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How Effective is the Taylor rule? Some Insights from the Time-Frequency Domain

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Abstract

When the central bank sets monetary policy according to a conventional or modified Taylor rule (which is known as the Taylor Principle), does this deliver the best outcome for the macroeconomy as a whole? This question is addressed by extending the wavelet-based control (WBC) model of Crowley and Hudgins (2015) to evaluate macroeconomic performance when the central bank sets interest rates based on a conventional or modified Taylor rule (TR). We compare the simulated performance of jointly optimal fiscal and monetary policy under an unrestricted baseline model with performance under the TR. We simulate the model un-der relatively small and large weighting of the output gap in the TR specification, and for both low and high inflation environments. The results show that the macroeconomic outcome de-pends on whether the conventional or modified Taylor rule is used, and whether the central bank is operating in a low or high inflation environment.

Keywords: Discrete Wavelet Analysis; Monetary Policy; Optimal Control
JEL codes: C61, C63, C88, E52, E61, F47

A substantially different version of this paper which considers "hawkish" and "dovish" monetary policy and the Taylor rule is forthcoming in the journal Applied Economics Letters.

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1. Introduction

The analysis presented in this paper integrates a passive conventional and modified Taylor rule (TR) for monetary policy within a large-scale Wavelet Based Control (WBC) model of the U.S., and compares the simulated results to the case where monetary policy determines interest rates through an active optimal control strategy. Our paper is the first to analyze the TR effects in a WBC model context.

WBC models have recently been used as part of a series of papers to simulate economic policy for the U.S., euro area, and South African economies (for example, see Crowley and Hudgins, 2015; 2017; 2018). WBC models first obtain the time-frequency domain cyclical decomposition of quarterly domestic and foreign GDP component and financial data, and then simulate jointly optimal fiscal and monetary policy under a linear-quadratic tracking control model. These models can be utilized in conjunction with standard macroeconomic models to improve forecasting by incorporating two factors that are lacking in aggregate models. First, the WBC models allow the policymaker to place more weight on selected frequency ranges, and in particular the U.S. political cycle, thus allowing more appropriate policy implementation. Secondly, WBC models can utilize cyclical information within time series that time domain methods do not typically capture, thus allowing policymakers to target cycles that are operational within the macroeconomic variables.

The Taylor rule was first proposed by Taylor (1993) as an approximation to a central bank reaction function in terms of the nominal interest rate, and its original formulation included just inflation and the output gap as determinants. The original form of the Taylor rule can be written as:

$$ir_k = rir^* + inf_{k-1} + \beta_1 (Y_{k-1} - Y^*_{k-1}) / Y^*_{k-1} + \beta_2 (inf_{k-1} - inf^*) \qquad (1)$$

for time k, where ir is the nominal interest rate, rir^* is the targeted real interest rate (usually assumed to be 2% in the U.S.), inf is inflation and Y is real GDP with starred versions of these symbols represented targets. The equation in its original form used GDP inflation, and used a 2 percent target growth path for real GDP. Interest rate smoothing or “gradualism” in monetary policy adjustment is also an issue with the specification as a very gradual policy adjustment would imply more lagged variables. In addition, as noted by Fernandez et al (2008), in many countries exchange rates could logically be added as explanatory variables.

The values assigned by Taylor (1993) were β_1 = 0.5 and β_2 = 0.5, which under general conditions imply that the central bank will respond to increases in inflation by raising nominal interest rates by a greater amount [$(1+\beta_2)$ to be exact]. Despite the issues and problems with implementation of the rule in practice, as Asso et al (2010) make clear, central bankers around the world now use the Taylor rule as an input to decision-making regarding monetary policy formulation.

Various further modifications of the Taylor rule have been proposed, including setting β_1=1 and β_2 = 0.5 so as to put a higher relative weight on the output gap in monetary policy responses, and also using PCE rather than the GDP deflator as the preferred measure of inflation[1]. More recently Taylor has also proposed making the Taylor rule an actual prescriptive policy for the central bank (the so-called “Taylor Principle”). Although the Taylor Principle is controversial (see Bernanke (2015), the Taylor rule remains an important benchmark for assessing the stance of monetary policy.

Despite the fact that there are numerous papers which use the Taylor rule in the time domain, there is very little research in macroeconomics that is focused on its time-frequency features. Choi and Wen (2010) consider the frequency range of impulse responses revealed using Taylor rules to uncover monetary policy reactions, which pointed to greater responsiveness to inflation changes over shorter horizons than to output growth which in turn occurred over longer horizons. Aguiar-Conraria et al. (2018) was the first to formally analyze the TR in the time-frequency domain using wavelets, and found meaningful shifts in the policy focus between the short, intermediate, and long cycles across different time periods. Additionally,

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[1] *For discussions and modification of the Taylor rule, see Bernanke (2015).*

Aguiar-Conraria et al. (2018) provides a thorough discussion of the relevant aspects of the TR in the literature.

Given the importance of the TR as a benchmark of monetary policy, this current analysis adds considerable insight into differences in the central bank's interest rate policy that occur under a TR versus optimal control policy rules, and as such our paper is the first to analyze the TR effects in a WBC model. The results show that within a low inflation environment, the TR is likely to deliver higher interest rates, diminished investment, and appreciated real exchange rates, but in a high inflation environment the modified TR appears to yield enhanced growth compared with the baseline. Since our WBC model is not a fully calibrated large-scale econometric model, the results are meant to be primarily illustrative.

2. Data and Methodology

Discrete wavelet analysis extracts cyclical information from time series by expressing the value of a variable *x* at time instant *k*, x_k, using Mallat's pyramid algorithm and multiresolutional analysis, as

$$x_k \approx S_{J,k} + d_{J,k} + d_{J-1,k} + \ldots + d_{1,k} \tag{2}$$

The $d_{j,k}$ terms are wavelet detail "crystals", $j = 1,\ldots, J$; $S_{J,k}$ is a trend component, called the wavelet "smooth", and *J* represents the number of scales (frequency bands). As detailed in Crowley and Hudgins (2018), we utilize the asymmetric Daubechies 4-tap (D4) wavelet function, and employ the Maximal Overlap Discrete Wavelet Transform (MODWT) as the method of time-frequency decomposition. We apply the MODWT to the US national income data, OECD data, US inflation rate, nominal and real interest rates, and the foreign (G6=G7 minus US) GDP weighted nominal interest rate,[2] over the period 1973–2018, using a two-step procedure that extracts the crystals and the smooth (trend and any residual cycles) at frequencies $j = 1, \ldots, 5$[3]. Table 1 defines the time-frequency ranges for all of the wavelet decompositions.

