $\bar{m}$ is the long-run equilibrium monetary growth rate, $(\pi^* - \pi_t)$ is the inflationary gap, $(y^* - y_t)$ is the output growth gap, and λ_π and λ_y are the inflation and output growth gap coefficients respectively.

This equation is largely consistent with the New Keynesian standard Taylor rule equation as it changes the rate of growth of money supply rate of growth in response to both gaps. However, the weights to inflation and inflation targets are different from the Taylor rule. In the Taylor rule, the weights to the policy rate is $[\pi_t (1 + \rho_\pi) - \rho_\pi \pi^*]$, whereas, in the money growth rule, the weight is shown by $[\lambda_\pi \pi^* - \lambda_\pi \pi_t]$. This difference results in a slight, generated oscillation for the Taylor rule and no oscillation for the money growth rule under a standard form. After a shock the rule specifies a change in m_t^*, the changes to which set in motion a change in DAD. The result is that the target m_t^* will change asymptotically toward $\bar{m}$ and π and y will both move toward their targets in the same manner.

In contrast, the MAIT monetary growth rule is modeled here as

$$m_t^* = \bar{m} - \lambda_\pi \left(\left(\pi^* * \kappa - \pi_{t-1} - \pi_{t-2} - \pi_{t-3} - ... - \pi_{t-(\kappa-1)} \right) - \pi_t \right) - \lambda_y (y^* - y_t) \tag{4}$$

where κ is the number of lagged periods. This study uses five lagged periods ($\kappa = 5$) but the key results are robust to different lagged periods.

Like the standard monetary rule, this equation is also consistent with a New Keynesian standard Taylor rule equation approach as it changes the rate of growth of money supply rate of growth in response to both gaps. After a shock the rule specifies a change in m_t^*, the changes to which set in a motion a change in DAD. However, this time the result is that the target m_t^* will change will follow a damped oscillation toward $\bar{m}$, and π and y will both move toward their targets in the same manner.

2.2 Economic Shocks

Figure **??** includes the dynamics of the inflation rate and real GDP growth rates in the Dynamic Aggregate Demand - Aggregate Supply model where a negative aggregate demand shock is simulated.

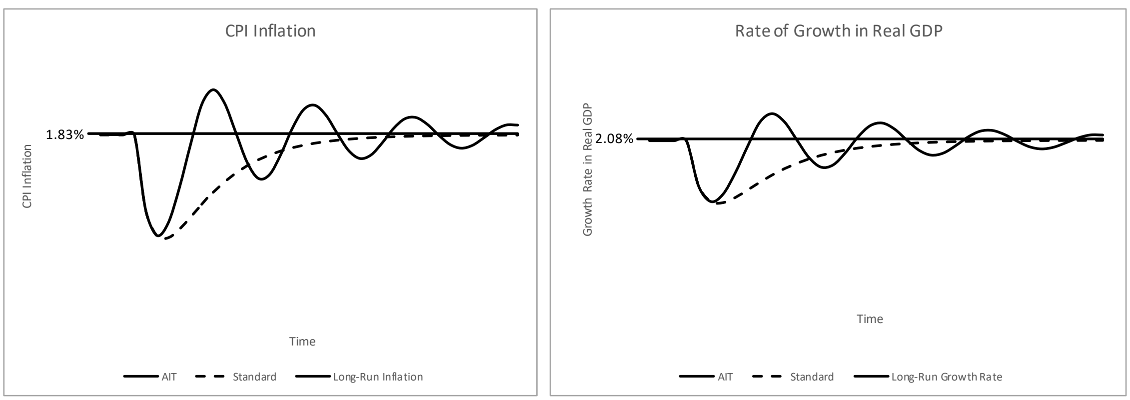

Figure **??** *considers the transitional dynamics of inflation rates and GDP growth rates following a negative aggregate demand shock in the DAD-DAS model. The long-run inflation rate is 1.83% and the long-run growth rate is 2.08% based on the US data from Q1, 2002 until Q4, 2019.*

The initial effects under both standard and MAIT approaches are similar, namely, a sharp decline in both inflation and real GDP growth rate. Inflation and real GDP growth rate gradually return to the long-run level with very limited fluctuations under the standard monetary approach. The variability is substantially larger under Moving Average Inflation Targeting. Both inflation and real GDP growth overshoot the long-run level after the initial shock followed by significant volatility before returning the long-level.

