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Macroeconomic models and the yield curve: An assessment of the fit

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ABSTRACT

Many have questioned the empirical relevance of the Calvo–Yun model. This paper adds a term structure to three widely studied macroeconomic models (Calvo–Yun, hybrid and Svensson). We back out from observations on the yield curve the underlying macroeconomic model that most closely matches the level, slope and curvature of the yield curve. With each model we trace the response of the yield curve to macroeconomic shocks. We assess the fit of each model against the observed behaviour of interest rates and find limited support for the Calvo–Yun model in terms of fit with the observed yield curve, we find some support for the hybrid model but the Svensson model performs best.

1. Introduction

Many have questioned the empirical relevance of the Calvo–Yun optimising model (see, for example, Rudd and Whelan, 2005). This paper examines the relationship between the yield curve and the macroeconomy using three models that have been widely used to study problems of optimal monetary policy. These models can be derived from intertemporal optimisation by households and firms with imperfect competition in goods markets, nominal rigidities arising from sticky prices and timing conventions. We use these models to solve for the yield curve (see, for example, Ellingsen and Söderström, 2001) and examine their ability to replicate three features of the curve—the level, slope and curvature—calculated from historical data.[1] Our main results suggest that a model that is backward looking in prices and output does best. A model which is entirely forward looking does particularly badly.[2]

The term structure is an important conduit for the transmission of monetary policy to output and inflation. Understanding the yield curve is helpful for both market participants and the monetary authorities since yield curves can provide useful information about underlying expectations of inflation and output over a number of different horizons. Financial economists typically make use of factor models. For example, Knez et al. (1994), Duffie and Kan (1996), and Dai and Singleton (2000) all consider models in which a handful of unobserved factors explain the entire set of yields. By contrast monetary economists attempt to proxy these unobservable factors by macroeconomic conditions (Ang and

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[1] Modern approaches to the study of the yield curve stress the need to focus on these aspects (see Bekaert et al., 2006).

[2] Our results mirror recent research by Rudd and Whelan (2005) that has surveyed and cast considerable doubt on the extent to which purely forward-looking rational expectation sticky price models can match the data. The behaviour of the yield curve can thus be thought of as a diagnostic on the implicit macroeconomic model used by the bond markets.

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Piazzesi, 2003, 2005; Wu, 2006). For example, Diebold et al. (2006) and Hordahl et al. (2008) argue that a joint macro-finance research strategy is likely to provide the most comprehensive understanding of the term structure. Macroeconomists see the short term interest rate as a policy instrument that the Central Bank uses to pursue objectives concerning the price level and output. Financial economists in turn will see the policy rate as a crucial building block for the whole term structure since each yield at a different maturity will be a risk adjusted average of future expected short term rates. Macroeconomics can contribute by providing the basis upon which the Central Bank sets interest rates. We add to this literature by examining how three stylised macroeconomic models, widely used in macroeconomic theory, can replicate key features of the term structure.[3]

We assess the fit of each model in terms of the behaviour of the model-consistent yield curve implied by each of the three macroeconomic models and the actual behaviour of the yield curve. As there is a literature that draws attention to the extent to which the yield curve can be informative about future output and inflation movements (Estrella and Hardouvelis, 1991; Estrella and Mishkin, 1997) we also examine the ability of the artificial (or model consistent) yield curve to predict output and inflation dynamics. In this paper, we show that the predictive capabilities of the yield curve seem to stem from the markets' forward-looking expectations of how the monetary authority will use the short term interest rate to stabilise incipient, or pipeline, inflation and output.

The relationship between the volatility of the short and long term interest rates has also been of continuing interest to economists. In a seminal paper, Shiller (1979) drew attention to an important implication of the expectations model of the term structure, where the long term interest rate is the average of a stream of future expected short rates, the smoothing that this implies should provide limits on the volatility of the long rate. However, Shiller pointed out there appears to be excess volatility in long rates when the data is examined. To some extent, this problem persists in our analysis, as it looks quite difficult to replicate the term structure of volatility with completely forward-looking behaviour. By using a model in which shocks are amplified by an endogenous persistence mechanism the problem appears somewhat less intractable and in this regard we echo a solution offered by Turnovsky (1989, p. 323), who suggested that increasing the relative importance of persistence shocks would help explain 'the apparent excess volatility of long term rates'.

Building on the previous two points, this paper also contributes to the literature on persistence of macroeconomic variables and the need to develop models in which amplification and persistence occur (see, Kocherlakota, 2000). To match the observed mean and volatility of the yield curve, the paper suggests that we need models that generate their own persistence.[4] The mechanism is as follows: with little or no internal propagation of shocks future output and inflation can be stabilised without recourse to persistent interest rate responses and hence future interest rates should display limited volatility. As the propagation mechanism becomes more persistent, a shock will create momentum for future pressure on output and on inflation and hence will require some response and volatility in future interest rates.

The paper is organised as follows. In Section 2 we set out the models we will analyse and the term structure recursion, Section 3 outlines the key stylised facts on macroeconomic data and the yield curve, Section 4 outlines the results, and Section 5 draws some conclusions.

2. Macroeconomic models and the term structure

We take three simple sticky-price macroeconomic models, widely used to study optimal economic policy (Yun, 1996; Svensson, 1999; Amato and Laubach, 2003; Smets and Wouters, 2003; Woodford, 2003). The models that form the basis for the analysis of this paper is the Calvo–Yun model of forward-looking price-setting, the so-called hybrid model and the Svensson model, where inflation responds to monetary policy with a two-period lag. The models have a similar structure in so far as aggregate demand is determined by real short term interest rates, there is a short trade-off between inflation and output, the money market clears endogenously with respect to a policy rule for interest rates and there is a flex–price equilibrium level of output.

The key difference between these models is the timing conventions that output and inflation follow. In the Calvo–Yun set-up, both key variables are forward looking, whereas in the hybrid model both variables have backward- and forward-looking adjustment paths. In the Svensson model, inflation becomes pre-determined and output adjusts to within period shocks gradually. The models are subject to a variance–covariance matrix of standard shocks to aggregate demand, the mark-up, monetary policy and flex–price output.

2.1. Calvo–Yun

The key equations in each model are the aggregate demand and supply equations. For the Calvo–Yun model these are as follows:

$$y_t = E_t y_{t+1} - \sigma(i_t - E_t \pi_{t+1}) + \varepsilon_{A,t} \tag{2.1}$$

[3] Rudebusch and Wu (2008) provide a recent important example of evaluating the correct macroeconomic model to use when understanding the yield curve.

[4] Evans and Marshall (2007) show that persistence captured by interest rate smoothing plays an important role in explaining both the level and volatility of the nominal yield curve.