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Abstract: This paper shows that *announced credible disinflations under inflation targeting* lead to a boom in a standard New Keynesian model (i.e. a disinflationary boom). This finding is robust with respect to various parameterizations and disinflationary experiments. Thus, it differs from previous findings about *disinflationary booms under monetary targeting*.

Keywords: Disinflation, Disinflationary Boom, Inflation Targeting
JEL codes: E30, E31

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1 Introduction

Ball (1994) shows in an influential theoretical paper that an announced credible disinflation leads to a boom in a New Keynesian model (NKM) under monetary targeting (i.e. a central bank that controls the money supply). By contrast, disinflations in reality are associated with major output losses. Disinflationary booms have thus been considered as one of the major weaknesses of this model class (e.g. Mankiw 2001 and Mankiw and Reis 2001). However, follow-up research has shown that disinflationary booms under monetary targeting may disappear when money demand is interest sensitive (Ascari and Rankin 2002).

In the last decades, monetary policy in most OECD countries has moved from monetary targeting to inflation targeting (i.e. central banks follow interest rate rules with an inflation target). This paper considers the effects of an announced credible disinflation in a NKM with a Taylor interest rate rule. It is first to show that *disinflationary booms* are a robust feature of small-scale NKMs *under inflation targeting*.

2 Model and Disinflation Experiment

I use a standard small-scale NKM where prices are set according to Calvo (1983).[1] All findings are established in a full nonlinear setting to prevent biases due to the loglinearization (Ascari and Merkl, 2009). See the Appendix for the full set of nonlinear equations.

The central bank follows a Taylor interest rate rule. The nonlinear version is:

$$\left(\frac{1+i_t}{1+\bar{\imath}_t}\right) = \left(\frac{\pi_t}{\bar{\pi}_t}\right)^{\phi_\pi}, \tag{1}$$

i.e. the central bank targets a certain steady state inflation rate $\bar{\pi}_t$. It reacts to positive (negative) deviations of the actual inflation rate π_t from its target by changing the actual nominal interest rate i_t above (below) the natural rate of interest $\bar{\imath}_t$. The weight on inflation is denoted by ϕ_π (with $\phi_\pi > 1$ to ensure that the Taylor principle holds). The more aggressive the central bank reacts to inflation, the larger is ϕ_π. For simplicity

[1] No indexation is assumed. The robustness with respect to this assumption will be discussed at the end of Section 3.

and illustration purposes, I do not include output in the Taylor rule. However, including empirically plausible output coefficients leaves the main result of this paper unaffected.

An announced disinflation means that the central bank will reduce its inflation target to a lower level in the future (in period $t + x$), while following the old inflation target from period t to $t + x - 1$. There is no credibility problem, i.e. rational economic agents trust the central bank and it actually implements the policy in period $t + x$. In my numerical exercise, I use the Newton-Raphson algorithm proposed by Boucekkine (1995) and Laffargue (1990).

3 Baseline Results and Robustness

In the baseline specification, I parameterize the model with standard values (see the Appendix for a table). The subjective discount factor β is set to 0.99. Utility is separable in consumption and leisure. The utility is logarithmic in consumption and the disutility of labor is quadratic. The elasticity of substitution for different goods types under monopolistic competition is equal to 10 (i.e. the average mark-up is 11 percent). The Calvo non-readjustment probability is equal to 75 percent per quarter (i.e. the average price duration is one year). The production function is assumed to be linear in labor. The weight on inflation in the Taylor rule is 1.5. I assume a disinflation from 1 percent annual inflation to zero percent because this leaves the steady state almost unaffected. It turns out that this normalization is irrelevant but useful for illustration purposes. In the baseline scenario, I assume that the inflation is announced four quarters before it is actually implemented.

