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Trend inflation, firms' backward-looking behavior, and inflation gap persistence☆

Insu Kim [a], Myung-Soo Yie [b,*]

[a] Department of Economics, Sungkyunkwan University, Seoul, South Korea
[b] Economic Research Institute, the Bank of Korea, South Korea

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ABSTRACT

In the macroeconomics literature, it is often believed that inflation persistence can be attributed to variations in the Federal Reserve's long-run inflation target rather than to firms' backward-looking pricing behavior. With this in mind, this paper investigates the need for a role of firms' backward-looking behavior in accounting for inflation persistence after trend inflation is eliminated from the inflation rate. Our findings are twofold. First, the observed low contemporaneous correlation and reverse dynamic correlation between the output gap and the inflation gap cannot be replicated by a standard dynamic stochastic general equilibrium (DSGE) model incorporating the purely forward-looking New Keynesian Phillips Curve (NKPC) and trend inflation. When the NKPC is replaced with its hybrid version, the DSGE model does provide a reasonable description of the observed joint dynamic correlation between the output and the inflation gaps. Second, the second moments of key macroeconomic variables are best explained by the hybrid NKPC emphasizing both firms' forward- and their backward-looking behaviors. These results dispute the view that trend inflation is able to replace the role of firms' backward-looking behavior in generating inflation persistence.

1. Introduction

A large body of literature has employed the hybrid New Keynesian Phillips Curve (NKPC) to study monetary policy and business cycles. However, there is still disagreement on the issue of intrinsic inflation persistence introduced by Fuhrer and Moore (1995). The survey papers of Schorfheide (2008) and Mavroeidis et al. (2014) find that the estimates of the hybrid NKPC differ substantially across different papers. In particular, Mavroeidis et al. (2014), in their survey of more than 100 papers, discover that the estimates of the weight of inflation expectations in the hybrid NKPC based on a broad range of estimation techniques used in the literature are distributed very widely, between minus one and plus two, rather than being centered around a particular point. This makes it clear that the literature has not reached any conclusion on the importance of inflation persistence in accounting for the inflation dynamics.

In the recent literature, the hypothesis that inflation persistence is a consequence of variations in the Fed's long-run inflation target (equivalently, trend inflation) has gained attention. However, there is still no consensus on estimation of the hybrid NKPC even after the trend inflation component is eliminated from inflation. Ireland (2007) estimates a dynamic stochastic general equilibrium (DSGE) model incorporating the Federal Reserve's long-run inflation target, and finds that the lagged inflation term of the hybrid NKPC does not play any role in explaining the inflation dynamics. Cogley and Sbordone (2008) also document evidence showing that there is no need for the lagged inflation term once the low frequency component is eliminated from the inflation rate. Their results imply that the level of inflation is persistent, but the deviation of inflation from its long-run trend is not. In contrast to these works, Barnes et al. (2011) report, based on Monte Carlo exercises, that the empirical results of Cogley and Sbordone (2008) are not only sensitive to the model specifications but also biased toward the forward-looking component.

This article examines whether firms' backward-looking pricing behavior is a feature essential to accounting for the dynamics of the inflation gap, defined as the deviation of inflation from its trend. We do not attempt to re-estimate the hybrid NKPC, as the results of hybrid NKPC estimation are highly controversial. We instead evaluate the purely forward-looking NKPC and its hybrid variants with respect to their ability to match the observed joint dynamic behavior between the output and inflation gaps. This evaluation is required given that the essential role of the Phillips curve is providing a plausible description of this behavior. We also investigate whether the purely forward-looking NKPC and its hybrid variants are able to match the standard deviations of key macroeconomic variables, since a model's ability to match the

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* Corresponding author.
E-mail addresses: insu.kim@skku.edu (I. Kim), yie@bok.or.kr (M. Yie).

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second moments of key macroeconomic variables is often considered in the literature to be a crucial criterion for empirical success.