Table 1. The time intervals associated with each of the frequency ranges

J	*Time interval in quarters*	*Time interval in years*
1	2 to 4 quarters	6 months to 1 year
2	4 – 8 quarters	1 – 2 years
3	8 – 16 quarters	2 – 4 years
4	16 – 32 quarters	4 – 8 years
5	32 – 64 quarters	8 – 16 years

Based on the wavelet decomposition above, the model nests the GDP components of domestic output (*Y*) are in the following blocks: consumption (C_j); investment (I_j); government expenditure (G_j); net exports (NX_j). For each frequency range, each component removes the effects at all other four frequency ranges, so that a variable only includes the crystal (*d*) and the modified smooth base-level trend (*S*). The wavelet-based components for any variable are therefore defined in equation (3) as follows:

$$X_{j,k} = d_{X,j,k} + S_{X,j,k} \qquad j = 1,\ldots,5; \quad k = 1, \ldots, K \tag{3}$$

[2] *G6 interest rates are sourced from the OECD and US rates are sourced from the Federal Reserve. The G6 rates use real GDP in US$ weights sourced from either the IMF or OECD.*
[3] *Further details can be found in Crowley and Hudgins (2018).*

The model in equations (4) through (15) utilizes the framework in Crowley and Hudgins (2018) for each frequency range, j = 1,…,5, as, where the $\beta_{j;0}$ coefficients are constants and $L_{(.)}$ denotes the number of lags for any given variable. Blocks ir^{US}_j and ir^f_j are wavelet decompositions of the short-term domestic (US) and foreign (G6) interest rates, respectively. Block RER_j is the wavelet decomposed real exchange rate (index of foreign currency unit per US dollar), and the $\omega_{(.),j}$ terms represent blocks of random disturbance errors. Equation (4) specifies the consumption block as linearized functions of lag structures of consumption, expected and lagged government spending, and the real exchange rate (*RER*). Expected government spending (G^e) permits a rational expectations component whereby GDP is crowded-out at each frequency range by increases in the national debt (*DEBT*).

$$C_{j,k} = \beta_{C,j,0} + f_{C,j}(C_{j,k-1}, \ldots, C_{j,k-L_C}, G^e{}_{j,k-1}, G_{j,k-1}, \ldots, G_{j,k-L_G}, RER_{j,k-1}, \ldots, RER_{j,k-L_{RER}}) + \omega_{C,j,k-1} \quad (4)$$

Investment is determined by domestic GDP interest rates in equation (5). Net exports are a function of the lag structures of net exports, domestic GDP (Y^{US}), foreign GDP (Y^f), and the *RER*, as given in equation (6). The *RER* in equation (7) captures interest rate parity influences from domestic and foreign interest rates.

$$I_{j,k} = \beta_{I\,j,0} + f_{I,j}(Y^{US}{}_{j,k-1}, \ldots, Y^{US}{}_{j,k-L_C}, ir^{US}{}_{j,k-1}, \ldots, ir^{US}{}_{j,k-L_{irUS}}) + \omega_{I,j,k-1} \quad (5)$$

$$NX_{j,k} = \beta_{NX,j,0} + f_{NX,j}(NX_{j,k-1}, \ldots, NX_{j,k-L_{NX}}, Y^{US}{}_{j,k-1}, \ldots, Y^{US}{}_{j,k-L_{Y^{US}}}, Y^f{}_{j,k-1}, \ldots, Y^f{}_{j,k-L_{Y^f}}, RER_{j,k-1}, \ldots, RER_{j,k-L_{RER}}) + \omega_{NX,j,k-1} \quad (6)$$

$$RER_{j,k} = \beta_{RER,j,0} + f_j^{(5)}(ir^{US}{}_{j,k-1}, \ldots, ir^{US}{}_{j,k-L_{irUS}}, ir^f{}_{j,k-1}, \ldots, ir^f{}_{j,k-L_{irf}}, RER_{j,k-1}, \ldots, RER_{j,k-L_{RER}}) + \omega_{RER,j,k-1} \quad (7)$$

Inflation (*inf*) is determined in equation (8) by the inflation lags, the GDP gap, money supply growth (*MS*), and the *RER*. Since the Fed primarily utilizes the interest rate as an operating target, equation (9) determines the real money growth by adjusting to the lags of the real interest rate, the output gap, and real money growth.

$$inf_k = \beta_{inf,0} + \beta_{inf,1}\, inf_{j,k-1} + \beta_{inf,2}(Y_{k-1} - Y^*_{k-1}) + \beta_{inf,3}\, RER_{k-1} + \beta_{inf,4}\, MS_{k-1} + \beta_{inf,5}\, inf_{k-2} + \omega_{inf,k-1} \quad (8)$$

$$MS_k - inf_k = \beta_{MS,0} + \beta_{MS,1}(ir^{US}{}_{k-1} - inf_{k-1}) + \beta_{MS,2}(Y_{k-1} - Y^*_{k-1}) + \beta_{MS,3}(MS_{k-1} - inf_{k-1}) + \beta_{MS,4}(MS_{k-2} - inf_{k-2}) + \omega_{inf,k-1} \quad (9)$$

When we restrict the model so that the central bank follows a modified TR, then the domestic interest rate is determined by equation (10), where the target real interest rate is given by *rir** = 2%, and the target inflation rate is *inf**= 2%.[4]

[4] *The FOMC noted that an inflation rate of 2 percent (as measured by the annual change in the price index for personal consumption expenditures, or PCE) is most consistent over the longer run with the Federal Reserve's statutory mandate." Dec 19, 2018, Federal Reserve. Kliesen (2019a,b) explores versions of a TR used in practice that are modified by incorporating a variable real interest rate target. Although we have simulated the model with a similarly modified TR, this does not substantially alter our main conclusions. Our model uses interest rates on short-term US Treasury securities (3-month T-bill rates), which follow the Fed Funds rates closely. See the Fed data for details at*

$$ir^{US}_k = rir^* + inf_{k-1} + 0.5\,(Y_{k-1} - Y^*_{k-1}) / Y^*_{k-1} + 0.5\,(inf_{k-1} - inf^*) \quad (10)$$

The model is closed by equations (11) through (14), which contain the national income identity, passively determined net taxes (*T*), the quarterly budget deficit (*DEF*), and the debt stock.

$$Y_k = C_k + I_k + G_k + NX_k \quad (11)$$

$$T_k = \tau Y_k \quad (12)$$

$$DEF_k = G_k - T_k \quad (13)$$

$$DEBT_k = 0.25\,DEF_k + (1 + i_k)\,DEBT_{k-1} \quad (14)$$

The fiscal policymakers choose government spending while the central bank chooses the interest rate at each frequency range in order to minimize the expected value of a quadratic performance index consisting of the weighted tracking errors for the variables of the model. Let *x* denote a state vector, and *u* denote a policy vector. Define the (*) as the target for any given variable, and let the superscript (^{T}) represent the matrix transpose. The objective is to minimize the quadratic tracking index in expression (15).

$$\min_u E[J(u)] = (x_{K+1} - x^*_{K+1})^T Q_f (x_{K+1} - x^*_{K+1}) \quad (15)$$
$$+ \sum_{k=1}^{K} \left[(x_k - x^*_k)^T Q_k (x_k - x^*_k) + (u_k - u^*_k)^T R_k (u_k - u^*_k) \right]$$

The three terms in (15) penalize the policymakers for the tracking errors in the final state vector (with penalty matrix Q_f), the state vector in each period (with penalty matrix Q_k), and the control vector (with penalty matrix R_k). Following Crowley and Hudgins (2018), this determines the optimal simulated values for the 10 control variables and the 137 state variables in the large-scale WBC model.

3. Simulation Analysis

We estimated the model using standard OLS regression techniques for the post-Bretton-Woods period of 1973 quarter 3 to 2018 quarter 2. This yielded satisfactory empirical results, which are given in the appendix. These coefficients are then used in our model to simulate beyond 2018 quarter 2. The annual target growth rates for all real GDP variables are set at 2.5%. The 2% target inflation rate, combined with the targeted real GDP growth, results in a 4.5% annual nominal GDP growth target, which is consistent with a 4.5% money growth target. Given the 2% real interest rate target, nominal interest rate is 4%.[5] Given that the initial nominal interest rate was only 2%, the unrestricted simulations specify approximate the Fed's "liftoff" strategy, as in Crowley and Hudgins (2018), where the target annual interest rate is initially 2%, but steadily increases over the horizon, where it achieves a final value of 4%.[6]

So as to calibrate the model for simulation, political cycle targeting is assumed, so the primary emphasis is on the cycles between 2 and 8 years. The main purpose of the simulations is to analyze the relative changes in the optimal forecast trajectories that occur when the

https://www.stlouisfed.org/on-the-economy/2017/october/increases-fed-funds-rate-impact-other-interest-rates.

