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Modifying Taylor reaction functions in the presence of the zero-lower-bound — Evidence for the ECB and the Fed[☆]

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ABSTRACT

We propose an alternative way of estimating Taylor reaction functions if the zero-lower bound on nominal interest rates is binding. This approach relies on tackling the real rather than the nominal interest rate. So if the nominal rate is (close to) zero central banks can influence the inflation expectations via quantitative easing. The unobservable inflation expectations are estimated with a state-space model that additionally generates a time varying series for the equilibrium real interest rate and the potential output — both needed for estimations of Taylor reaction functions. We test our approach for the ECB and the Fed within the recent crisis. We add other explanatory variables to this modified Taylor reaction function and show that there are substantial differences between the estimated reaction coefficients in the pre- and crisis era for both central banks. While the central banks on both sides of the Atlantic act less inertially, put a smaller weight on the inflation gap, money growth and the risk spread, the response to asset price inflation becomes more pronounced during the crisis. However, the central banks diverge in their response to the output gap and credit growth.

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1. Introduction

The reaction of almost all central banks in industrialized countries to the financial crisis was cutting the policy rate aggressively. So also the US Federal Reserve (Fed) and the European Central Bank (ECB) reacted in this manner, although with a different speed. While the Fed cut rates immediately after the first signs of the financial crisis emerged, the ECB did not lower rates until the crisis intensified with the collapse of Lehman Brothers in late 2008. Moreover, the ECB did not lower the rates close to zero as the Fed. Instead it set its target rate to 1%. But this does not make much of a difference since the decisive variable is the interbank lending rate which is significantly lower and takes values closer to the rate of the deposit facility which is set 0.75 percentage points below the rate of the main refinancing operations. Thus, also the room to cut rates for the ECB is limited.

However, if nominal interest rates reach the lower bound of zero, traditional monetary policy which targets the interest rate can no longer be used.[1] Hence, in the recent financial crisis central banks had to find new ways of stimulating the economy. The programs implemented by central banks can be subsumed under the notion of unconventional monetary policy and they cover measures of quantitative and qualitative easing.[2] Using quantitative easing, central banks intend to influence inflation expectations and, by this, also the real interest rate which is generally considered to be the relevant rate for investment and consumption decisions. In this paper, we develop a model which takes this relationship explicitly into account. Moreover, our model generates a time series of potential output and the equilibrium real interest rate which are both time varying and thus needed to estimate Taylor reaction functions precisely. Strictly following McCulley and Toloui (2008) or Tucker (2008), we suspect that there is a break in the equilibrium real interest rate starting with the beginning of the crisis. Hence, holding this variable constant does not appear appropriate within the framework we apply here.

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[1] Iwata and Wu (2006) show that the transmission channel between interest rates and output becomes nonlinear in such a situation.

[2] While quantitative easing refers to programs that expand the central bank's balance sheet, measures of qualitative easing cover a broader range of programs with the goal of e.g. increasing the range of collateral for central bank money or the maintenance period. Since measures of qualitative easing are hard to quantify in our framework, we will only use a measure of quantitative easing here.

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The generated time series will be used in a second step to estimate whether there are significant differences in the reaction coefficients of the ECB and the Fed before and after the crisis begun as Gerlach (2011) suggests. Moreover, we check if other variables can explain the differences in the reactions of monetary policy before and after the crisis started. These additional variables in the spirit of Tucker (2008) are credit and money growth, an interest rate spread variable and (overall) asset price inflation, the latter being represented by stock and real estate price inflation.

The remainder of this paper proceeds as follows. In Section 2 we provide our model that is used to estimate inflation expectations, the equilibrium real interest rate and the potential output. Section 3 explains the modifications needed to model the standard Taylor reaction functions properly in the recent financial crisis. Estimations of the accordingly modified Taylor reaction functions are presented in Section 4. Section 5 concludes.

2. The equilibrium real interest rate and inflation expectations — construction and estimation

In this section we will explain how the time series of the equilibrium real interest rate and the inflation expectations are constructed. For this purpose we will merge two models. The first one is proposed by Laubach and Williams (2003) who estimated a state-space-model for the equilibrium real interest rate using quarterly data.[3] The second model developed by Klose (2011a) estimates a system of equations using a similar specification as Laubach and Williams (2003) but focuses on the estimation of inflation expectations. Moreover, the second model is developed using monthly data, which generates more data in the still short period of the recent financial crisis. We will also rely on this monthly specification but estimate a state-space-model with a time-varying equilibrium real interest rate as Laubach and Williams (2003) did.