Figure 1 shows the model economy's reaction to this disinflationary experiment. Period 0 depicts the old steady state before the disinflation announcement. The central bank announces in period 1 that it will lower its inflation target from period 5 onwards. What is the intuition for the rise in output (i.e. the disinflationary boom), which amounts to a peak effect of almost one quarter percentage point of GDP?

Firms anticipate the lower inflation rate in the future and start adjusting to this new policy once they learn about it in period 1. Those firms that are allowed to adjust their prices according to the Calvo mechanism therefore raise them by less than in the absence of the announced disinflation policy. Equation (2) illustrates the underlying

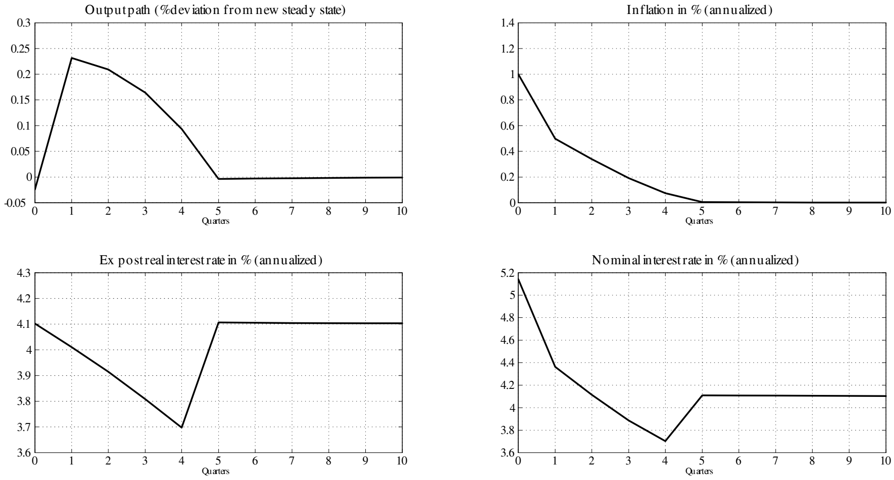

Figure 1: Announced disinflation from 1% to 0% steady state inflation. Announcement in period 1, changed inflation target in period 5.

mechanism.

$$P_{i,t} = \left(\frac{\varepsilon}{\varepsilon - 1}\right) \frac{E_t \sum_{j=0}^{\infty} \theta^j \Delta_{t,t+j} P_{t+j}^{\varepsilon} Y_{t+j} MC_{i,t+j}^{r}}{E_t \sum_{j=0}^{\infty} \theta^j \Delta_{t,t+j} P_{t+j}^{\varepsilon-1} Y_{t+j}}. \tag{2}$$

The optimal price $P_{i,t}$ of those firms that can readjust is a mark-up $\frac{\varepsilon}{\varepsilon-1}$ over the expected future nominal marginal costs,[2] weighted with the stochastic discount factor $\Delta_{t,t+j}$ and the Calvo non-adjustment probability θ. There is a direct and an indirect effect under announced disinflations. The lower future inflation target leads to a smaller growth rate of nominal marginal costs as soon as the disinflation is implemented. This affects the price setting behavior directly. Since firms anticipate this and adjust to it before the central bank shifts the inflation target, this indirect effect dampens prices and nominal marginal costs immediately and has a further moderating effect on inflation.

Since the central bank still follows its old inflation target at the time of the announcement and the natural interest rate still remains at its old level due to the Taylor rule, the more moderate inflation leads to a reduction of nominal interest rates. This

[2] The nonlinear expression contains aggregate prices P, aggregate output Y and firm-specific real marginal costs $MC_{i,t+j}^{r}$. The dependence on future marginal costs is easier to see in the log-linearized equation: $\hat{p}_{i,t} = (1 - \beta\theta) E_t \sum_{j=0}^{\infty} \beta\theta \hat{mc}_{t+j}^{n}$, where hatted variables refer to log-deviations from the steady state and ^{n} refers to the nominal marginal costs.

generates a lower real interest rate[3] and stimulates consumption (according to the Euler consumption equation), i.e. it creates a disinflationary boom.