[5] *This balances a real interest rate of 2% with a productivity growth of 2%. For an annual population growth of 0.5%, this is consistent with an annual real GDP target growth of 2.5%.*

[6] *The target interest rate is thus growing at a quarterly compounded growth rate of 0.04729. This approximates an interest rate response in the short-term bond market to series of eight semi-annual Fed discount rate increases by 25 basis points over the four-year horizon.*

central bank follows a modified TR versus the base case where the central bank sets the interest rate based on the optimal feedback control rules that track the target under its unrestricted liftoff strategy.

Figure 1. Financial Variables when Monetary Policy is determined by Optimal Control Liftoff Strategy

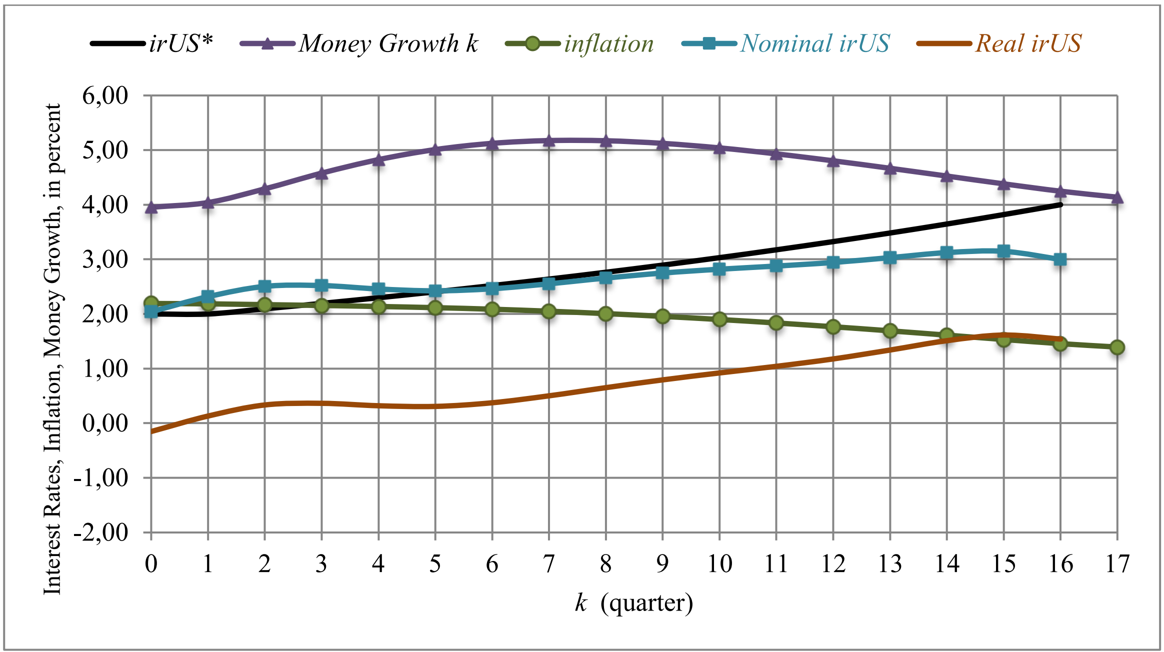
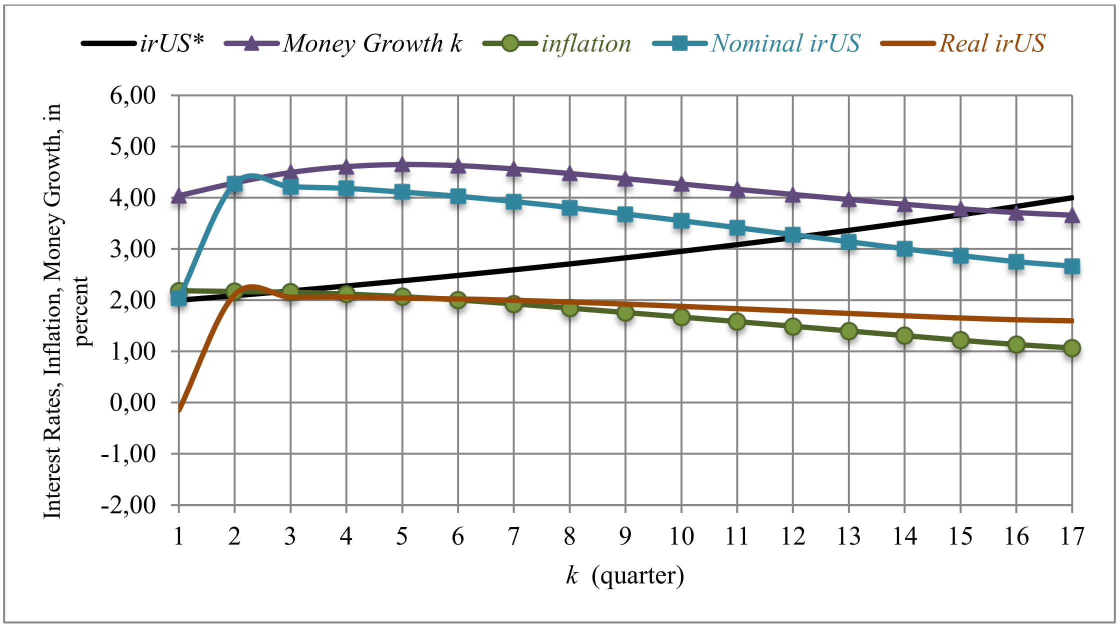


Figure 2. **Financial Variables when Monetary Policy follows a Taylor Rule**



Figures 1 and 2 show the forecast trajectories for the US short-term interest rates, inflation, and money growth. The nominal interest rate in Figure 1 increases over the horizon, but begins to fall increasingly short of its target from the middle to the end of the horizon. For the TR in Figure 2, however, the nominal interest rate immediately jumps above its 4% target, and then slightly declines thereafter. The relatively tighter monetary policy under the TR in Figure 2 also leads to a lower trajectory for both the money supply growth and inflation when compared to the unrestricted case in Figure 1.

Figures 3 and 4 show that higher interest rates under the TR strategy lead to substantially lower investment. Under the TR in figure 4, investment at frequency range 3 (2 to 4 years) falls in relationship to that of the base case shown by Figure 3. Cumulative aggregate investment over the entire horizon is 12% lower under the TR restriction.

Figure 3. ***Investment*** **(*I*) when Monetary Policy is determined by Optimal Control Liftoff Strategy**

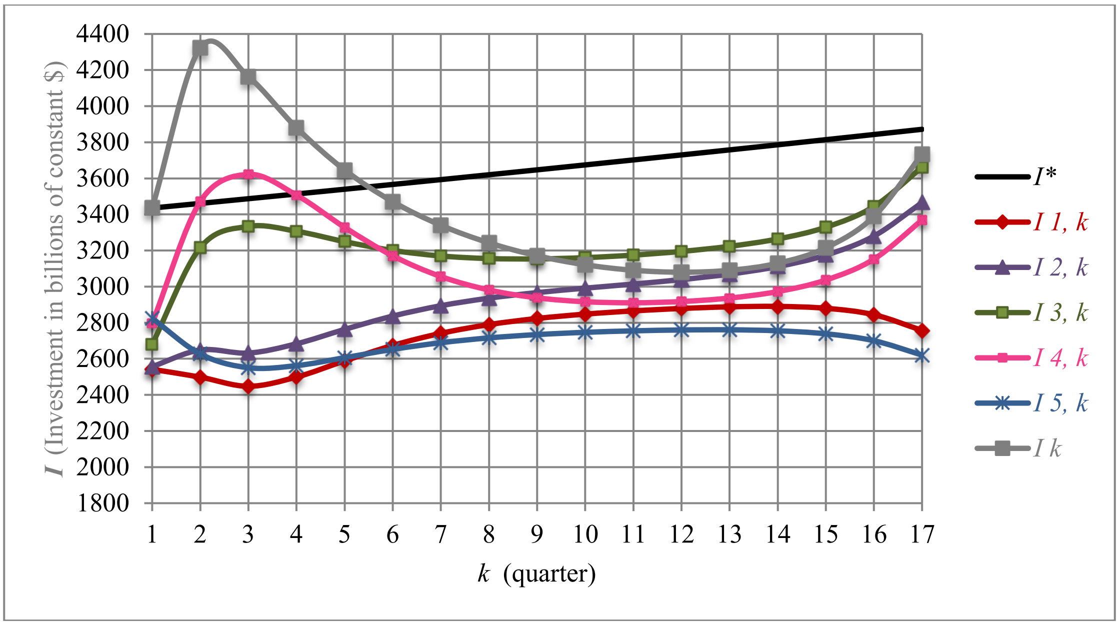


Figure 4. ***Investment*** **(*I*) when Monetary Policy follows a Modified Taylor Rule**

