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Has trend inflation shifted?: An empirical analysis with an equally-spaced regime-switching model[☆]

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ABSTRACT

This paper proposes a new econometric framework for estimating trend inflation and the slope of the Phillips curve with a regime-switching model. A unique aspect of our approach is to assume equally-spaced regimes. In our baseline model, we specify regimes for the trend inflation at one-percent intervals. This framework serves as a parsimonious trend inflation model, and the estimated probability of the trend inflation being in each regime provides an easily interpretable illustration in policy debate and analysis. An empirical result for the United States shows a considerably stable trend inflation at two percent since the late 1990s. A result for Japan indicates that the trend inflation stayed at zero percent for about 15 years after the late 1990s, and then shifted away from zero percent after the introduction of the price stability target and the quantitative and qualitative monetary easing in 2013.

1. Introduction

A concept of trend inflation is at the core of academic and policy discussions on inflation dynamics. Although the definition of trend inflation varies depending on the context, it is often treated as the private sector's perception about the level at which inflation is expected to prevail in the medium to long run. The trend inflation plays a principal role in various aspects of modern economic models. In particular, under a certain condition, if trend inflation is consistent with the price stability target, the actual inflation rate is expected to converge to the target eventually. Otherwise, the actual inflation rate tends to deviate from the target persistently. In this sense, the deviation of trend inflation from the price stability target serves as a practical and effective measure of whether inflation expectations remain anchored in line with the price stability target.

A number of studies have estimated trend inflation with a wide variety of econometric models.[1] The most important issue in this literature is how to pin down the trend inflation, which is solely an unobservable variable, from realized inflation and other series of economic variable (e.g., Nason and Smith, 2008). A popular approach employs multivariate time series models such as vector autoregressive (VAR) models (e.g., Quah and Vahey, 1995; Claus, 1997; Mertens, 2016). Estimating

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1 A comprehensive survey for this area of study can be found in Faust and Wright (2013) and Ascari and Sbordone (2014).

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trend inflation with the VAR model requires an appropriate restriction that identifies trend inflation from macroeconomic variables. Several existing studies directly use survey data on inflation expectations to estimate trend inflation (e.g., Brissimis and Magginas, 2008; Kozicki and Tinsley, 2012). Alternatively, an unobserved component (UC) model has become a standard approach to estimate trend inflation (e.g., Stock and Watson, 2007; Cecchetti et al., 2007; Kiley, 2008; Clark and Doh, 2014). These studies assume that dynamics of realized inflation can be decomposed into trend and cycle components. In addition, Stock and Watson (2007) propose a stochastic volatility for innovations of the trend and cycle components, resulting in a flexible model for describing various changes in the realized inflation.

Yellen (2017) mentions that the recent shortfall of inflation rates from the two-percent inflation target is a "mystery" in the United States (see also, Cecchetti et al., 2017). This stably low inflation phenomenon has been observed in major advanced economies. Under this environment, there has been a pressing need for an approach that addresses how well the current trend inflation is anchored at the level of inflation target. To this end, this paper proposes a new econometric framework for estimating trend inflation and the slope of the Phillips curve using a regime-switching model. A unique aspect of our approach is to assume equally-spaced regimes. For example, a baseline model specifies regimes for the trend inflation at one-percent intervals. This idea of one-percent intervals for our trend-inflation model is consistent with the tendency for major central banks to use an integer as the inflation target.[2]

This proposed framework serves as a parsimonious trend inflation model. To our knowledge, this paper is the first to explicitly introduce that type of regime-switching model into trend-inflation dynamics. Based on the proposed framework, we can directly address the following policy question: *What is the probability that the current trend inflation is two percent?* The estimated probability of the trend inflation being in each regime provides for an easily interpretable illustration in policy debate and analysis. In addition, the analysis demonstrates that this equally-spaced regime-switching model provides robust estimation regardless the size of intervals. In this paper, we provide empirical evidence on the U.S. and Japan's time series data to illustrate how the proposed model works in practice.

The rest of the paper is organized as follows. In Section 2, we propose the regime-switching trend-inflation model. Section 3 develops an estimation method for the proposed model using the Markov chain Monte Carlo (MCMC) sampling technique. Section 4 provides empirical results on U.S. and Japan's inflation dynamics and forecasting performance of the proposed model. Section 5 concludes.

2. The model

2.1. Phillips curve

We consider a hybrid Phillips curve, where the current inflation rate depends on both the lagged inflation and the trend inflation that reflects inflation expectations.[3] Namely,

$$y_t = \sum_{i=1}^{k} \alpha_i y_{t-i} + \left(1 - \sum_{i=1}^{k} \alpha_i\right) \mu_t + \beta_t x_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_t^2), \tag{1}$$

for $t = 1, \ldots, n$, where y_t is the inflation rate; μ_t the trend inflation; x_t the output gap; β_t the slope of the Phillips curve; and ε_t an error term. The coefficients for the lagged realized inflation, $\alpha = (\alpha_1, \ldots, \alpha_k)$, are assumed to satisfy the condition $\left|\sum_{i=1}^{k}\alpha_i\right| \leq 1$.

To understand the characteristics of the trend inflation in Eq. (1), we consider a steady state where the output gap x_t is zero in Eq. (1). Because the sum of the coefficients of the lagged inflation y_{t-i} and the trend inflation μ_t is unity, it leads to $\lim_{\tau\to\infty} \mathrm{E}_t y_{t+\tau} = \mu_t$, if we assume $\mu_t = \mathrm{E}_t \mu_{t+1}$, which implies that the current trend inflation is an optimal forecast of itself in all future periods. As we will discuss in Section 2.2, the trend inflation μ_t is formalized to satisfy this equation. This implies that the conditional distribution of the realized inflation converges to the current trend inflation. In other words, we can interpret that the trend inflation in Eq. (1) is the level at which inflation is expected to prevail in the long run.

We assume a stochastic volatility (SV) for the error term in (1). The SV has become the standard in macroeconomic time series analysis to address changes in a size of shocks over time, which is widely employed in the literature (e.g., Cogley and Sargent, 2005; Primiceri, 2005; Stock and Watson, 2007). Specifically, we assume that the log-volatility, $h_t \equiv \log \sigma_t^2$, follows the random-walk process:

$$h_{t+1} = h_t + \eta_t, \quad \eta_t \sim N(0, v^2).$$

for $t = 1, \ldots, n-1$.

2 Related to this point, Kamada (2013) uses household survey data in Japan to show that households often express their inflation expectations in integers.

3 For different specifications of hybrid new-Keynesian Phillips curve, see e.g., Cogley and Sbordone (2008) and Kim et al. (2014).