A few words are in order why inflation converts back to the new steady state (almost) immediately when the new inflation target is implemented. The reason is straightforward in the linearized version of the small-scale NKM where the dynamic system only contains forward looking variables (i.e. no state variables). Thus, the dynamic system has no endogenous persistence and converges back to the steady state once the central bank implements the new inflation target.[4]

The intuition for disinflationary booms is similar to Ball's (1994) reasoning under monetary targeting. At the time of the announcement, the nominal money supply growth remains unaffected, but prices start growing at a slower pace (due to the anticipation effects of price setters as illustrated by equation (2)). Thus, the real money supply increases, leading to a boom. However, there is one major difference. Ball's result can be reversed if the interest rate sensitivity of money demand is sufficiently large (Ascari and Rankin 2002). In this case, an announced disinflation also raises the money demand due to lower nominal interest rates (i.e. the opportunity costs of holding money falls). This money demand effect may overturn the money supply effect. Thus, under monetary targeting, it is an empirical question which of these effects dominates. However, under inflation targeting there is no comparable countervailing effect because the money demand is irrelevant for the outcomes in the economy.

To illustrate the robustness of this disinflationary boom result, Figure 2 shows that disinflationary booms occur under various parameterizations and disinflation experiments. The upper left panel shows the magnitude of the disinflationary boom under different initial steady state inflation rates. The larger the initial steady state inflation rate, the larger is the disinflationary boom. A stronger announced disinflation leads to a stronger reduction of inflation during the anticipation period, thereby reduces nominal and real interest rates by more and stimulates consumption more substantially.[5] The

[3] Due to the Taylor principile ($\alpha_\pi > 1$), the central bank reduces the nominal interest more than proportionally relative to the lower inflation. Note that real the interest rate in Figure 1 is the ex post interest rate , i.e. calculated based on the realized nominal interest rate and the realized inflation (not the ex ante expected values).

[4] In the full nonlinear setting, the price dispersion is a state variable and thus generates a tiny deviation from steady state after the implementation of the new inflation target (see Figure 1).

[5] Note that the steady state shift of output is more severe with a larger initial steady state inflation

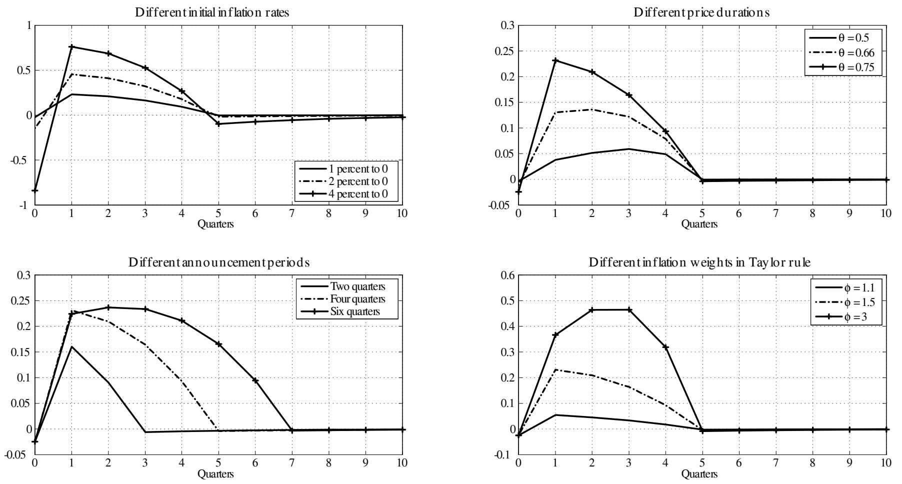

Figure 2: Output deviations (as percent of new steady state) under different parameterizations and disinflation experiments.