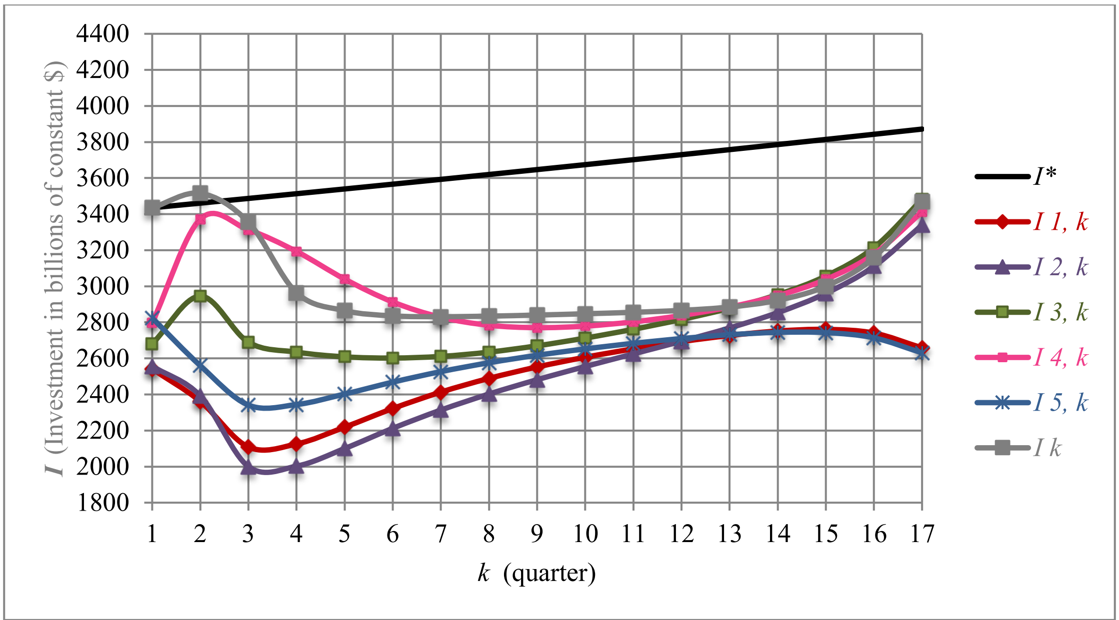


Figure 5 shows that the higher interest rates and lower money growth under the TR lead to an appreciated *RER* where the trajectory is substantially higher than under the unrestricted liftoff case. This arises due to the inflow of financial assets which moves the exchange rate towards interest rate parity. Under the TR, the appreciated *RER* exerts downward pressure on *NX* due to the terms of trade substitution, but causes an even larger upward pressure due to the lower investment and GDP, which result in diminished imports.

Figure 5. ***Real Exchange Rate*** **(*RER*) Optimal Forecasts**

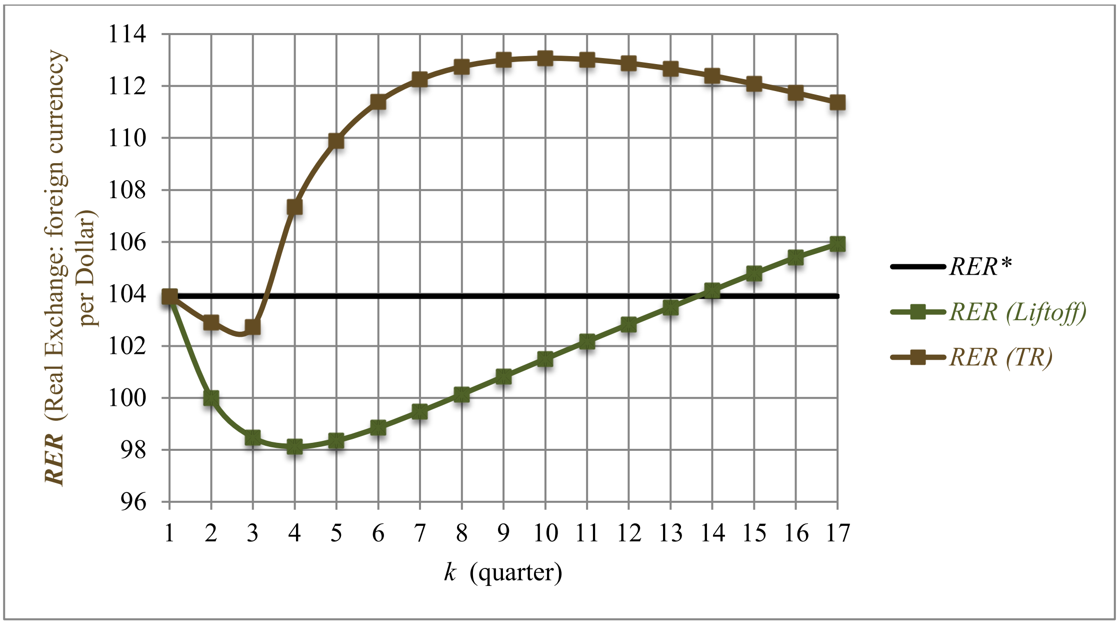


Table 2 compares the cumulative changes in each of the real GDP components over the forecast horizon under the TR with the baseline liftoff case. The simulations results are reported under the standard TR where the output gap coefficient is 0.5, and also for amodified TR where the output gap coefficient is increased to 1. Cumulative government expenditure is 1.95% larger under the TR, since fiscal policy becomes more expansionary (with larger debt) in order to counteract more contractionary monetary policy. Consumption is slightly higher under the TR strategy due to the higher *G* and an appreciated *RER* that increases imports.

Table 2. Comparison of Cumulative Differences (in %) by Real GDP component under the TR restriction

Case	% Change under TR	% Change under modified TR
C	0.112	0.129
I	– 12.03	– 11.97
G	1.95	1.52
NX	2.93	2.93
Y	– 1.69	– 1.76
inf	– 0.15	– 0.15

The largest shortcoming of the TR restriction, however, is the negative effect on investment and economic growth. Under the TR, cumulative output is 1.69% lower than in the baseline optimal control model. This points to the inability of the TR to capture not only the real-world interaction with fiscal policy and the external sector, but also the lack of any time-frequency elements in the TR, as in reality inflation and output dynamics are concentrated over different time horizons.

As a robustness check, we also simulated the model when the economy initially experiences high inflation and high money growth that exceeds targeted levels, where all else remains as in the previous scenarios. The results are shown in figures 6 through 13. Figures 7, 10, and 12 show the simulated forecasts with a conventional TR, and figures 8, 11, and 13 display the simulated forecasts under the modified TR where the weight on the output gap is relatively larger.

