Journal of Banking & Finance 33 (2009) 934–943

Contents lists available at ScienceDirect

Journal of Banking & Finance

journal homepage: www.elsevier.com/locate/jbf

Testing the expectations hypothesis when interest rates are near integrated

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ARTICLE INFO

Article history:
Received 11 June 2008
Accepted 15 October 2008
Available online 1 November 2008

JEL classification:
C22
G12

Keywords:
Bonferroni tests
Cointegration
Expectations hypothesis
Near integration
Term premium

ABSTRACT

Nominal interest rates are unlikely to be generated by unit-root processes. Using data on short and long interest rates from eight developed and six emerging economies, we test the expectations hypothesis using cointegration methods under the assumption that interest rates are near integrated. If the null hypothesis of no cointegration is rejected, we then test whether the estimated cointegrating vector is consistent with that suggested by the expectations hypothesis. The results show support for cointegration in 10 of the 14 countries we consider, and the cointegrating vector is similar across countries. However, the parameters differ from those suggested by theory. We relate our findings to existing literature on the failure of the expectations hypothesis and to the role of term premia.

Published by Elsevier B.V.

1. Introduction

Empirical tests of the expectations hypothesis of the term structure often fail to find support for the theory. The logic underlying the theory, that expectations of future short interest rates shape the term structure of longer interest rates, is intuitive, appealing, and a common assumption in macroeconomic modelling. However, the predictability of excess returns shown by Fama and Bliss (1987), Campbell and Shiller (1991) and more recently by Cochrane and Piazzesi (2005) undermines the premise that long interest rates are rational expectations of future short rates up to a constant term premium. Rather, such evidence points strongly toward time-varying risk premia. Indeed, Dai and Singleton (2002) demonstrate that interest rates adjusted for time-varying risk premia estimated from dynamic term structure models meet the predictions of the expectations hypothesis in traditional excess-return regressions.

One strand of the empirical literature on interest rates has sought to test the expectations hypothesis using the techniques of cointegration. As pointed out by Engle and Granger (1987) in their seminal paper on cointegration, if nominal interest rates are generated by a unit-root process, cointegration between yields of different maturities is a necessary condition for the validity of the expectations hypothesis. Intuitively, if interest rates are integrated of order one, the expectations hypothesis implies that the spread between any pair of yields is stationary. Following Engle and Granger's early work, several studies have taken a similar path and have found only mixed evidence for the expectations hypothesis; see, for example, Campbell and Shiller (1987), Boothe (1991), Hall et al. (1992), Zhang (1993) and Lardic and Mignon (2004).

It is an empirical fact that nominal interest rates are highly persistent and the poor power of traditional univariate Dickey–Fuller type tests against the null of a unit root (Stock, 1994) has led many researchers to conclude that interest rates are integrated of order one. Moreover, the convenience of working with established results for integrated processes has made it attractive to assume the presence of a unit root for empirical purposes. As such, nominal interest rates have been treated as integrated of order one in numerous empirical papers, including Karfakis and Moschos (1990), Bremnes et al. (2001), Chong et al. (2006), Kleimeier and Sander (2006), De Graeve et al. (2007) and Liu et al. (2008). For theoretical purposes, the unit-root assumption can also be a useful modelling device to capture stylistically the highly persistent nature of interest rates in finite samples, exemplified by Cogley and Sargent's (2001) approach to modelling the dynamics of a system of macroeconomic variables.

However, the exact unit-root assumption for nominal interest rates can be questioned on both empirical and theoretical grounds.

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0378-4266/$ - see front matter Published by Elsevier B.V.
doi:10.1016/j.jbankfin.2008.10.008

Empirically, standard tests for unit roots have difficulty discriminating true integration from highly-persistent dynamics but panel unit-root tests – which tend to be more powerful than univariate tests – tend to find support for mean reversion in nominal interest rates (Wu and Chen, 2001). Theoretically, it might be unsatisfactory to model interest rates as unbounded in the limit.[1] More importantly though, most economic models predict that real interest rates possess a long-run equilibrium value, determined by the long-run rate of potential output growth and population growth, and agents' rate of time preference and risk aversion. Similarly, consumption growth is typically viewed as stationary – albeit slowly mean reverting (Bansal and Yaron, 2004). The standard consumption Euler equation thus implies stationary real interest rates. Nominal interest rates have varied substantially in recent decades, partly reflecting the undulations of inflation expectations, but over the long-run, have wandered within reasonable bounds. Indeed, from an historical perspective, short-term nominal interest rates were in the range of 4–8% during the years of the Roman Empire, and western European commercial and mortgage borrowing rates moved in the 4–8% range from the 13th to 17th century (Homer and Sylla, 1996). Private nominal interest rates are in a similar range today, an outcome that would be virtually impossible if interest rates possessed a unit root but consistent with a highly-persistent data generating process.