To construct our model, we start with the formulation of inflation expectations which consist of observed inflation rates and a measure of quantitative easing. The natural candidate for this is the size of the central banks' balance sheet. We use this measure but specify a so called *balance sheet gap*, represented by the deviation of the balance sheet from its "natural" level. The "natural" or equilibrium balance sheet is constructed by taking the end-of-month size of the balance sheet[4] for each month from 1996M6 to 2008M8 for the Fed and for each month from 1997M9 to 2008M8 for the ECB. The starting dates are chosen in an unbalanced way just according to the criterion of maximum data availability. It seems advisable to us to rely on the longest possible sample period in order not to bias our results by sticking to a shorter period which does not cover the overall trend. However, since the Fed balance sheet size evolved smoothly before the financial crisis started, our results are not influenced by our choice of the sample period. In case of the ECB, the starting date is chosen using balance sheet data provided in the monthly bulletins of the ECB. However, from 1997M9 to 1998M12 the ECB was not yet responsible for the balance sheet in the Euro area. Hence, the ECB balance sheet variable employed by us is a combined measure of the balance sheets of the individual member countries for this short period. However, there is no indication of a break in the time series when the ECB took over responsibility as shown, for instance, by Klose (2011a).

[3] Several other papers have applied this model for various industrial countries. See Clark and Kozicki (2005), Trehan and Wu (2006) for the US, Wintr et al. (2005), Mésonnier and Renne (2007), Garnier and Wilhelmsen (2009) for the euro area and Larsen and McKeown (2004) for the UK.

[4] Since the end of month size of the balance sheet might be influenced by the minimum reserve requirements the financial institutions have to fulfill, we also checked whether there is a bias by comparing this measure to the average size of the balance sheet for each month. However, the results are not altered by this exercise, so we can conclude that there is no bias in taking the end-of-month values.

2008M8 is chosen to be the end date for the construction of the equilibrium balance sheet because from 2008M9 onwards we find ample evidence of quantitative easing of the Fed and the ECB, so the balance sheet expands from its equilibrium value from this time onwards. The expansion of the balance sheet was more pronounced for the Fed since her balance sheet more than doubled immediately after quantitative easing was employed. This stronger response might be due to the fact that the Fed had at this point less room to cut rates any further since interest rates had already approached values of about 2% when quantitative easing started while the ECB interest rate still was at 4%. We estimate a linear trend for the period up to 2008M8 and treat it as the natural level of the balance sheet in our estimations. In order to calculate the balance sheet gap we subtract this measure from the true values for the whole sample period (thus also including data from 2008M9 onwards) using the following formula:

$$b_t = 100\left(\log(balance_t) - \log\left(balance^{T}_{08\,08t}\right)\right), \qquad (1)$$

with b_t being the balance sheet gap, $balance_t$ representing the size of the balance sheet and $balance_{0808}{}^{T}{}_{t}$ as the respective trend value up to 2008M8.

Considering a linear time trend as the "natural level" of the balance sheet implies that the natural level is increasing constantly over time. To get an intuition of this measure, we plot the time series of the time trend and the actual level – their difference corresponds to the balance sheet gap – in a figure for the US and the Euro area, respectively (Figs. 1 and 2).

We feel legitimized to emphasize that it may be hard to reconcile actual inflation expectations with the assumption of rational expectations. At the same time, however, inflation expectations may become increasingly forward-looking precisely because a crisis leads to structural change. In fact, when we compare our estimated inflation expectations with survey data (their results are available on request), it becomes apparent that they perform quite sluggish and overshoot during the crisis. In other words, it seems that agents' inflation expectations seem to be at least in part forward looking during the crisis.

From any survey of the recent empirical literature on the New Keynesian Phillips curve such as Henzel and Wollmershäuser (2008) or Palovita (2008) it may well be concluded that inflation expectations are consistent with some form of 'hybrid' Phillips curve, that is, a Phillips curve that features both a forward-looking and a backward-looking component. If so, we would feel legitimized to argue that our model focuses on the backward-looking component and, at the same time, acknowledge that one could think of other specifications as well. Hence, we link our approach to earlier empirical research on the formation of inflation expectations.[5]

Another argument that supports our specification relies on the fact that we assume that market participants form their inflation expectations knowing the current inflation rate. In a forward-looking model, the current inflation rate should reflect the present-discounted value of the path of future inflation rates. In other words, the current inflation rate is the forward-looking component in our model. This is one more good reason not to push the literature on R.E. models too far aside.[6]

We use the balance sheet gap to estimate inflation expectations which are formed as a weighted average of the current inflation rate and the rate of the preceding eleven months plus the balance sheet gap. So inflation expectations are defined as:

$$\pi^e_t = \frac{1}{12}\sum\nolimits_{i=0}^{11}\pi_{t-i} + c_b b_t, \qquad 2$$

[5] However, estimating a rational expectations model would be valuable but surely necessitate writing a second long paper.

[6] We are grateful for an anonymous referee for raising this issue.

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