Figure 6 illustrates that with the joint optimal control strategy, if inflation were initially quite high, then given current macroeconomic conditions the only way this could occur would be with negative real interest rates throughout the period, so that nominal rates fluctuate between 2% and 3%. Also we see money supply expanding to accommodate the higher inflation and then start to contract so that the central bank can track its objective. In figure 7, with a conventional TR, nominal interest rates immediately soar to reach nearly 10%, with real rates rising to nearly 4% before dropping back to under 3% by the end of the horizon. In figure 8, when the modified TR is more focused on the output gap but with high initial inflation, the response is immediate in the simulations, with nominal interest rates immediately rising by 2% following the TR, which brings the inflation rate down to 1% by the end of the forecast horizon, but this also increases in the real rate of interest into positive territory for the rest of the forecast horizon.

In figure 9, under the joint optimal strategy, investment surges for a year, but for the remaining 3 years of the forecast horizon, investment falls below the growth objective. Using a conventional TR, investment in figure 10 collapses as real rates soar, troughing in Q6 and then slowly recovering, but still remaining well below targeted levels by the end of the horizon. With a TR focused on the output gap in figure 11, the higher profile for nominal interest rates and real rates causes only a short-lived increase in investment, after which it remains subdued for the rest of the forecast horizon, but much less so than in figure 10 with the TR.

Figure 12 shows the forecasts for NX when the central bank implements the jointly optimal policy with high initial inflation, but in addition we also show the effect on the RER with a conventional TR. Clearly the conventional TR increases interest rates, with quite a dramatic effect on the RER. With a higher weight on the output gap, as figure 13 shows, the impact on interest rates is not so severe, so that the RER doesn't appreciate by nearly as much. Under the conventional TR, the nominal and real interest rates are much higher than for the modified TR. Thus, the RER trajectory is much higher, while the investment path is lower than in the case of the modified TR.

Figure 6. Financial Variables when Monetary Policy is determined by Optimal Control Liftoff Strategy. High initial Inflation

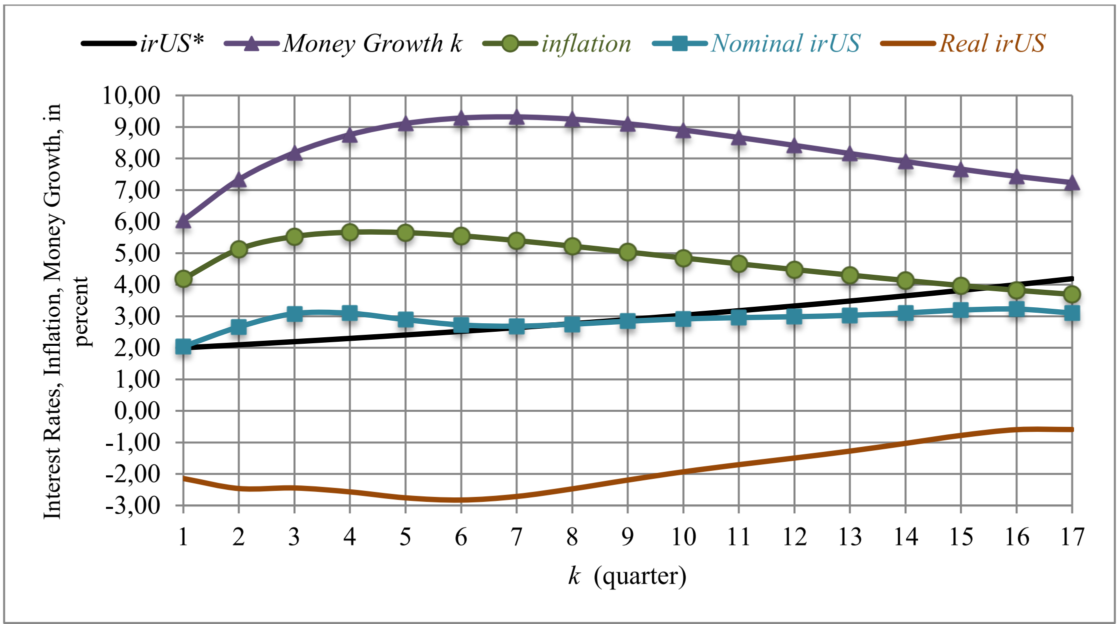


Figure 7. **Financial Variables when Monetary Policy follows a TR with high initial Inflation**

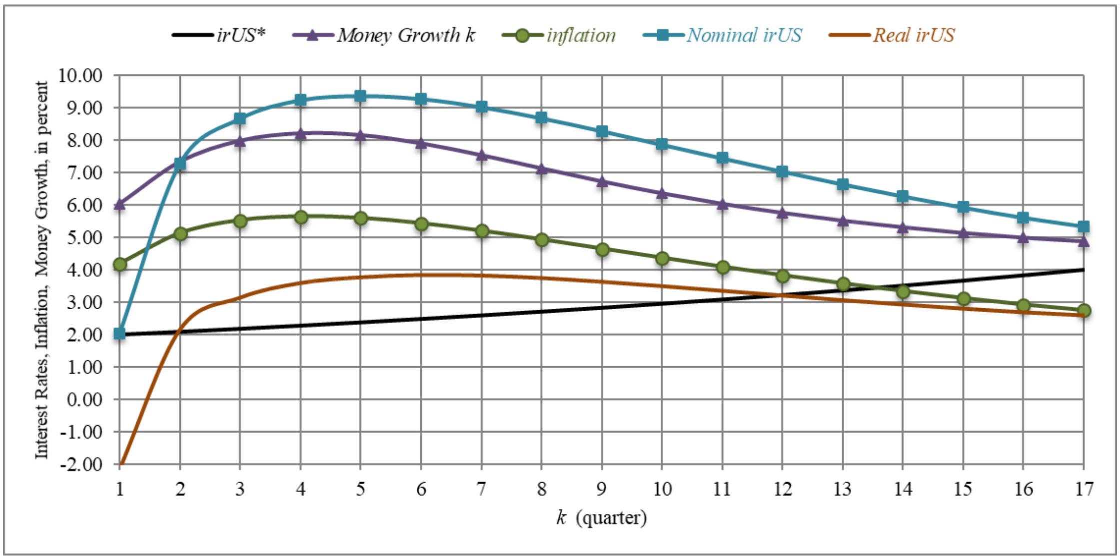


Figure 8. **Financial Variables when Monetary Policy follows a modified TR with high initial Inflation**

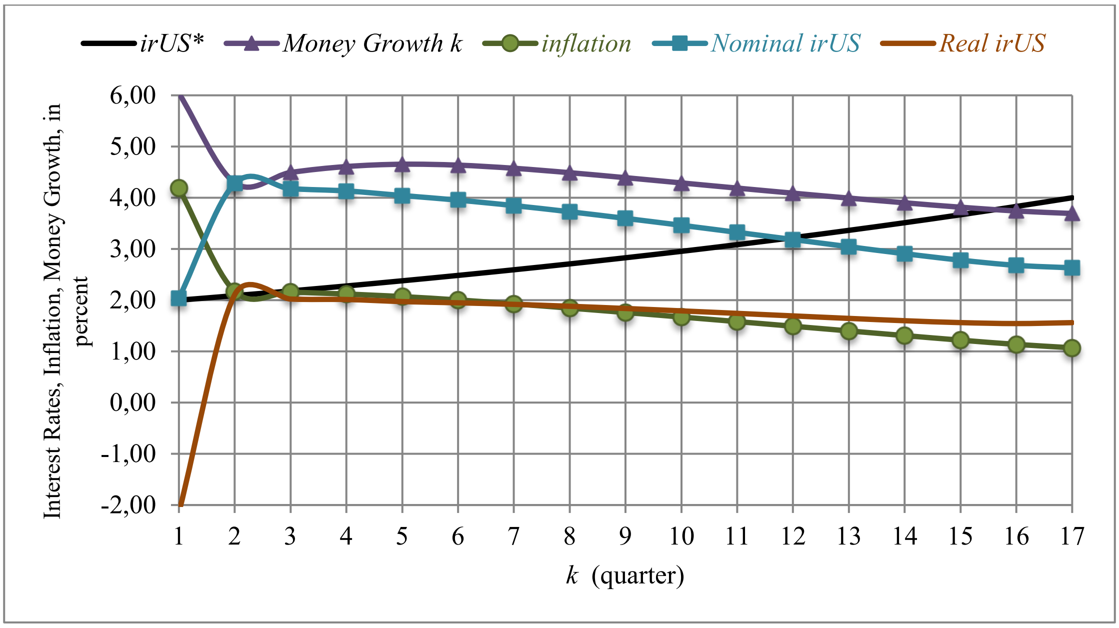


Figure 9. *Investment* (*I*) **when Monetary Policy is determined by Optimal Control Liftoff Strategy with high initial inflation**