lower left panel shows the model reaction when disinflation is announced 2 or 6 periods in advance instead of 4 periods. The longer the announcement period, the stronger is the boom. A longer annoucement period means that the central bank implements the lower inflation via its Taylor rule at a later stage, while inflation drops from the time of announcement. Thus, it leads to a longer time period with lower real interest rate and a prolonged boom. The upper right panel shows the output response when the Calvo parameter is reduced to 0.5 and 0.66 (i.e. an average price duration of 2 and 3 quarters respectively), as price adjustments may be more frequent in times of disinflations. The quantitative magnitude of the disinflationary boom is reduced because future periods obtain a smaller weight in equation (2). However, output gains remain. And the lower right panel shows the response under a different Taylor rule parameter (namely, 1.1 and 3 instead of 1.5). The more aggressive the central bank reacts to inflation, the stronger is the disinflationary boom. Since the inflation is reduced, before the inflation target moves, this leads to a stronger immediate interest rate reduction by the central bank.

Variations of the other parameters (e.g., different degrees of risk aversion, the convexity of the disutility of labor, decreasing returns to labor, a different elasticity of

rate. Price dispersion effects generate inefficiencies in the nonlinear framework and thus reduce output. See e.g. Graham and Snower (2008) for a more detailed discussion.

substitution) also do not overturn the key result and are available on request.

Given that there is some micro and macro evidence for a moderate degree of backward looking behavior, it is worthwhile to check how robust my result is in this dimension. Based on microeconomic datasets Altissimo et al. (2006) argue that roughly one third of firms behave in backward looking manner.[6] Smets and Wouters (2007) estimate a degree of indexation of roughly one quarter in their medium-scale DSGE model. When I amend the disinflation experiment by partial indexation, either to past or trend inflation[7], this reduces the quantitative size of a disinflationary boom (results available on request). But for degrees of partial indexation up to roughly 50%, the disinflationary boom has a very similar qualitative shape as in the baseline scenario.[8] The intuition is that the inflation reduction after the disinflation announcement is somewhat more sluggish because firms who cannot adjust their prices follow the backward looking rule. This generates a countervailing effect to those firms who can adjust prices. Thus, according to the Taylor rule, the central bank cuts nominal interest rates by less and the boom is somewhat smaller. Overall, realistic moderate degrees of partial indexation do not overturn the key result of the paper.

4 Conclusion and Outlook

This paper shows that disinflationary booms under inflation targeting are a robust model feature of small scale NKMs. In the worst case, this paper provides yet another model technical artifact that remains to be solved. Ascari and Repelo (2012) have recently shown that a medium-scale DSGE model with Calvo-price setting and wage contracts and indexation on lagged inflation for firms (wage setters) which cannot re-optimize their

[6] This is evidence for the euro zone. Given the more flexible US product markets, this may be an upper bound for the US.

[7] Trend inflation refers to the old target inflation, i.e. firms that cannot adjust according to the Calvo mechanism partially update their old price, namely $P_{i,t} = \bar{\pi}^{\xi} P_{i,t-1}$, where ξ is the degree of partial indexation. The Appendix incorporates partial indexation to trend inflation. The equations for indexation to past inflation are available on request. Indexing to the new trend inflation (which is zero) would generate the same results as the baseline model.

[8] Even for somewhat larger degrees of partial indexation, the model generates a disinflationary boom (i.e. the key result of this paper is sustained), followed by a recession before the implementation of the new inflation target. For example, with an indexation of 75% to the old trend inflation, boom and bust have roughly the same size. The boom only disappears (or is negligible) with (almost) full indexation.

prices (wages) does a reasonable job to replicate the sacrifice ratios for an *unannounced* disinflation. However, they point out that their result hinges heavily on the degree of indexation, which may not be a stable feature under disinflations. Recently, Bloch (2013) proposed free-entry of firms as a mechanism to generate output losses in the short run in a small NKM in the nonlinear version of the NKM under *unannounced* disinflations. It is certainly an interesting empirical question whether indexation, free entry of firms or other mechanisms play a quantitatively important role under disinflations.

