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Nonlinear effects of monetary policy on stock returns in a smooth transition autoregressive model

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ABSTRACT

This paper employs smooth transition autoregressive (STAR) models to investigate the nonlinear effect of monetary policy on stock returns. The change in the Federal funds rate is used as an endogenous measure of monetary policy, and the growth rate of industrial production is also considered in the model. Our results show that the relationship between the monetary policy and excess returns on stock prices is positive and nonlinear. A decrease in the Federal funds rate causes a larger increase in excess returns if excess stock returns are located in the extreme low excess returns regime.

1. Introduction

Although the issue of whether monetary policy affects stock markets has been much debated, the question remains unsolved. In the early empirical studies, money aggregate data and linear regression models were employed to estimate the effects of monetary policy on stock prices, and their conclusions are diverse. For example, Pesando (1974), and Rogalski and Vinso (1977) concluded that there is no significant effect of changes in money on stock prices, but Homa and Jaffee (1971) found that expansionary policy increases stock prices significantly.

After Bernanke and Blinder (1992) found that Federal funds rate is a good measure of monetary policy, some papers re-estimated the relationship between monetary policy and stock prices or returns. Most of them agreed that monetary policy has effects on the stock market. Thorbecke (1997) used a vector autoregressive (VAR) model and concluded that a contractionary monetary policy decreases stock returns. By using the event-study approach, Rigobon and Sack (2004) found that an increase in the short-term interest rate has a negative impact on stock prices; Bernanke and Kuttner (2005) found that unexpected cuts in the Federal funds rate would lead to an increase in stock prices. Basistha and Kurov (2008) found the US stock returns respond to monetary surprises more strongly when the economy is in a recession and experiencing tight credit condition.

Financial constraints could be one reason that the conclusions vary. If some agents' behavior is constrained financially, monetary policy might have asymmetric effects on the financial market.[1] Since financial constraints are more serious in the bear market, monetary policy might have stronger effects on stock returns when the stock market nose dives. In recent years, there has been an increasing interest in assessing the asymmetric effects on the financial market.

Ehrmann and Fratzscher (2004) present the evidence that the stock market response to monetary policy is highly asymmetric. They divide the 500 individual stocks comprising the S&P 500 into several groups according to the degree of financial constraints of firms and find the firms with more financial constraints are affected significantly more by monetary policy. Chen (2007) investigated the asymmetric monetary policy effects on stock returns

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[1] The topic of financial constraints has been developed and discussed in previous literature. See, e.g., Bernanke (1983), Bernanke and Gertler (1989), Shleifer and Vishny (1992), Whited (1992), Kiyotaki and Moore (1997), Fazzari, Hubbard, and Petersen (1988), Almeida and Campello (2007), Livdan, Sapriza, and Zhang (2009), Denis and Sibilkov (2009).

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by using Markov-switching models. He found that monetary policy has larger effects on stock returns in bear markets and a contractionary monetary policy leads to a higher probability of switching to the bear-market regime. Also, Jansen and Tsai (2010) examined the asymmetric impact of monetary policy surprises, which are measured by the method introduced in Kuttner (2001),[2] on stock returns between bull and bear markets in the period of 1994 and 2005. They focus on the hypothesis of differential effects of external debt capacity on stock returns across two market regimes. Their results show that the impact of a surprise monetary policy in a bear market is large, negative, and statistically significant. Capacity for external finance in a bear market is more important as it mitigates the impact of monetary policy.

Apart from the asymmetric relationship between the monetary policy and stock returns, the relationship between stock returns and output growth is also an interesting subject.[3] Not to mention the effect of monetary policy on output growth is also a traditional focus in economics. Bradley and Jansen (2004) modeled the relationship between stock returns and industrial production. They made comparison of the forecasting performance between linear and nonlinear models and found that forecasts from nonlinear models, in which they mainly addressed smooth transition autoregressive (STAR) model, outperformed linear model for industrial production. Therefore, this paper attempts to investigate the nonlinear relationship among monetary policy, stock returns, and output growth by using the STAR model. In our models, monetary policy, stock returns, and the growth rate of output are endogenously and simultaneously determined.

The STAR model has been widely employed in analyzing economics issues.[4] The main benefit of using the STAR model is that it allows for a more general transition function, so the transition processes between regimes are smooth.[5] In this paper, excess stock returns, the change in the Federal funds rate that stands for monetary policy, and the growth rate of output are all allowed to be the possible threshold variable. Hence, this paper considers three asymmetries: the asymmetry related to the state of stock market, the asymmetry related to the direction and size of the monetary policy action, and the asymmetry related to the state of economy. By appropriately choosing the best threshold variable for the model of each variable and estimating the nonlinear models for them, the nonlinear relationship among excess stock returns, monetary policy, and output growth can be investigated. Also, the nonlinear impulse response functions can help us to understand how they affect each other.