Overall, the MAIT policy results in iterative overcompensation which leads to more economic volatility by creating higher amplitude oscillations in the response functions. The oscillations are a direct result of the moving average approach based on equation (**??**). The inflation gap is larger than it would be under standard targeting, and, as a result, the interest rate target is influenced more by the MAIT.

Conversely, the impact on real GDP growth rates, inflation, and interest rates following a one-time positive AD shock is in the opposite direction. While both policies are stable and return the economy to the long-run growth rates in real GDP and inflation, the transition dynamics depends on the policy pursued. In the immediate aftermath of the positive aggregate demand shock, real GDP growth rates increase, inflation increases and the Federal Reserve adjusts monetary growth rates in response by a greater and more sustained amount. Following MAIT, inflation will drop quickly, below the benchmark value and continue to oscillate until the average inflation target is reached.

Figure **??** includes the dynamics of the inflation rate and real GDP growth in the DAD-DAS following a negative aggregate supply shock.

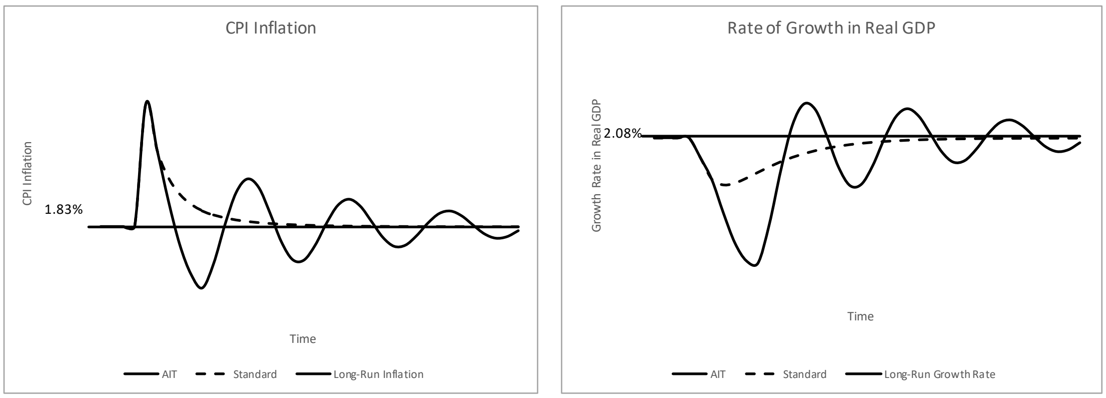

Figure **??** *considers the transitional dynamics of inflation rates and GDP growth rates following a negative aggregate demand shock in the DAD-DAS model. The long-run inflation rate is 1.83% and the long-run growth rate is 2.08% based on the US data.*

The negative supply shock leads to an initial increase in inflation and a decrease in real GDP growth in both the standard policy approach and the MAIT approach. In terms of inflation, the initial increase are similar but the dynamics differ. Under the standard policy, after the initial jump, there is a gradual, smooth decrease back to the long-run level without significant volatility. Under MAIT, the initial increase in inflation is followed by a significant drop to below long-run levels and then significant volatility approaching the long-run level.

The dynamics of GDP growth follow a similar pattern. The initial fall in GDP growth is followed by a smooth transition back to the long-run level under the standard policy. Under MAIT the growth rate of GDP falls by a greater amount and is sustained for a longer time period. During the transition back to the long-run level, there is greater volatility.

3 Robustness: New Keynesian Model

The New Keynesian model employed as a robustness check is a familiar three-equation model consistent with Woodford (2010) and many others. It is expected that the real GDP growth rate is positively affected by the previous growth rate, and negatively affected by the previous period interest rate. The New Keynesian Phillips curve relates inflation to past inflation and the output gap. It is expected that both the previous inflation rate and the output gap have a positive effect on the current inflation rate.