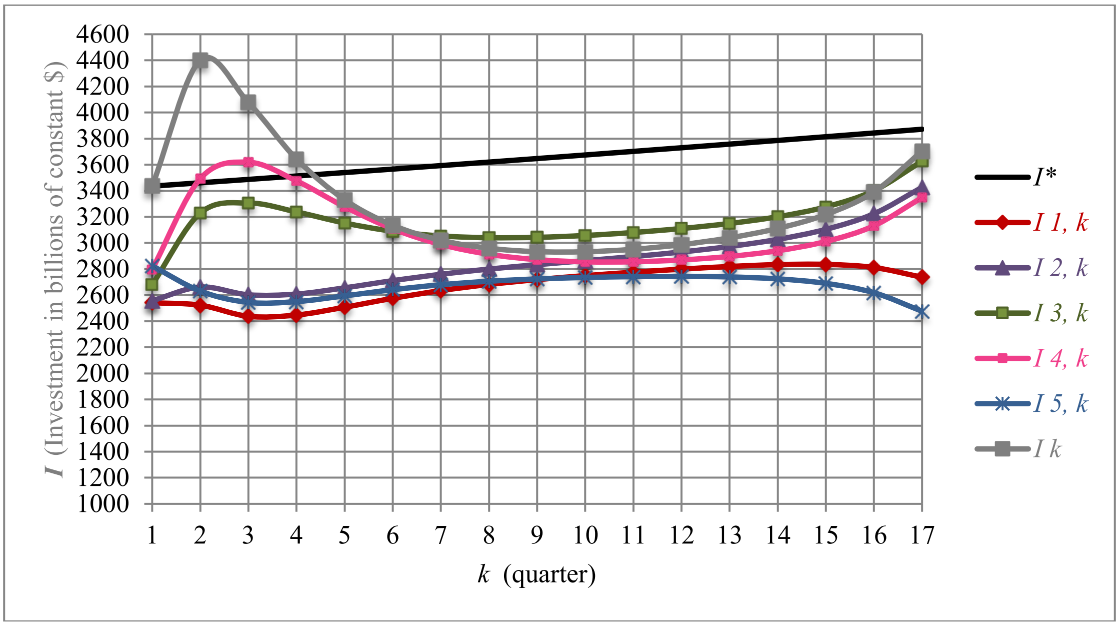


Figure 10. *Investment* (*I*) **when Monetary Policy follows a conventional TR with high initial inflation**

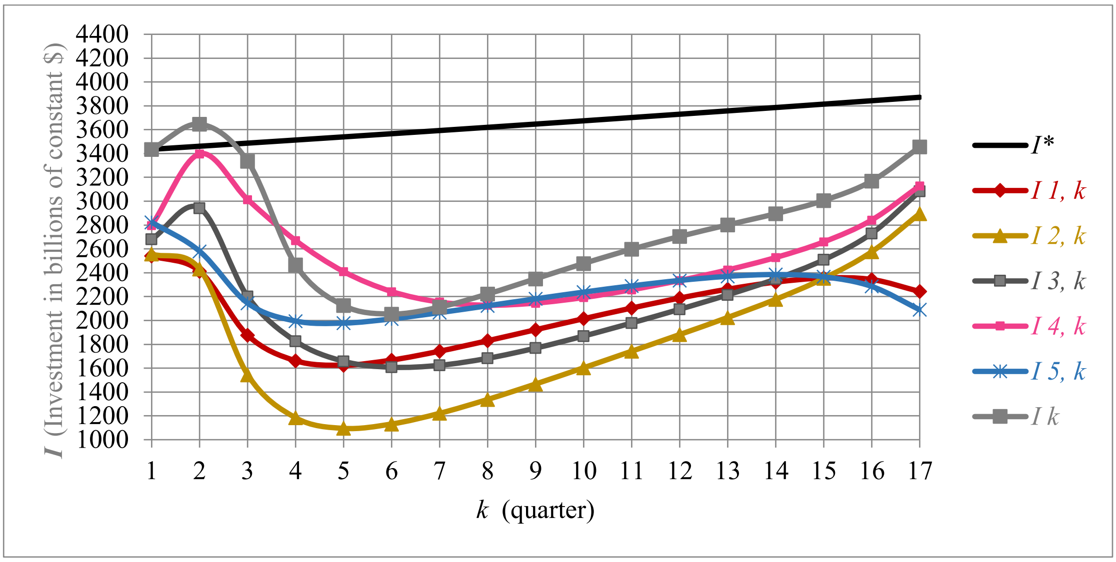


Figure 11. ***Investment*** **(*I*) when Monetary Policy follows a modified TR with high initial inflation**

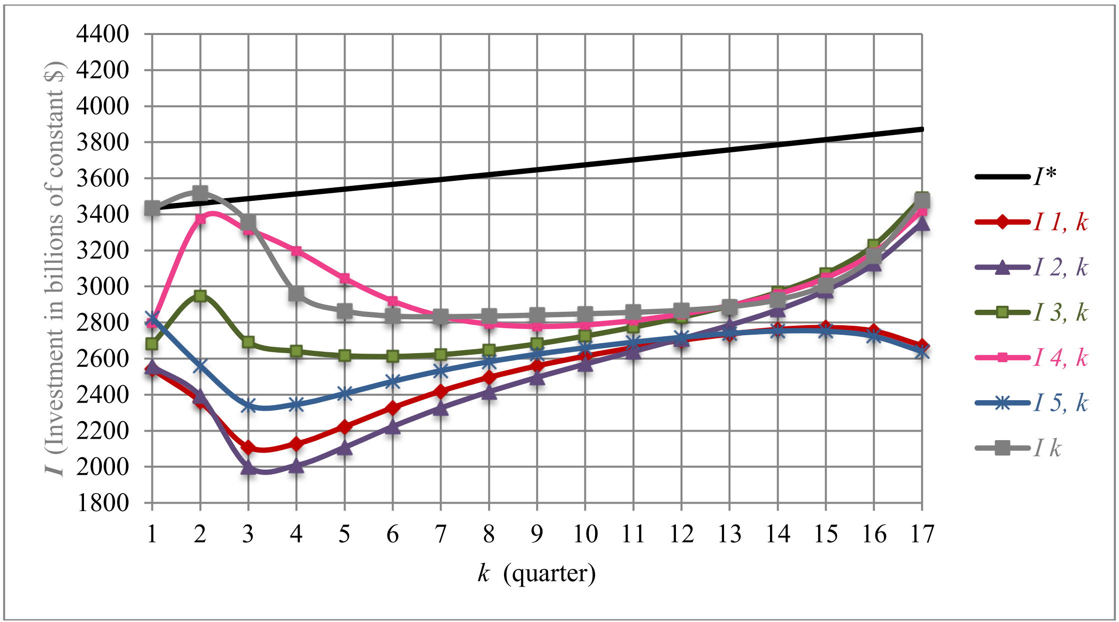


Figure 12. ***Real Exchange Rate*** **(*RER*) Optimal Forecasts with high initial inflation under conventional TR**

