A Smooth Transition Autoregressive Conditional Duration Model
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Asset price information is revealed to the market via investor trades. Thus, retrieving and extracting information from the order sequence can help understand the assimilation of asset price information. Easley and O'Hara (1992) established a model demonstrating how the time between trades contains information owing to event uncertainty. Accordingly, the correlation between the time between trades and information occurs when the order sequence is connected to the time between trades. The seminal paper by Engle and Russell (1998) established the autoregressive conditional duration model (ACD) for capturing the dynamic behavior of trade durations (time between trades). Such modeling for high-frequency data has proven useful in studying the empirical implications of market microstructure theory. Engle and Russell (1997) applied the ACD model to investigate foreign exchange quotes and support the asymmetric information model of price setting. Moreover, Hamelink (1998) found a significant correlation between the durations and returns of French CAC 40 using the ACD model. Consequently, durations provide a channel for asset price information.

Extensions of the ACD model focus mainly on two directions: one is for distribution of standardized durations (Grammig and Maurer (2000)); the other is for specification of conditional expected durations (Zhang et al. (2001) and Bauwens and Giot (2003)). Generally, the variants of the above ACD model depend on the features of nonlinearity, past price changes, past durations, or distribution assumptions. However, none of these variants integrate features of nonlinearity, past price changes, and past durations. This study proposes a nonlinear type of autoregressive conditional duration model, termed the smooth transition autoregressive conditional duration model of price and duration (STACD-PD), which considers the previous price change and duration. The nonlinearity in the STACD-PD model enables the process of the conditional expected trade duration to follow a regime-switching behavior. Meanwhile, the model specification tests are provided for academic researchers and practitioners when doing empirical works and actually making trades.

The STACD-PD model presented here has similar features to the threshold autoregressive conditional duration (TACD) model of Zhang et al. (2001), the asymmetric ACD model of Bauwens and Giot (2003) and the ACM-ACD model of Russell and Engle (2005), but differs from these models in some respects. First, Zhang et al. (2001) proposed a threshold model for the duration process, termed the threshold ACD (TACD) model, by incorporating the duration of the previous transaction as a threshold variable. Consequently, the structural change pattern of the TACD model exhibits abrupt changes over distinct
duration regimes. Unlike the threshold discontinuity in the TACD model, the structural change pattern of the duration in the STACD-PD model is determined by the duration data regarding whether the changes are instantaneous. Second, the effect of price change on the duration is considered in the asymmetric ACD model of Bauwens and Giot (2003), the ACM-ACD model of Russell and Engle (2005) and the STACD-PD model presented here. Bauwens and Giot (2003) considered the price trend effect on the duration process by employing the two-state transition probability matrix to model the price change directions. Russell and Engle (2005) considered the multiple states of price changes and modeled the price change as a multinomial process termed the autoregressive conditional multinomial model (ACM). The models of both Bauwens and Giot (2003) and Russell and Engle (2005) use the joint distribution of the duration and the price change to estimate the impact of price change on the duration process. Although the joint distribution approach theoretically can be adapted to numerous states, determining the number of states in terms of empirical applications is highly subjective. Unlike the joint distribution approach to price change effect on the duration process in the models of Bauwens and Giot (2003) and Russell and Engle (2005), the STACD-PD model does not treat price change as a distribution process. Instead, the price change effect on the duration process adopts a smooth transition to affect the coefficients in the STACD-PD model similar to the past duration effect on the duration process in the STACD-PD model. Consequently, the STACD-PD model permits the price change data to determine the number of states in the smooth transition function and the adjustment speed of the structural change of the duration process in response to price changes.

The STACD-PD model is applied to IBM trade durations. The expected trade duration behavior during the trading hours is affected by past price changes and trade durations. Expected trade durations are much more persistent in the upward market compared to the downward market. Shocks to trade durations are more persistent on the market opening and gradually decrease in the downward market.

This study proposed a smooth transition autoregressive conditional duration model of price and duration (STACD-PD) which considers past price changes and trade durations. The STACD-PD model expresses a nonlinear type of the autoregressive conditional duration (ACD) model with a regime-switching feature. The regime switches following smooth transition functions in which the past price changes and past durations are state variables. Accordingly, the STACD-PD model is able to capture the effects of past price changes and past trade durations on the expected trade durations. Meanwhile, the specification tests of the STACD-PD model are also constructed for testing linearity of the expected trade duration process against the smooth transition nonlinearity.

References:

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