



Modeling the dynamics of Chinese spot interest rates

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ABSTRACT

Using the daily data of Chinese 7-day repo rates from January 1, 1997 to December 31, 2008, this paper tests a variety of popular spot rate models, including single-factor diffusion, GARCH, Markov regime-switching and jump-diffusion models. We document that Chinese spot rates are subject to both market forces and administrative forces. GARCH, regime-switching and jump-diffusion models capture some important features of the dynamics of Chinese spot rates, but all models under study are overwhelmingly rejected. We further explore possible sources of model misspecification using diagnostic tests.

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1. Introduction

The spot rate is the yield on a zero-coupon bond with zero maturity and is the most important factor of the term structure of interest rates. A vast literature has been devoted to modeling the dynamics of spot rates in mature markets. These include, among many others, Chan, Karolyi, Longstaff and Sanders (CKLS, 1992), Ait-Sahalia (1996, 1999), Gray (1996), Stanton (1997), Brenner et al. (1996), Andersen and Lund (1997), Ahn and Gao (1999), Conley et al. (1997), Chapman and Pearson (2000), Dai and Singleton (2000), Elerian et al. (2001), Ang and Bekaert (2002), Das (2002), Durham (2003), Jones (2003), Johannes (2004), Hong et al. (2004) and Hong and Li (2005). These studies document some important features of spot interest rates in mature markets, particularly the US markets. For example, there exists significant mean reversion when using one-factor diffusion models for the US interest rates, although whether there exists a nonlinear drift is inconclusive. Ait-Sahalia (1996), Stanton (1997), Conley et al. (1997), Ahn and Gao (1999) report the evidence of nonlinear drifts, whereas Chapman and Pearson (2000), Hong et al. (2004) cast

doubts on it. Chan et al. (1992) and Hong et al. (2004) document that the interest rate volatility tends to be higher when the interest rate level is higher, which is called the “level effect” and often is characterized by a Constant Elasticity Variance (CEV) specification. Moreover, Brenner et al. (1996) and Andersen and Lund (1997) find that it is important to capture the conditional heteroskedasticity of interest rates via stochastic volatility/GARCH models. Gray (1996), Ang and Bekaert (2002), Das (2002), Johannes (2004), Kanas (2008) and Jiang and Yan (2008) find that that regime-switching and jump models help capture volatility clustering and especially the excess kurtosis and heavy tails of spot interest rates. Once stochastic volatility/GARCH, regime switching, or jump effects are introduced, the importance of modeling mean reversion in drift diminishes substantially. A sophisticated specification for the drift usually provides little help to the overall goodness of fit of spot rate models (Durham, 2003).

While the spot rate dynamics have been extensively examined in mature markets, such as the US markets, there has been little study of spot interest rates in China and other emerging markets.¹ This is perhaps due to the relatively short history of the Chinese bond markets and the strict regulation of Chinese interest rates.

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¹ Fan and Zhang (2007) is one of the few literatures that explore market segmentation in the two Chinese repo markets, i.e., the interbank repo market and the exchange repo market.

However, understanding the dynamics of Chinese spot rates is important for developing efficient financial markets, determining effective interest rate policy and piloting optimal investments. Moreover, knowledge of Chinese interest rate dynamics aids in the determination of security prices, the prediction of interest rate changes and the choice of hedging strategies. Generally, in an emerging market such as China, the spot rate plays a role similar to the fed fund rate in the US and it is a fundamental instrument in developing bond markets and other fixed-income markets.

It is undoubted that Chinese spot rates are quite heavily managed by the authorities. It is often argued that Chinese spot rates are strongly subject to administrative control by the government, their mechanism is quite different from that of other developed markets, and the models popular in US markets do not work for the Chinese market. On the other hand, the degree of marketization in China has been gradually improving. Chinese spot rates are becoming increasingly market-oriented. It is very interesting to study the dynamics of such heavily managed but gradually reformed spot rates as well as the similarities and differences between Chinese spot rates and US spot rates. In particular, we are interested in whether Chinese spot rates are subject to both market forces and administrative forces, which is evidence of a transition economy. On the one hand, we examine whether Chinese spot rates share similar dynamic features to US spot rates and whether the models that can capture important features of US interest rate dynamics can also characterize important features of Chinese spot rates. This is a test of the degree of marketization in China using spot rate data. If Chinese spot rates share important features with US spot rates, it indicates the development of Chinese fixed-income markets towards market orientation. On the other hand, we would like to test whether Chinese spot rates are also subject to external impacts. We consider two types of external events that have significant impact on the dynamics of Chinese spot rates in this paper. One is the set of administrative events including the institutional change in 1999 and interest rate policy changes.² The other is the spillover effect from Chinese stock market IPOs.³