Our results show that the relationship between excess stock returns, monetary policy, and the growth rate of output all can be expressed by nonlinear STAR models. The estimated coefficients and the impulse response functions show that an expansionary (contractionary) monetary policy significantly and nonlinearly increases (decreases) excess returns on stock prices. Monetary policies cause a larger change in excess returns if excess stock returns are located in the extreme low excess returns regime and the idea of financial constraints is the most likely explanation.

[2] Chulia, Martens, and van Dijk (2010) also employed the measurement of monetary surprises proposed by Kuttner (2001) to discuss the asymmetric impact of surprising changes of federal funds target rate on stock returns, volatilities, and correlations. They found that a surprising increase in the funds target rate of 10 basis points causes a stuck return decline of 46 basis points.

[3] See, e.g., Mullins and Wadhwani (1989), Morck, Shleifer, and Vishny (1990), Blanchard, Rhee, and Summers (1993), Mauro (2003), Bradley and Jansen (2004).

[4] See Bradley and Jansen (2004) for detailed literature survey.

[5] Comparing to the works such as Jansen and Tsai (2010) and Chulia et al. (2010) who adopted a dummy variable to distinguish different regimes, the transition process in STAR model is much smooth.

2. The STAR model

2.1. The basic approach

The STAR model is a general form of the threshold autoregressive (TAR) model. A STAR model can be written as

$$y_t = a_0 + \alpha(L)x_t + [a_1 + \beta(L)x_t]F(z_{t-d}) + \varepsilon_t \tag{1}$$

where y_t is the dependent variable, x represents all the explanatory variables, including autoregressive lags of y_t. $F(z_{t-d})$ is the transition function, z_{t-d} is the transition variable that determines the switch between regimes, and d is the lag length of the transition variable. The dynamics of Eq. (1) changes with values of the transition variable. The nonlinear dynamics can be expressed as $\alpha(L)+\beta(L)F(z_{t-d})$.

Two common specifications for transition functions are the logistic and the exponential functions. The logistic transition function is

$$F(z_{t-d}) = [1 + e^{-\gamma(z_{t-d}-c)}]^{-1} \tag{2}$$

where γ determines the speed of transition and c is the threshold critical value. If $\gamma > 0$ ($\gamma < 0$), the logistic transition function changes smoothly from zero to one (from one to zero) with the increasing transition variable z_{t-d}. The exponential STAR model has the transition function

$$F(z_{t-d}) = [1 - e^{-\gamma(z_{t-d}-c)^2}], \quad \gamma > 0 \tag{3}$$

The exponential transition function smoothly approaches zero when the transition variable z_{t-d} is close to the threshold value c and approaches one when the transition variable z_{t-d} deviates further from the threshold value c.

2.2. Identifying and estimating methods

The STAR model, developed by Luukkonen, Saikkonen, and Terasvirta (1988), Terasvirta and Anderson (1992), and Terasvirta (1994), has four steps to identify and estimate its coefficients. The first step is to estimate a linear autoregressive model. It is crucial to estimate the lag length of the autoregressive process. In this paper, a search over possible combinations of explanatory variables' lag length is conducted, and the Schwarz information criteria (SIC) is used as the criterion for selecting proper lag length, which is the lag length with the minimum SIC.

The second step is to identify possible candidates for the transition variable and test for the appropriateness of linearity. Terasvirta and Anderson (1992) propose an approximating equation and a procedure to test a linear AR model against a nonlinear STAR model. The approximating equation of Eq. (1) can be expressed as:

$$y_t = c_0 + \phi_0(L)x_t + \phi_1(L)x_t z_{t-d} + \phi_2(L)x_t z_{t-d}^2 + \phi_3(L)x_t z_{t-d}^3 + v_t \tag{4}$$

The lag length of x_t was determined in the first step. For a given transition variable z and the amount of delay d, Eq. (4) can be estimated and also be tested for the hypothesis $\phi_1(L)=\phi_2(L)=\phi_3(L)$. If there are one or more values of d that reject the null hypothesis of linearity, it indicates a nonlinear STAR model and a delay d with the lowest probability value (i.e., the highest F-statistic) will be chosen.

The third step is to identify the specification of the STAR model. If the null hypothesis of linearity is rejected and the transition variable is determined, the specification of the STAR model must be chosen between a logistic STAR (LSTAR) and an exponential STAR (ESTAR) model. A sequence of hypothesis tests and decision rules