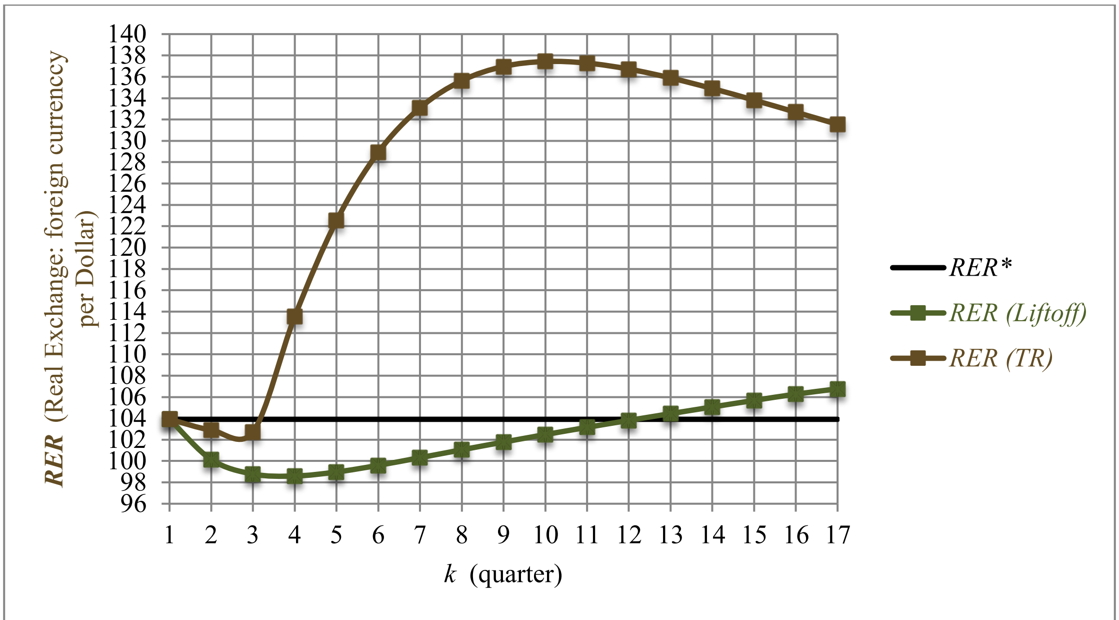
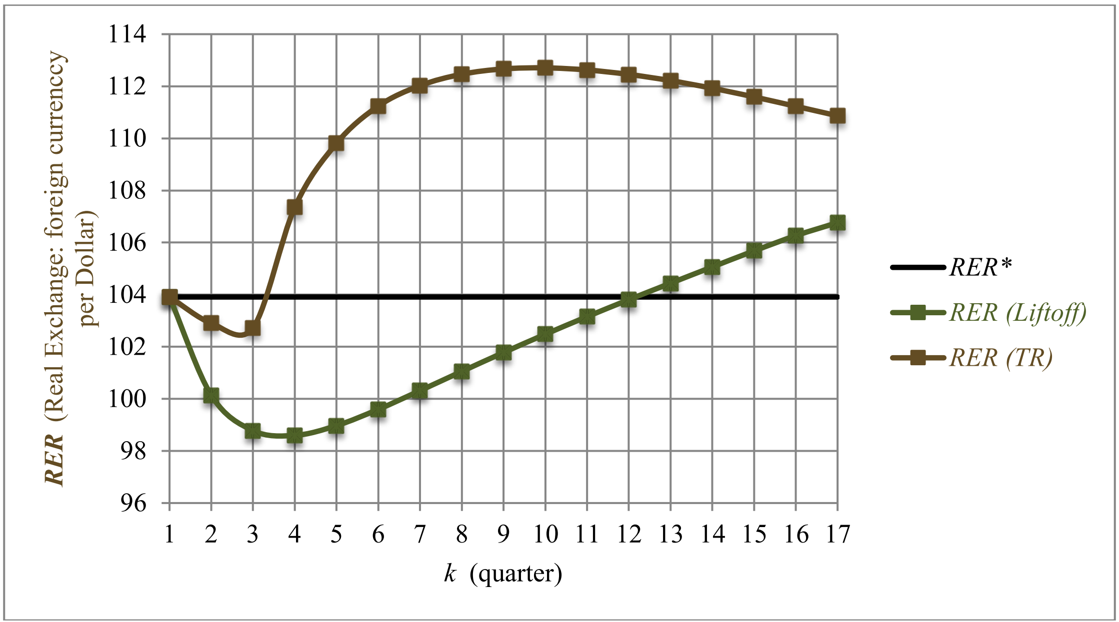


Figure 13. ***Real Exchange Rate*** **(*RER*) Optimal Forecasts with high initial inflation under a modified TR**



The general effect of a modified TR with greater emphasis placed on the output gap is to moderate the effect of the TR on investment and in fact to boost consumption, government spending, and consequently overall real GDP as well. Under the conventional TR, aggregate government spending is more volatile and falls below its target during periods 3 through 9, mostly due to smaller spending at frequency ranges 1 and 2. Aggregate government spending under the conventional TR then ends the horizon above the spending level under the modified TR, mostly due to the higher spending at the political cycle frequency ranges 3 and 4 to counteract the depressed levels of investment under the conventional TR.

Table 3. Comparison of Cumulative Differences (in %) by Real GDP component under the TR restriction with high initial inflation

Case	% Change under TR	% Change under modified TR
C	0.078	0.708
I	– 16.73	– 8.44
G	4.29	15.06
NX	9.71	– 1.55
Y	– 1.70	1.39
Inf	– 0.09	– 0.62

4. Conclusion

This paper is the first paper to simulate the policy effects of using a TR within a WBC model. It illustrates the effects across frequency ranges and in the aggregate of monetary policy utilizing unrestricted and TR-restricted approaches to interest rate targeting in an optimal control setting, thus giving policymakers additional insights in forecasting the effects of different strategies.

The main result of this research is that within this framework, the TR is not as effective as a jointly optimal policy in that it yields lower output growth, but this result only appears to hold at low rates of inflation with low emphasis placed on the output gap in the TR, as when higher rates of inflation are used with a modified TR to consider a higher emphasis on the output gap, this yields higher output growth. This has 2 implications – first, that in the time-frequency domain the modified TR appears to be more effective compared to the conventional TR, and at high inflation rates, the modified TR even delivers higher output in a simulation, compared with the jointly optimal strategy case. This higher output though is caused by the response of fiscal policymakers to the modified TR. The second implication is that the time-frequency implications of the form of monetary policy and its interaction with fiscal policy is state dependent in terms of how effective it is at promoting economic growth.

So, in policy terms, the answer to the question that we pose in the title of this paper is dependent on various factors, and those factors include both the level of inflation as well as the nature of the TR being used by the central bank.

