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Autoregression-based estimation of the new Keynesian Phillips curve

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ABSTRACT

We propose an estimation method of the new Keynesian Phillips curve (NKPC) based on a univariate noncausal autoregressive model for the inflation rate. By construction, our approach avoids a number of problems related to the GMM estimation of the NKPC. We estimate the hybrid NKPC with quarterly U.S. data (1955:1–2010:3), and both expected future inflation and lagged inflation are found important in determining the inflation rate, with the former clearly dominating. Moreover, inflation persistence turns out to be intrinsic rather than inherited from a persistent driving process.

1. Introduction

According to the new Keynesian Phillips curve (NKPC), the inflation rate π_t depends linearly on the expected inflation rate next period, $E_t\pi_{t+1}$, and a measure of marginal costs, x_t. This equation is a central building block of modern macroeconomic models, and it can be derived from several sets of microfoundations, although probably most often it is attributed to Calvo's (1983) price-setting model where only a fraction of firms can change prices in a given period (or equivalently, each firm is able to adjust its price with a fixed probability). Incorporating lagged inflation π_{t-1} into this equation has typically been found to improve the empirical fit, and Galí and Gertler (1999) called this augmented equation the *hybrid* NKPC. They showed that this version can be obtained by modifying the assumptions of Calvo's (1983) model such that only some firms that are able to change prices, choose to do so optimally, while the rest use a simple rule of thumb based on recent history of aggregate price behavior.

There is an ongoing debate about the importance of forward-looking behavior in the determination of inflation. The issue is particularly important from the viewpoint of monetary policy whose design depends on the sources of inflation persistence. In empirical studies employing univariate methods (see, e.g., Cecchetti and Debelle, 2006), inflation has invariably been found highly persistent, and this persistence has typically been interpreted as dependence on past inflation in forming expectations and, hence, as evidence against the NKPC. Also, Rudd and Whelan (2005a, 2007), and Nason and Smith (2008a), inter alia, have found little evidence of forward-looking inflation dynamics in analyses based on estimated NKPCs for the U.S. On the other hand, the recent results of Lanne and Saikkonen (2011a) and Lanne et al. (2012a,b) based

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on so-called noncausal autoregressive (AR) models suggest that the persistence in the U.S. inflation results from agents' forward-looking behavior rather than dependence on past inflation. The NKPC estimation results of Galí and Gertler (1999), and Galí et al. (2005), to name but a few, also lend support to the NKPC in the U.S.

The principal econometric method used in single-equation estimation of the NKPC is the generalized method of moments (GMM), where lags of inflation and the marginal cost variable have typically been used as instruments. As already pointed out above, the results have been contradictory. In particular, they seem to strongly depend on the set of instruments and the variable used as a proxy for marginal costs that are not directly observable. Because π_t, π_{t-1}, and x_t included in the NKPC equation cannot act as instruments for π_{t+1}, higher-order dynamics are called for, i.e., inflation should be predictable by higher lags of these variables. Alternatively some other variables could be used as instruments, but it is not easy to find variables with predictive power for inflation (see, e.g., Stock and Watson, 1999, 2009). Nason and Smith (2008a) show that lack of higher-order dynamics gives rise to the problem of weak instruments in estimating the NKPC, resulting in weak identification and strong dependence of the results on the choice of instruments. To avoid these problems, they employ methods robust with respect to weak instruments and find little evidence in favor of the hybrid NKPC in U.S. data.

In addition to the problem of weak instruments, there may be another problem hampering the GMM estimation of the NKPC. Namely, Lanne and Saikkonen (2011b) have recently shown that if any of the time series used as instruments is noncausal, i.e., depends on its future values, the GMM estimator is inconsistent. Moreover, in this case, endogeneity of such an instrument is not reliably revealed by Hansen's (1982) *J* test. Noncausality of inflation found by Lanne and Saikkonen (2011a), and Lanne et al. (2012a,b) thus indicates that using lags of inflation as instruments as is commonly done in the previous literature, is likely to yield misleading results. Lanne and Saikkonen (2011b) also found noncausality very common in a comprehensive data set comprising more than 300 macroeconomic and financial time series, which suggests that finding valid additional instruments for the estimation of the NKPC may be challenging.

In this paper, we introduce a single-equation estimator of the parameters of the NKPC based on a noncausal AR model specified for inflation. As discussed in Section 2 below, identification of noncausality requires non-Gaussian errors, and it is this feature combined with a suitably specified parametric process for the marginal cost variable that facilitates identification. This is different from the GMM where identification is based on a suitable proxy for the marginal cost variable. Hence, our identification is statistical, with the drawback that is does not directly yield an estimate of the coefficient of the marginal cost. On the other hand, we obtain consistent estimates of the coefficients of lagged and expected future inflation that are independent of any selected marginal cost proxy. Furthermore, leaving a marginal cost proxy unspecified, facilitates reverse-engineering of the process driving inflation consistent with the model.

In short, the benefits of the proposed estimation procedure are twofold. First, no instrumental variables are needed, which abolishes the problems of weak and noncausal instruments prevalent in much of the previous literature. Second, we avoid the difficult problem of finding a proxy for the marginal cost as none is needed. As pointed out by Schorfheide (2008), measurement errors pertaining to the marginal cost series can potentially distort the inference about the NKPC parameters in dynamic stochastic general equilibrium (DSGE) models. We expect this problem to be even more severe in the single-equation setup. Indeed, Nason and Smith (2008b) recently compared the estimates of the U.S. NKPC with nine different marginal cost variables and found that most of them were highly insignificant and greatly affected the values of the parameters of interest. Similarly, Rudd and Whelan (2005b) found that neither labor's share of income nor detrended real GDP provide good proxies for the U.S. marginal cost.

With quarterly U.S. data from 1955:1–2010:3, we demonstrate the problems of the GMM mentioned above. For two inflation measures, we find the best-fitting noncausal non-Gaussian AR model. There is strong evidence of deviations from normality of the errors of the estimated AR models. In both cases, the selected model turns out to be mixed, including both lags and leads of inflation. This suggests that both expected future inflation and lagged inflation are important in determining the inflation rate. Estimates of the parameters of the hybrid NKPC based on the noncausal AR models indicate that expected inflation is the dominant factor determining inflation, but backward-looking behavior is not insignificant either. Moreover, inflation persistence is found to follow mostly from agents' forward-looking behavior, while the persistence inherited from the driving variable plays a minor role.

The rest of the paper is structured as follows. Section 2 describes the noncausal AR model of Lanne and Saikkonen (2011a) and discusses model selection. In Section 3, we derive the maximum likelihood estimator of the NKPC based on the selected noncausal AR model for inflation. In Section 4, the empirical results are presented. Finally, Section 5 concludes.

2. Noncausal autoregression

2.1. Model

The starting point of our procedure for estimating the NKPC is an adequate noncausal AR model for inflation, and in this section, we briefly describe the noncausal AR model of Lanne and Saikkonen (2011a).[1] Consider a stochastic process y_t

[1] Alternatively, estimation could be based on the formulation of Breidt et al. (1991). However, as Lanne and Saikkonen (2011a) point out, their model has the advantages that it is straightforward to test for the specified number of leads and lags and inference on the autoregressive parameters and the parameters of the error distribution is asymptotically independent.