Unfortunately, standard cointegration-based inference designed for unit-root data is typically not robust to even small deviations from the unit-root assumption. Results will generally be biased when the autoregressive roots in the data are close, but not identical, to unity; this is true both for actual tests of the cointegrating rank (Hjalmarsson and Österholm, 2007a,b) as well as for inference on the cointegrating vector (Elliott, 1998). Conclusions of empirical tests of the expectations hypothesis that rely on traditional cointegration are therefore called into question. As such, empirical analysis within a framework that acknowledges the high persistence in nominal interest rates but that does not impose the strict assumption of a unit root is desirable but very few examples exist in the literature. To our knowledge, exceptions include one study of the Fisher effect (Lanne, 2001) and one on the term structure of interest rates (Lanne, 2000).

In this paper, we revisit the question of cointegration between yields of different maturities using methods that allow for valid inference when data are near integrated. That is, we assume that interest rates are highly persistent with autoregressive roots that are close to unity. The empirical framework nests the standard unit-root assumption used in the traditional cointegration studies mentioned above, but also permits interest rates to be (slowly) mean reverting. We test for cointegration using the recently developed methods of Hjalmarsson and Österholm (2007a) that are robust to deviations from the pure unit-root assumption and apply the tests to monthly data of the term structure of interest rates in several developed and emerging economies, namely Australia, Canada, Hungary, India, Japan, Mexico, New Zealand, Poland, Singapore, South Africa, Sweden, Switzerland, the United Kingdom and the United States. The results provide strong support for cointegration between long and short interest rates in 10 of these countries. Among the developed countries, results show support for cointegration in Australia, Canada, New Zealand, Sweden, Switzerland and the United States. Among the emerging economies, a similar result is returned for Hungary, Mexico, Poland and Singapore.

Cointegration is only one of two necessary conditions for the validity of the expectations hypothesis; the theory also contains strong predictions about the parameters of the cointegrating vector. However, earlier work has largely overlooked the interpretation of the parameters of the cointegrating vector. We test whether the parameters are consistent with the theoretically-suggested values using an extension of fully-modified estimation that is again robust to deviations from the pure unit-root assumption. Fully modified estimation of cointegrated systems was initially developed by Phillips and Hansen (1990) and discussed by Hjalmarsson (2007) in the context of predictive regressions with near unit-root variables; in the current paper, we extend those ideas further to accommodate inference in a general bivariate cointegrating relationship with nearly integrated variables.[2] For the 10 countries in which cointegration is detected, the cointegrating vector does *not* coincide with that suggested by theory. In each case, long rates move by less than short rates, with the similarity of the estimated vectors across countries hinting at a common explanation. Indeed, the estimated cointegrating vectors suggest that another near-integrated variable that covaries inversely with the short rate also affect the term structure of longer interest rates. This is consistent with time-varying bond risk premia put forward by Campbell and Shiller (1991) and Dai and Singleton (2002) to explain the puzzling patterns of coefficients from yield-spread regressions, and with the countercyclical pattern of excess returns noted by Fama and Bliss (1987) and Cochrane and Piazzesi (2005). We conjecture that the phenomenon underlying the rejection of the expectations hypothesis in excess-return regressions may also be responsible for the failure of the expectations hypothesis in cointegration methods.

The remainder of the paper is organized as follows: Section 2 presents the theoretical framework regarding the term structure of interest rates and the econometric methodology. In Section 3, the empirical analysis is conducted and the results discussed and Section 4 concludes. Some sensitivity analysis is presented in the appendix.

2. Theoretical framework

This section presents the theoretical motivation for our empirical tests. We briefly lay out the expectations hypothesis of the term structure then move on to the econometric methodology of testing for cointegration between near-integrated processes.

2.1. The term structure of interest rates

We begin with a statement of the expectations hypothesis of the term structure similar to that found in Campbell and Shiller (1991):

$$i_t^n = \frac{1}{n}\sum_{j=0}^{n-1} E_t(i_{t+j}^1) + \xi^n. \quad (1)$$

Simply put, the expectations hypothesis posits that the interest rate on a longer-term n-period bond, i_t^n, is equal to the average of the expected path of future one-period interest rates over the life of the

[1] Because nominal interest rates are bounded downward, they cannot strictly be a linear unit-root process with an additive error term fulfilling standard assumptions (Nicolau, 2002). However, the approximation error from making such an assumption is likely to be negligible, and other bounded variables, such as unemployment rates, are often treated as possessing a unit root for this reason. Moreover, the problem of boundedness can be overcome by transforming the series, for example, by taking the natural logarithm of nominal interest rates. A discussion of such transformations can be found in Wallis (1987).

[2] As mentioned above, Lanne (2000) also analyses the term structure of interest rates within a framework of near-integrated processes but takes quite a different approach to that in this paper. He applies a joint test of cointegration and the value of the cointegrating vector(s) to US term structure data, whereas we sequentially test for the presence of cointegration and for specific values of the cointegrating vector in a larger international data set. The different approaches have different benefits. Our approach enables us to detect departures of the cointegrating vector from theory in the presence of cointegration. This could provide insight into how and why the expectations hypothesis fails to describe the dynamic behaviour of the term structure.