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An estimated DSGE model: Explaining variation in nominal term premia, real term premia, and inflation risk premia

Martin M. Andreasen*

CREATES, Aarhus University, Fuglesangs Allé 4, 8210 Aarhus V, Denmark

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ABSTRACT

This paper develops a DSGE model which is shown to explain variation in the nominal and real term structure as well as inflation surveys and four macrovariables for the UK economy. The model is estimated based on a third-order approximation to allow for time-varying term premia. We find a fall in nominal term premia during the 1990s which mainly is caused by lower inflation risk premia. A structural decomposition further shows that this fall is driven by negative preference shocks, lower fixed production costs, positive investment shocks, and a more aggressive response to inflation by the Bank of England.

1. Introduction

The nominal term structure reveals expectations about future one-period nominal interest rates and investors' compensation for uncertainty related to interest rates with longer maturities. This compensation is typically referred to as the nominal term premium. The expected nominal one-period interest rate may further be decomposed into a real interest rate and expected inflation. Similarly, the nominal term premium can be split into the real term premium and the inflation risk premium. Decomposing term structure data in this way is often useful for monetary policy. For instance, a central bank pursuing inflation targeting may only raise the policy rate in response to a steepening of the nominal yield structure if this increase is caused by higher inflation expectations and not if it is due to higher nominal term premia.

Several papers have used reduced-form term structure models to study nominal and real interest rates and their term premia.[1] However, little is known about the structural determinants behind the dynamics of these term premia. The contribution of the present paper is to close this gap in the literature by estimating a Dynamic Stochastic General Equilibrium (DSGE) model to carry out a structural decomposition and interpretation of nominal term premia, real term

* Tel.: +45 87165982.
E-mail address: mmandreasendk@gmail.com

[1] A non-exhaustive list includes the work by Barr and Campbell (1997), Evans (1998), Evans (2003), Ang et al. (2008), Christensen et al. (2010), and Joyce et al. (2010).

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premia, and inflation risk premia. We use a New Keynesian DSGE model with Epstein–Zin–Weil preferences, capital accumulation, stochastic and deterministic trends, sticky prices, and a central bank controlling monetary policy based on a Taylor-rule. To allow for time-variation in term premia, the model is solved to third order by the perturbation method. Using UK data, we estimate the model by non-linear filtering methods to match the nominal and real term structure, inflation surveys, and four macrovariables.

To provide the structural interpretation of term premia, we need to overcome a number of challenges. Firstly, it is difficult for DSGE models to reproduce the dynamics of the nominal term structure (see Rudebusch and Swanson, 2008). Matching this aspect of the data is clearly a necessary first step for a reliable decomposition of the information content in term structure data.

Secondly, the mechanisms driving the nominal and real term structure impose substantial requirements on the stochastic discount factor and the DSGE model in general. Broadly speaking, in order to match the real term structure the model should generate levels of future consumption that correspond to the average expectations of investors. The model is also required to generate inflation expectations in line with expectations held by the average investor in order to fit the nominal term structure. Furthermore, we also require that the model reproduces observed time series for consumption and inflation along with inflation expectations from surveys.

Thirdly, the solution to DSGE models must be approximated with non-linear terms in order to generate time-varying term premia, but such approximations are quite time consuming to compute. For instance, Rudebusch and Swanson (2008) report that it takes about 10 min to solve a third-order approximation to their benchmark model. If the model is estimated, hundreds of thousands of function evaluations are necessary and a new model solution must be computed for every evaluation.

Finally, the existing literature uses a normality assumption or a second-order approximation of the stochastic discount factor to decompose the information content in the nominal and real term structure. We cannot apply this decomposition as our model is approximated to third order. Hence, an extension of the current method to decompose term structure data is required.

In an empirical application, the suggested model is estimated on UK data after 1992 when the current inflation targeting regime was initiated. Our focus on the UK economy is motivated by the presence of a large and liquid market for real bonds. We highlight the following results. Firstly, the model generally delivers a satisfying fit to the two term structures while simultaneously matching inflation expectations and four macrovariables. The only exception is the 1-quarter nominal interest rate where relatively large model errors are encountered. In total, we match 17 time series using just 7 structural shocks. Secondly, and as in much of the finance literature, we find a reduction in nominal term premia immediately after inflation targeting was adopted in 1992 and again after the Bank of England became operational independent in 1997. Nominal term premia then rise from 2000 to 2002 but remain at a new lower level until 2006, after which they start to increase. In general, most of the variation in nominal term premia relates to inflation risk within our model. Thirdly, a decomposition of the 10-year inflation risk premium shows that favorable preference and investment shocks contribute to a permanently lower level of inflation risk from 1992 to 2008. Upward pressure on the 10-year inflation risk premium during this period is mainly related to a rise in fixed production costs, possibly due to higher oil and gas prices, and this explains the increase in inflation risk after 2006. We also find that a more aggressive monetary policy to inflation lowers inflation risk premia after inflation targeting in 1992 and operational independence to the Bank of England in 1997. Fourthly, adopting the typical terminology from the finance literature, our model implies a gradual reduction in the market price of inflation risk during the 1990s. We also find that the quantity of inflation uncertainty falls after inflation targeting is adopted in 1992 and again after the Bank of England is given operational independence in 1997. Finally, our estimated model generates a high level of nominal term premia which display notable variation. For the 10-year nominal term premium, the mean level is 92 basis points and its standard deviation is 14 basis points. These model properties are achieved by relying on a high relative risk-aversion for the household through Epstein–Zin–Weil preferences.

The rest of this paper is organized as follows. Section 2 presents our New Keynesian DSGE model which is extended with the nominal and real term structure in Section 3. It is also shown in Section 3 how the information content in these term structures can be used to extract nominal term premia, real term premia, and inflation risk premia. Section 4 discusses how the solution to our model is approximated by a third-order perturbation approach. We estimate the model on UK data and conduct the structural decomposition of term premia in Section 5. Concluding comments are provided in Section 6.

2. The DSGE model

This section presents a DSGE model with the same basic structure as in Smets and Wouters (2007) and Altig et al. (2011), who show that this setup can reproduce several stylized features of a closed economy. Below, we describe the behavior of the three types of agents in this economy: (i) households, (ii) firms, and (iii) a central bank.[2]

[2] As in Ravn (1997), Nelson and Nikolov (2004), DiCecio and Nelson (2007), among others, the UK economy is here modelled as a closed economy.