Our findings are twofold. First, firms' backward-looking behavior is an element essential to accounting for the observed dynamic correlation between the output and the inflation gaps, while trend inflation as a source of inflation persistence is not. The data show that the current output gap is related positively to the future inflation gap and negatively to the lagged inflation gap. This reverse dynamic correlation structure cannot be replicated by a standard DSGE model incorporating the purely forward-looking NKPC and trend inflation. We also demonstrate that the DSGE model generates an unrealistically high contemporaneous correlation between the output gap and the inflation gap, while the contemporaneous correlation found in the data is very close to zero. In contrast to the purely forward-looking NKPC model, its hybrid variants perform well in accounting for the observed reverse dynamic correlation as well as the contemporaneous correlation between the output and the inflation gaps. The poor performance of the purely forward-looking NKPC model is ascribed to its inability to generate the slow and delayed impact of the output gap on the inflation gap. Second, we find that the moments of key macroeconomic variables are best explained by the hybrid NKPC in which both forward- and backward-looking behaviors play crucial roles in determining the inflation gap dynamics. These results disagree with the view that there is no need for the lagged inflation term in the hybrid NKPC when trend inflation is eliminated from the inflation rate. Our findings are robust to a variety of output gap and inflation gap measures.

The remainder of this paper is organized as follows. Section 2 explains the trend inflation estimates that are used to measure the inflation gap. We then estimate the DSGE model and conduct simulation exercises to investigate how the backward-looking component helps to explain the observed moments of key macroeconomic variables and the dynamic correlation between the output and the inflation gaps. The last section concludes.

2. Sources of inflation persistence: trend inflation versus lagged inflation

Galí and Gertler (1999) point out that the current output gap is positively linked to future inflation while being negatively associated with past inflation. The hybrid NKPC is able to account for this (Smets and Wouters, 2007). On the other hand, as shown in Chauvet et al. (2015), the purely forward-looking NKPC cannot replicate the reverse dynamic correlation.

In this section, we explore this issue further, and then demonstrate that the reverse dynamic correlation between the output gap and inflation is still observed even after the low frequency component is eliminated from inflation. To this end, we study whether the observed reverse dynamic correlation can be successfully replicated by a New Keynesian DSGE model incorporating the (hybrid) NKPC and trend inflation. Our work here is in response to the previous studies finding inflation persistence to be driven mainly by the Fed's long-run inflation target rather than firms' backward-looking pricing behavior.

2.1. Trend inflation measures, and joint dynamic behavior of output and inflation gaps

Statistical models are often used instead of DSGE models to estimate trend inflation, since the estimates vary with the Phillips curve specifications and their coefficients are not robustly identified in DSGE models (see Ireland, 2007, and Schorfheide, 2008). As in Cogley and Sargent (2005) and Cogley and Sbordone (2008), trend inflation can be estimated using a Bayesian Vector Autoregression (VAR) model with drifting coefficients. An alternative way to measure trend inflation is to use the Unobserved Components (UC) model adopted by Stock and Watson (2007), in which inflation is decomposed into a trend component and a serially uncorrelated innovation. However, as Ascari and Sbordone (2014) point out, this approach is "unsuitable" for the study of inflation gap persistence because the assumption of serially uncorrelated innovation implies no persistence in the inflation gap. In this respect, the Bayesian VAR model with drifting coefficients has an advantage over the UC model for the study of inflation gap persistence.

Recently Chan et al. (2016); Kim et al. (2014), and many others have embedded a cyclical component that shows some serial correlation in their UC models. This model framework is compatible with existing macroeconomic models in which inflation is determined by a cyclical component such as the output gap (or the labor share of income).