The standard model follows the Taylor rule in which targeted nominal Federal Funds rates are based on real interest rates (r^*), inflation (π_t), output growth rate deviations, and the differences between inflation and targeted inflation rates (π^*). Equation (**??**) is the Taylor rule where the coefficients, ρ_π and ρ_y, are for both the inflation and output gap, respectively.

$$\dot{i}_t^* = r^* + \rho_\pi \left(\pi_t - \pi^*\right) + \rho_y \left(y_t - y^*\right), i_t^* \geq 0 \tag{5}$$

To incorporate MAIT policies, the subtle difference is found within the inflation differential. In the standard Taylor rule, actual inflation is compared to a fixed inflation target (π^*), whereas the MAIT policy is compared to the average inflation target ($\pi^*_{avg,t}$). Equation (**??**) includes this MAIT adjustment to the Federal Reserve policy.

$$\dot{i}_t^* = r^* + \rho_\pi \left(\pi_t - \pi^*_{avg,t}\right) + \rho_y \left(y_t - y^*\right), i_t^* \geq 0 \tag{6}$$

The MAIT policy is a long-run inflation averaging process where $\pi^*_{avg(\kappa),t} = \pi^* * \kappa - \pi_{t-1} - \pi_{t-2} - \pi_{t-3} - ... - \pi_{t-(\kappa-1)}$. This represents an average inflation rate, $\pi^*_{avg(\kappa),t}$, to be a κ-period moving average of inflation with each period given equal weight. This is an initial averaging process and can be modified to give different weights to different periods. It shows the long-run inflation average process where $\pi_t * \kappa$ is the pursued long-run inflation rate multiplied by the order of the period moving average. A five period moving average used in this study ($\kappa = 5$) but is robust to other lagged periods. Our baseline simulation uses equal weights to the inflationary gap $\rho_\pi = 0.5$ and output gap $\rho_y = 0.5$. The long run inflation value based on US data is 1.83% and the GDP real growth rate is 2.08%.

The simulations in the New Keynesian Model are based on the regression results from Table **??** using US data from 2002Q1 to 2019Q4.

Table **??**: New Keynesian Model
2002Q1 - 2019Q4

	IS Curve	Phillips Curve
Intercept	0.3408** (0.1660)	-1.0914*** (0.4995)
y_{t-1}	0.8889*** (0.0603)	
i_{t-1}	-0.0772 (0.0599)	
π_{t-1}		1.0435*** (0.1622)
$(y_t - y^*)$		0.2168*** (0.0519)
R^2	0.7689	0.4969
$Adj.R^2$	0.7618	0.4817
Obs.	69	69

Table 2: ** p < 0.10, ** p < 0.05, *** p < 0.01. Standard error is in parentheses. The dependent variable in the IS Curve is the real GDP growth rate and the dependent variable in the Phillips Curve is the rate of inflation.*

Using the regression results, the simulations are based on the following:

$$y_t = 0.3224 + 0.8938 y_{t-1} - 0.0143 i_{t-1}$$

and

$$\pi_t = 0.4208 + 0.7836 \pi_{t-1} + 0.0557 \left(y_{t-1} - y^* \right).$$

Following an Aggregate Demand shock in the NK model, the transition to the long-run growth levels depends on the type of policy via the changes in interest rates. In response to a negative AD shock and the immediate drop in inflation, the Federal Reserve responds by lowering interest rates by a greater amount and maintaining lower interest rates for a longer period in order to boost inflation above the long-run target when following the MAIT policy compared to the standard policy.

With both the standard Taylor rule and MAIT augmented Taylor rule, inflation returns to the target as does real GDP growth. However, under MAIT, with interest rates lower for longer, inflation exceeds the long-run level and real GDP growth exceeds the long-run level in the dynamic transition by a greater amount, creating the volatility.

A similar oscillation process takes place in the New Keynesian model similar to the DAD – DAS model. The difference is in how monetary policy is modeled. Interest rates are changed to implement monetary policy rather than monetary growth rates. Overall, the MAIT policy results in overcompensation which leads to more economic volatility by creating higher amplitude oscillations in the response functions. The oscillations are, again, a direct result of the moving average approach. The inflation gap is larger than it would be under standard targeting, and, as a result, the interest rate target is influenced more by the AIT.