Spot rate models are widely used in risk management and the pricing of fixed-income securities. Different information of spot rate models is used for different applications. For example, the marginal distribution is important when we forecast the distribution and calculate the VAR, while the model dynamics are used more when we price fixed-income securities. It is important to know whether a complicated model improves the marginal distribution when we calculate the VAR and whether it improves the model dynamics when we price the fixed-income securities. The model specification test in this paper provides useful information regarding the improvement of more complicated models on marginal distribution and model dynamics, and could therefore be used to select the most appropriate spot rate model.

In this paper, we provide the first comprehensive empirical study on the dynamics of Chinese spot rates. We consider a wide variety of spot rate models, including single-factor diffusion, GARCH, Markov regime-switching and jump-diffusion models, and we examine how well they can capture important features of Chinese spot rates. We use a nonparametric test proposed by Hong and Li (2005) and Hong et al. (2007) to test the adequacy of these models for Chinese spot rates. We introduce dummy variables to account for external impacts, which include the impact of administrative events including institutional change and interest rate policy changes, and the spillover from stock market IPOs. We find that there are both similarities and differences between

the dynamics of Chinese spot rates and US spot rates. The spot rate models popular in the US could also successfully capture some important features of Chinese spot rates. This is evidence of the development of Chinese fixed-income markets towards a market orientation. However, the models considered in this paper are all rejected and thus misspecified. We have not yet found a correct model that could be used to capture Chinese spot rates. We also find that Chinese spot rates are subject to external impacts. Chinese spot rates are subject to both market and administrative forces. The separate specifications show that GARCH models reduce specification errors in both the marginal distribution and model dynamics. Regime-switching and jump models mainly reduce the specification errors in the marginal distribution, but they do not help much in reducing the misspecification of model dynamics.

In Section 2, we review the history of the Chinese interest rate liberalization and describe the data on Chinese spot rates. In Section 3, we introduce a wide variety of spot rate models and the nonparametric tests by Hong and Li (2005) and Hong et al. (2007). In Section 4, we report the empirical results. Section 5 concludes the paper.

2. Interest rate liberalization in China and proxy for chinese spot rates

2.1. Interest rate liberalization in China

China regulated savings rates until the mid-1980s. Due to the short history of the Chinese market economy and the main focus on developing the stock market, the Chinese bond market and interest rate liberalization are underdeveloped. Chinese spot interest rate is determined in two main markets, i.e., the interbank borrowing/offering market and the bond repurchase market. Chinese interbank borrowing/offering markets appeared in the 1980s at different locations over China and were united into a single market in January 1996 with “CHIBOR” as its uniformed rates. CHIBOR mainly consists of short-term interest rates, with four months as the longest maturity. On January 4, 2007, the Chinese interbank borrowing/offering center located in Shanghai began to report the Shanghai interbank offered rate, which is called SHIBOR. CHIBOR and SHIBOR mainly characterize the Chinese short-term interest rates.

Chinese collateralized bond repurchase began in 1991 at four stock exchanges, i.e., the Shanghai Stock Exchange, the Wuhan Stock Trading Center, the Tianjin Stock Trading Center, and the STAQ system (the later three have been closed). In 1997, to prevent banks from stock markets, the Chinese central bank, the People's Bank of China, prohibited all commercial banks from the collateralized bond repurchase on stock exchanges and opened another bond repurchase sub-market in the interbank market. This leads to two independent and segmented bond repurchase markets in China, i.e., the OTC market at interbank markets and the electronic market at stock exchanges. These two markets are artificially segmented, with different prices for the same bond.

The long-term interest rates are determined by the Chinese long-term bond market. There are also two segmented long-term bond markets, the OTC bond market at the interbank market and the electronic market at stock exchanges. The interest rates of middle maturities are controlled tightly by the Chinese central bank. They do not change every day to reflect market information but remain unchanged for a relatively long period. They change only when the Chinese government uses them as instruments of interest rate policy.

There are two main deficiencies of the current interest rate mechanism in China that hinder the play of its fundamental roles

² Fan and Johansson (2010) show that Chinese bond yields are influenced by the monetary policy decisions.

³ Li and Zou (2008) show that the correlation between Chinese's T-bond and stock returns is affected by the policy and information shocks.

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