This article studies the dynamics of inflation using Cogley and Sbordone (2008)'s trend inflation measure as a benchmark. For robustness check, we consider an alternative trend inflation measure based on a UC model with a cyclical component. The Unobserved Component model is described by

$$\begin{bmatrix}\pi_{t,\mathrm{GDP}}\\ \pi_{t,\mathrm{NFB}}\end{bmatrix}=\begin{bmatrix}1 & 1\\ 1 & 1\end{bmatrix}\begin{bmatrix}\pi_t^*\\ c_t\end{bmatrix}+\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}\begin{bmatrix}\epsilon_{t,\mathrm{GDP}}\\ \epsilon_{t,\mathrm{NFB}}\end{bmatrix} \tag{1}$$

$$\begin{bmatrix}\pi_t^*\\ c_t\end{bmatrix}=\begin{bmatrix}1 & 0\\ 0 & \kappa\end{bmatrix}\begin{bmatrix}\pi_{t-1}^*\\ c_{t-1}\end{bmatrix}+\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}\begin{bmatrix}\epsilon_t^{\pi^*}\\ \epsilon_t^{c}\end{bmatrix} \tag{2}$$

This paper adopts inflation measures based on the GDP deflator and the non-farm business sector (NFB) deflator. $\pi_{t,\mathrm{GDP}}$ ($\pi_{t,\mathrm{NFB}}$) represents the rate of GDP (NFB) inflation. The trend inflation component π_t^* follows a driftless random walk process, and c_t represents a cyclical component of inflation that follows an AR(1) process with the autoregressive parameter κ. We assume that the trend inflation component as a proxy of the Fed's long-run inflation target is common to the GDP and NFB inflation rates. We also treat the cyclical component c_t as being common to the inflation rates, because the individual prices for the NFB deflator constitute a subset of all prices for the GDP deflator, and the transitory price movements of the farm sector are less likely to be associated with business cycles. $\epsilon_{t,\mathrm{GDP}}$ ($\epsilon_{t,\mathrm{NFB}}$) captures both a component specific to the GDP (NFB) inflation rate and its measurement errors. We assume that $\epsilon_{t,\mathrm{GDP}}$ ($\epsilon_{t,\mathrm{NFB}}$) follows a normal distribution with mean zero and standard deviation σ_{GDP} (σ_{NFB}). $\epsilon_t^{\pi^*}$ (ϵ_t^c) denotes an innovation to the trend (cyclical) component with mean zero and standard deviation σ_{π^*} (σ_c).

We estimate the UC model using the method of maximum likelihood. The interior solution that maximizes the log-likelihood function is obtained using the Marquardt algorithm. The sample starts in 1960 and ends in 2003. For comparison, we focus on the same sample period considered in Cogley and Sbordone (2008). The parameter κ is estimated to be 0.763 with standard error 0.144. The estimates of σ_{π^*}, σ_c, σ_{GDP}, and σ_{NFB} are 0.244, 0.533, 0.245, and 1.046, respectively.[1] The log-likelihood value is −561.2.

The top panel of Fig. 1 depicts GDP inflation (solid line), NFB inflation (dashed line), Cogley and Sbordone's estimate of trend inflation (line with circles), that estimate's 90% credible sets (dash-dot lines), the trend inflation estimate from the UC model (line with crosses), and the trend component of GDP inflation based on the Hodrick-Prescott (HP) filter (dotted vertical line). The panel shows that GDP inflation is very closely related to NFB inflation. The correlation between them is 0.93. Cogley and Sbordone (2008)'s estimate shows a rising trend inflation in the 1960s and 1970s and a declining trend in the 1980s. Trend inflation becomes quite flat in the 1990s and the early 2000s.[2] The 90% credible sets of Cogley and Sbordone (CS)'s trend inflation indicate that it is measured with substantial uncertainty. It is therefore natural to consider an

[1] The standard deviations of σ_{π^*}, σ_c, σ_{GDP}, and σ_{NFB} are 0.158, 0.146, 0.065, and 0.094, respectively.

[2] Using the combined survey data of Blue Chip and Livingston for ten-year ahead CPI inflation expectations, we find that the correlation between the UC (CS) trend inflation and the survey inflation expectations is 0.97 (0.94). The Blue Chip survey for 10-year inflation expectations is available from 1979:4 to 1991:1, while the Livingston survey for the same inflation expectations starts from 1990:2. We combine these two data sets to compare the correlations between the trend inflation estimates and ten-year ahead inflation expectations. The sample period considered here is 1979:4–2003:4.