An additional implication of MAIT policies pertains to the interest rate Zero-Lower Bound (ZLB). Under the MAIT framework, it is more likely for the nominal interest rates to reach the ZLB and more likely for interest rates to remain there for a longer period of time. This is, again, based on the need to increase inflation for a longer time period to maintain the overall average and to compensate for the initial decrease in inflation rates in the immediate aftermath of a negative aggregate demand shock.

The initial effect of a negative AS shock is a decrease in real GDP growth, an increase in inflation and a response from the Federal Reserve to increase interest rates. Under MAIT, after the initial increase in interest rates, the Federal reserve will decrease interest rates by a greater amount and for a longer time period. The lower interest rates under MAIT policy results in above target inflation and above long-run real GDP growth during the dynamic transition. It is also more likely that interest rates reach the Zero-Lower Bound when pursuing MAIT policy, the direct result of compensating for lower inflation in the transitional period.

The volatilities in real GDP growth rates and inflation rates are greater under MAIT policies in each simulation. When there is a positive shock to aggregate demand or aggregate supply, the Federal Reserve responds with higher interest rates for a longer sustained timeframe to compensate for the higher inflation rates. The results are below long-run levels of both real GDP growth and inflation during the transition.

However, when there is a negative shock to aggregate demand or aggregate supply, the Federal Reserve responds in a more expansionary manner under MAIT policy compared to the standard Taylor rule. Both real GDP growth and inflation rates are above long-run levels during the transition and, again, it is more likely to reach the ZLB.

4 Conclusions

This study compares the standard monetary policy approach of US Federal Reserve against the announced monetary policy targeting regime called Average Inflation Targeting (AIT), specifically Moving Average Inflation Targeting (MAIT). As a robustness check, two separate, significantly different simulation models are used for the comparison, the Dynamic Aggregate Demand - Dynamic Aggregate Supply (DAD - DAS) model and the New Keynesian (NK) model. The simulation models are calibrated based on recent US data, but are also consistent with longer time frames. In both simulation models, a monetary policy rule equation is employed that, first, follows the standard approach, and, second, is then modified to mimic an inflation targeting approach. The Taylor (1993) rule equation is used in the NK model, and a similarly developed monetary growth rule equation is used in the DAD – DAS model. These models are then subjected to aggregate demand and aggregate supply shocks to see how inflation and GDP growth rates respond, and to determine if there are any differences in the monetary targeting policies.

No past studies have indicated the oscillatory problems MAIT creates with both aggregate demand and aggregate supply shock responses. Most studies and commentaries have concentrated on aggregate supply shock responses to AIT. There is significantly more volatility for both macroeconomic variables if the Federal Reserve follows the MAIT approach. This result is robust to both positive and negative shocks and robust to both the New Keynesian and the Dynamic Aggregate Demand – Aggregate Supply models.

To date, there is limited research in comparing the older standard monetary approach to the new AIT approach and there are several avenues to extend this research. Of the few studies done, most have concentrated on the impact of AIT on real interest rates or on inflation expectations. In this study the real interest rate is not held constant, but instead, that the Wicksellian natural rate of interest is assumed to be constant in the long run, such that as the model approaches long-run equilibrium, the nominal interest rates will reflect a long-run equilibrium Fisher equation where the 'real interest rate' is the same natural rate as it was before the shock. Further, this study has purposefully assumed inflation expectations are based on prior data points. Because inflation expectations can drive any simulation model's responses to shocks, we are letting historical empirical expectations implicitly drive the simulations, which show that MAIT will increase volatility. A third focus can be to modify the MAIT approach itself. We have used a moving average approach here, but another type of AIT might be to generate a sustained, unchanging target for a fixed period of time, rather than using the moving average target approach. That approach can be implemented in numerous ways, from how quickly to get back to the long-run inflation target to how far from the long-run target inflation is allowed to go.

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