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Survey sentiment and interest rate option smile

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ABSTRACT

This paper finds that the presence of interest rate smile can be fully explained neither by the model misspecification nor by the buying pressure. First, volatility smile obtained from alternative interest rate models is not flat and interest rate smile significantly relates to survey sentiment after controlling for fundamental and liquidity variables. Second, a dynamic relation between sentiment proxies and interest rate smiles meets the limit to arbitrage hypothesis, which is the focal point of market friction. Third, the relation between survey sentiment proxies and option smiles is more pronounced during the crisis period than the pre-crisis and post-crisis period. While investor sentiment drives the smile curve, interest rate models cannot fully capture the smile since these models are formulated in a frictionless environment.

1. Introduction

To provide alternative explanations for the smile effect and to extend our understanding of the nature of the smile, this paper studies the extent to which investor sentiment affects time series variation of the interest rate option smiles. Prior studies have explained the presence of smiles as due to model misspecification, wherein the implied distribution is inconsistent with the model assumptions. According to the literature, volatility smiles can be found in interest rate option markets. For example, the smiles backed out from Eurodollar options using a one-factor Heath, Jarrow, and Morton (1992) model generally appear to have an asymmetric pattern in which the out-of-the-money (OTM) volatility is generally greater than in-the-money (ITM) volatility, but at-the-money (ATM) volatility is the lowest (Amin & Morton, 1994). The smile pattern exists not only in one-factor models, but also is apparent in the multifactor models (Kuo & Paxson, 2006), the jump-diffusion model (Das, 1999; Zeto, 2002), and stochastic volatility and jump model (Jarrow, Li, & Zhao, 2007).

Volatility smiles are present because of a deviation between option model prices and their corresponding market prices. Black-Scholes models and all interest rate models are formulated in an environment of frictionless markets where it is possible to create a hedged position whose option value does not depend upon the underlying asset price and permits no-arbitrage opportunities. But in reality, option prices are determined in an environment which is not frictionless. Hence, a continuous hedged position behind the option model is not feasible in any option market and thus arbitrage opportunities exist. Therefore, backing out volatility from market option prices using a continuous model does not guarantee that the implied volatilities across strikes are equivalent. In addition, using alternative models, such as jump or/and stochastic volatility, or the model relaxing part of the assumption cannot fully fit into option prices across strikes, revealing that inconsistency between model and market prices.

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This study investigates the extent to which interest rate option prices across strikes are set beyond macroeconomic components and interest rate option models. To do so, all macroeconomic variables and the buying pressure (Bollen & Whaley, 2004) are controlled. Then, we examine whether investor sentiment affect interest rate option smile. By examining the time-series relationship between sentiment and smile pattern, we test two competing hypotheses, namely the limits to arbitrage and the positive feedback trading hypothesis, to capture the dynamic interplay between sentiment-driven traders and arbitrageurs. From this we identify the role of arbitrageurs in influencing Eurodollar option prices, and determine if there is a transitory or persistent sentiment effect. Our findings support the limits to arbitrage hypothesis that the sentiment effect is transitory and the time series variation of volatility smile are closely related to the level of impediments of arbitrage. Finally, we investigate whether time variation of investor sentiment affects volatility smiles during the states of high/low volatility and different economic periods.

This study contributes to the literature in several aspects. First, the kurtosis as well as curvature of the smile are examined, which are important aspects of the smiles. Second, Han (2008) studys whether investor sentiment affects implied volatility smile on S&P500 options and found there is a significant relationship after control variables. In this study, we look at the role of sentiment in interest rate options markets rather than that in equity options market. In the equity options markets, the risk concentrates on the downside. In the interest rate options markets, however, the risk has been induced in the both rise and decline of interest rate. We find that, because of fear of rising borrowing costs, Eurodollar puts can be more influenced by investment sentiment than corresponding calls. Third, we extend Deuskar, Gupta, and Subrahmanyam (2008) who examine the relationship between economic determinants and interest rate caps smile. However, they do not consider the impact of sentiment on interest rate option smile. This paper also expends Chen and Kuo (2013) by looking at the relationship between Eurodollar option smile and investor sentiment with different economic states. More importantly, different survey sentiment measures are used to examine their impact on interest rate option smiles. Finally, this research provides implications for future development in the interest rate models, as well as pricing and hedging interest rate contingent claims in particular.

The remainder of the paper is organized as follows. In Section 2, the theoretical background and various sentiment measures are introduced and discussed. Section 3 describes the data and measures the shape of smile. Empirical results are presented and analyzed in Section 4.

2. Data and shape of the volatility smile

2.1. Data description

In this study, weekly observations of Eurodollar futures and options from January 1998 to December 2010 are used.[2] They are selected in this study because Eurodollar options are probably one of the largest interest rate derivatives in the world traded in exchange-traded markets. Several filtering procedures are applied for the concern of illiquidity or microstructure effects. First, we exclude options with a maturity greater than 180 days or less than 6 days because the longer contracts are traded infrequently and the contracts of less than a week have an expiration effect. Second, we collect quarterly matured options since non-quarterly matured options are less frequently traded. Third, those options with moneyness greater than 0.3 or less than −0.3 are deleted because they are either deep ITM or deep OTM options. Following Amin and Morton (1994), and Kuo and Paxson (2006), moneyness is defined as the futures price less strike price for calls and strike price less futures price for puts.[3]

2.2. Definitions of the implied volatility smiles

In this section, we describe how we obtain implied volatility from Heath et al. (1992). Since the objective of this study is to evaluate the impact of investor sentiment on volatility smile, we back out implied volatility from Eurodollar options using the one-factor HJM model. The implied volatility is obtained by minimizing the error between market and model price.[4] To reduce the number of observations, moneyness with 0.25 and −0.25 and maturity with 30 and 120 days are selected each day. Because there are no exact options matching these requirements for each day, a linear interpolation or extrapolation technique is used.

Fig. 1 displays the Eurodollar call and put option volatility across different ranges of moneyness on 11 November 2009. Strikingly, the volatilities do not all lie on a horizontal line. This pattern is the volatility "smile" and constitutes evidence against the HJM constant model. The volatility smile indicates that OTM volatility is greater than ATMs and ITMs for calls, but it is opposite for puts.

According to Fig. 1, the natural question to ask is how to measure the time series patterns of implied volatility smile in terms of their asymmetry and curvature. Following Deuskar et al. (2008), the measures of the asymmetry and curvature are used in this study, referred to respectively as "risk reversal" and "butterfly spread," which are widely used by practitioners. These empirical

[2] We select observations from each Wednesday since this day of the week is likely to be a trading day compared with others. If Wednesday is not a trading day, observations from the following day are selected.

[3] In equity options, Bollen and Whaley (2004) suggest defining the moneyness using the option's delta, but this rule may not be perfectly applicable to fixed-income options. The level of change in interest rates is relatively smaller compared to stock prices within a certain period, and therefore the moneyness in fixed-income options may incur bias by adopting the measures from equity options. The moneyness we apply can be handled easily with the same sign of moneyness for calls and puts, and this feature could be attractive if a sign change is evident in the regression analysis.

[4] The option price computed from one-factor model is obtained from the following procedure. First, we build a forward rate tree with 10 steps using the one-factor HJM model. Under the one-factor HJM model, the volatility function $\sigma(t,T)$ is set to be σ_0, where t is the starting time of forward rate and T is the terminating time. Second, an option price tree is built and calculated backward to the initial point. Then implied volatility for a given option is obtained when the difference between model and market prices are minimized.