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Appendix

Table A1

Consumption coefficient estimates from equation (3), with *(p-values)*

$$C_{j;k} = \beta_{C,j,0} + \beta_{C,j,1} C_{j,k-1} + \beta_{C,j,2} G_{j,k-1} + \beta_{C,j,3} C_{j,k-2} + \beta_{C,j,4} RER_{j,k-1} + \beta_{C,j,5} RER_{j,k-2} + \omega_{C,j,k-1}$$

j	*Quarters*	$\beta_{C,j,0}$	$\beta_{C,j,1}$	$\beta_{C,j,2}$	$\beta_{C,j,3}$	$\beta_{C,j,4}$	$\beta_{C,j,5}$	R^2
1	2 to 4	-111.08 *(0.1618)*	1.9374 *(0.0000)*	0.0498 *(0.0011)*	-0.9478 *(0.0000)*	1.2518 *(0.5886)*	-0.6029 *(0.7839)*	0.9996
2	4 to 8	-102.32 *(0.1283)*	1.9594 *(0.0000)*	0.0657 *(0.0004)*	-0.9690 *(0.0000)*	1.8540 *(0.4695)*	-1.2730 *(0.6014)*	0.9997
3	8 to 16	-94.07 *(0.1453)*	1.9424 *(0.0000)*	0.0325 *(0.0182)*	-0.9488 *(0.0000)*	1.8555 *(0.4022)*	-1.2478 *(0.5550)*	0.9998
4	16 to 32	-77.19 *(0.3218)*	1.8454 *(0.0000)*	0.0269 *(0.1918)*	-0.8506 *(0.0000)*	-2.3360 *(0.2984)*	2.8651 *(0.1885)*	0.9900
5	32 to 64	-110.23 *(0.1041)*	1.8445 *(0.0000)*	0.1059 *(0.0000)*	-0.8660 *(0.0000)*	-1.4095 *(0.5161)*	1.5700 *(0.4607)*	0.9900

Table A2

Investment coefficient estimates from equation (4), with *(p-values)*

$$I_{j;k} = \beta_{I,j,0} + \beta_{I,j,1} Y_{j,k-1} + \beta_{I,j,2} d_{irUS,j,k-1} + \omega_{I,j,k-1}$$

j	*Quarters*	$\beta_{I,j,0}$	$\beta_{I,j,1}$	$\beta_{I,j,2}$	R^2
1	2 to 4	-721.02 *(0.0000)*	0.2209 *(0.0000)*	-75.2372 *(0.6180)*	0.64
2	4 to 8	-678.68 *(0.0000)*	0.2172 *(0.0000)*	-143.8609 *(0.2010)*	0.65
3	8 to 16	-584.73 *(0.0000)*	0.2090 *(0.0000)*	-148.9494 *(0.0204)*	0.70
4	16 to 32	-485.83 *(0.0000)*	0.1999 *(0.0000)*	-97.1338 *(0.0003)*	0.81
5	32 to 64	-503.90 *(0.0000)*	0.2018 *(0.0000)*	-63.7730 *(0.0164)*	0.83

Table A3

Net Export coefficient estimates from equation (5), with *(p-values)*

$$NX_{j;k} = \beta_{NX,j,0} + \beta_{NX,j,1}\, NX_{j,k-1} + \beta_{NX,j,2}\, Y^{US}_{j,k-1} + \beta_{EX,j,3}\, Y^{f}_{j,k-1} + \beta_{NX,j,4}\, RER_{j,k-1} + \beta_{NX,j,5}\, RER_{j;k-2} + \omega_{EX\ j,k-1}$$

j	*Quarters*	$\beta_{NX,j,0}$	$\beta_{NX,j,1}$	$\beta_{NX,j,2}$	$\beta_{NX,j,3}$	$\beta_{NX,j,4}$	$\beta_{NX,j,5}$	R^2
1	2 to 4	69.02 *(0.4762)*	0.9716 *(0.0000)*	-0.0229 *(0.0052)*	0.02 *(0.0071)*	1.02 *(0.7415)*	-2.1956 *(0.4663)*	0.977
2	4 to 8	72.22 *(0.4259)*	0.9732 *(0.0000)*	-0.0199 *(0.0119)*	0.02 *(0.0186)*	3.83 *(0.3395)*	-4.9196 *(0.2068)*	0.980
3	8 to 16	139.56 *(0.1001)*	0.9830 *(0.0000)*	-0.0128 *(0.1067)*	0.01 *(0.1895)*	4.17 *(0.1959)*	-5.5679 *(0.0752)*	0.984
4	16 to 32	60.89 *(0.4817)*	0.9717 *(0.0000)*	-0.0191 *(0.0268)*	0.02 *(0.0496)*	0.74 *(0.7744)*	-1.6289 *(0.5134)*	0.980
5	32 to 64	-27.35 *(0.7130)*	0.9282 *(0.0000)*	-0.0252 *(0.0007)*	0.03 *(0.0014)*	0.58 *(0.8215)*	-0.9000 *(0.7212)*	0.965

Table A4

Real Exchange Rate coefficient estimates from equation (6), with *(p-values)*

$$RER_{j;k} = \beta_{RER,j,0} + \beta_{RER,j,1}\, ir^{US}_{j,k-1} + \beta_{RER,j,2}\, ir^{f}_{j,k-1} + \beta_{RER,j,3}\, RER_{j;k-1} + \omega_{RER\ j,k-1}$$

j	*Quarters*	$\beta_{RER,j,0}$	$\beta_{RER,j,1}$	$\beta_{RER,j,2}$	$\beta_{RER,j,3}$	R^2
1	2 to 4	5.3773 *(0.0000)*	0.3226 *(0.0035)*	-0.1664 *(0.1026)*	0.9402 *(0.0000)*	0.976
2	4 to 8	4.4362 *(0.0000)*	0.3598 *(0.0000)*	-0.2201 *(0.0048)*	0.9505 *(0.0000)*	0.987
3	8 to 16	5.0791 *(0.0000)*	0.4059 *(0.0000)*	-0.2447 *(0.0058)*	0.9434 *(0.0000)*	0.985
4	16 to 32	5.7034 *(0.0000)*	0.5318 *(0.0000)*	-0.3428 *(0.0006)*	0.9371 *(0.0000)*	0.980
5	32 to 64	6.3675 *(0.0000)*	0.5775 *(0.0000)*	-0.4015 *(0.0001)*	0.9318 *(0.0000)*	0.972

Table A5

Inflation coefficient estimates from equation (7), with *(p-values)*

$$inf_k = \beta_{inf,0} + \beta_{inf,1}\, inf_{j,k-1} + \beta_{inf,2}\,(Y_{k-1} - Y^*_{k-1}) + \beta_{inf,3}\, RER_{k-1} + \beta_{inf,4}\, MS_{k-1} + \beta_{inf,5}\, inf_{k-2} + \omega_{inf,k-1}$$

	$\beta_{inf,0}$	$\beta_{inf,1}$	$\beta_{inf,2}$	$\beta_{inf,3}$	$\beta_{inf,4}$	$\beta_{inf,5}$	R^2
Coefficient	0.002614	1.454326	0.000017	-0.000117	0.023288	-0.498588	0.96
(p-value)	*(0.9938)*	*(0.0000)*	*(0.7940)*	*(0.9743)*	*(0.1613)*	*(0.0000)*	

Table A6

Real Money Growth coefficient estimates from equation (8), with *(p-values)*

$$MS_k - inf_k = \beta_{MS,0} + \beta_{MS,1}\,(ir^{US}_{k-1} - inf_{k-1}) + \beta_{MS,2}\,(Y_{k-1} - Y^*_{k-1}) + \beta_{MS,3}\,(MS_{k-1} - inf_{k-1}) + \beta_{MS,4}\,(MS_{k-2} - inf_{k-2}) + \omega_{inf,k-1}$$

	$\beta_{MS,0}$	$\beta_{MS,1}$	$\beta_{MS,2}$	$\beta_{MS,3}$	$\beta_{MS,4}$	R^2
Coefficient	0.458430	-0.043637	0.000016	1.374078	-0.507528	0.87
(p-value)	*(0.0004)*	*(0.2548)*	*(0.9121)*	*(0.0000)*	*(0.0000)*	