In the best case, this paper points out a way how to prevent or to minimize output losses under a disinflation, namely a credible *announcement* of disinflations in an inflation targeting regime. There is indeed empirical evidence showing that disinflations are actually less costly under inflation targeting than under monetary targeting (Gocalvez and Carvalho 2009). But to the best of my knowledge, there is no case study about credibly *announced disinflations* under inflation targeting yet.

Given that the recent unconventional monetary policies may lead to inflationary pressures in the future, disinflations may be back on central bankers' agenda soon. This paper hints towards many open questions.

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Appendix: Model Equations and Parameters

$$\frac{1}{Y_t^{\sigma}} = \beta E_t \left[\left(\frac{1}{\pi_{t+1}} \right) (1 + i_t) \left(\frac{1}{Y_{t+1}^{\sigma}} \right) \right]. \tag{3}$$

$$\frac{W_t}{P_t} = N_t^{\varphi} Y_t^{\sigma}. \tag{4}$$

$$N_{i,t}^{d} = Y_{i,t}^{\frac{1}{1-\alpha}}. \tag{5}$$

$$MC_{i,t}^{r} = \frac{1}{1-\alpha} \frac{W_t}{P_t} \left[\left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon} Y_t \right]^{\frac{\alpha}{1-\alpha}}. \tag{6}$$

$$P_{i,t} = \left(\frac{\varepsilon}{\varepsilon - 1} \right) \frac{E_t \sum_{j=0}^{\infty} \theta^j \frac{Y_{t+1}^{-\sigma}}{Y_t^{-\sigma}} P_{t+j}^{\varepsilon} Y_{t+j} MC_{i,t+j}^{r} \bar{\pi}_{t+j}^{-\varepsilon \xi j}}{E_t \sum_{j=0}^{\infty} \theta^j \frac{Y_{t+1}^{-\sigma}}{Y_t^{-\sigma}} P_{t+j}^{\varepsilon - 1} Y_{t+j} \bar{\pi}_{t+j}^{(1-\varepsilon)\xi j}}. \tag{7}$$

$$1 = \left[\theta \left(\bar{\pi}_t^{(1-\varepsilon)\xi} \right) \pi_t^{\varepsilon - 1} + (1 - \theta) \left(\frac{P_{i,t}}{P_t} \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}. \tag{8}$$

$$N_t = Y_t^{\frac{1}{1-\alpha}} \int_0^1 \left[\left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon} \right]^{\frac{1}{1-\alpha}} di = s_t Y_t^{\frac{1}{1-\alpha}}. \tag{9}$$

$$s_t = (1 - \theta) \left[\frac{P_{i,t}}{P_t} \right]^{-\frac{\varepsilon}{1-\alpha}} + \theta \left(\frac{\pi_t}{\bar{\pi}_t^{\xi}} \right)^{\frac{\varepsilon}{1-\alpha}} s_{t-1}. \tag{10}$$

$$\left(\frac{1 + i_t}{1 + \bar{\imath}_t} \right) = \left(\frac{\pi_t}{\bar{\pi}_t} \right)^{\phi_\pi}. \tag{11}$$

Endogenous variables: $i, MC, N, P_i, P, s, W, Y, \pi$

Exogenous variables: $\bar{\imath}, \bar{\pi}$ due to the disinflation

Parameters: see table for baseline specification

Parameter	**Meaning**	**Value**
β	Subjective discount factor	0.99
ε	Elasticity of substitution	10
φ	Quadratic disutility of labor	1
σ	Logarithmic consumption utility	1
θ	Calvo-non-adjustment prob.	0.75
α	Constant returns to labor	1
ϕ_π	Central bank weight on inflation	1.5
ξ	Degree of partial indexation	0