Institute of Business Administration Karachi
Leadership and Ideas for Tomorrow

Business Review

Volume 12
Issue 2 *July - December 2017*

Article 2

7-1-2017

Real interest rate volatility in the Pakistani economy: a regime switching approach

Fahad Javed Malik
Monash University, Australia

Mohammed Nishat
Institute of Business Administration, Karachi, Pakistan

Business Review: (2017) 12(2):22-32
Original Paper

Real interest rate volatility in the Pakistani economy: A regime switching approach

Fahad Javed Malik · Mohammed Nishat

Abstract This paper assesses the volatility of short term real interest rates in Pakistan using the Markov switching model and drawing on monthly data from January 1964 to March 2016. This model holds that if a random walk pattern is not visible in the real interest rate series, fluctuations are temporary and the interest rate will eventually converge around the mean value. The results reveal that real interest rates in Pakistan have exhibited high volatility since 1973 due to high budget deficits and other sources of instability in the economy.

Keywords Interest rate · volatility · Markov switching model.

1 Introduction

Interest rate is one of the most important policy variables, which is directly related to economic growth. The movement in interest rate influences the financial market operations. A rising trend in interest rate negatively impacts overall investment decisions hence distorting the overall investment structure. The central bank of Pakistan (SBP) exerts significant influence on interest rates through monetary policy measures as is the practice in most developing countries.

The central bank uses the Taylor's rule to determine the short term interest rate in response to changes in inflation, output and other economic conditions. This is then translated into the long term interest rate which ultimately influences the investment and saving decisions in the economy. It is important to note that the short term interest rate fluctuations may be slower and sometimes more volatile. Consequently, we observe episodes of jumps, due to domestic economy

Fahad Javed Malik
Monash University, Australia
E-mail: fahad.malik@khi.iba.edu.pk

Mohammed Nishat
Institute of Business Administration, University Road, Karachi-Pakistan

performance, higher inflation, low growth rate in the economy, and or consequent to some disturbances in external market factors like inflow of FDI, foreign portfolio investment and remittances which have been supporting the economy.

Lessons from a developed economy like the US indicate that high interest rate volatility observed during the 1980s severely obstructed economic progress. Increase in the interest rate is associated with greater risk which translates into impressions of instability. This discourages investment and consumer expenditure resulting in a fall in national output and overall capital formulation.

A review of Pakistan's economy reveals that in the recent past, measures have been taken to lower the interest rate. However this is a short sighted policy that improves economic progress only in the short run. Such policy encourages a rising inflationary trend hindering the growth process. The rapid growth prospects in the short run improves the chances for the government in the next elections, however, economists argue that central bank operations should not be influenced by politics.

Pakistan has been highly vulnerable to changing policies throughout its existence due to frequently changing governments and varying economic agendas. This has resulted in increased domestic and external borrowing and significant budget deficits prevalent in most developing countries as identified by Fry (1998). In contrast, jumps in interest rate faced by developed economies are due to their own economic activities whereas in Pakistan, it is mainly due to factors like budget deficit, external factors and higher dependency on indebted finances. For Pakistan, the time frame and episodes of jumps and fluctuations are different and mainly due to the budget deficit.

The visible volatility and steeper spikes in interest rate affect the economy differently than smaller ones. As a policy maker one can anticipate and forecast these jumps which can make it easier to understand the pattern and direction of economic movements. Against the above background, one can observe the periods of small volatility and large jumps (figure 1). The small volatility episodes can easily be modeled through time-varying coefficient models such as State Space modeling approach. However, these episodes may not be of significant importance from the policy point of view. On the other hand, a study of the transition from the low to large or large to low volatility regimes can be of immense importance for policy makers in assessing the overall economic circumstances of the economy. Therefore, the regime switching approach seems to be more appropriate to capture large jumps in the observed interest rate series.

This study uses Markov's switching technique to pick such time frames and various magnitudes of jumps which can help to identify the long run jumps which are ultimately incorporated in monetary transmission for long run economic decisions. To capture the jumps, we can use various econometric methodologies for instance the Dummy variable approach, or threshold regression such as Structural Threshold Regression (STR). These approaches have the drawback that they require the specification of the time at which the interest rate jumps which makes them deterministic in nature. In the Regime switching approach we do not have to specify the prior time of change due to its probabilistic nature of estimation. It automatically identifies these jumps whether large or small.

For policy purposes and taking into consideration the investor's point of view

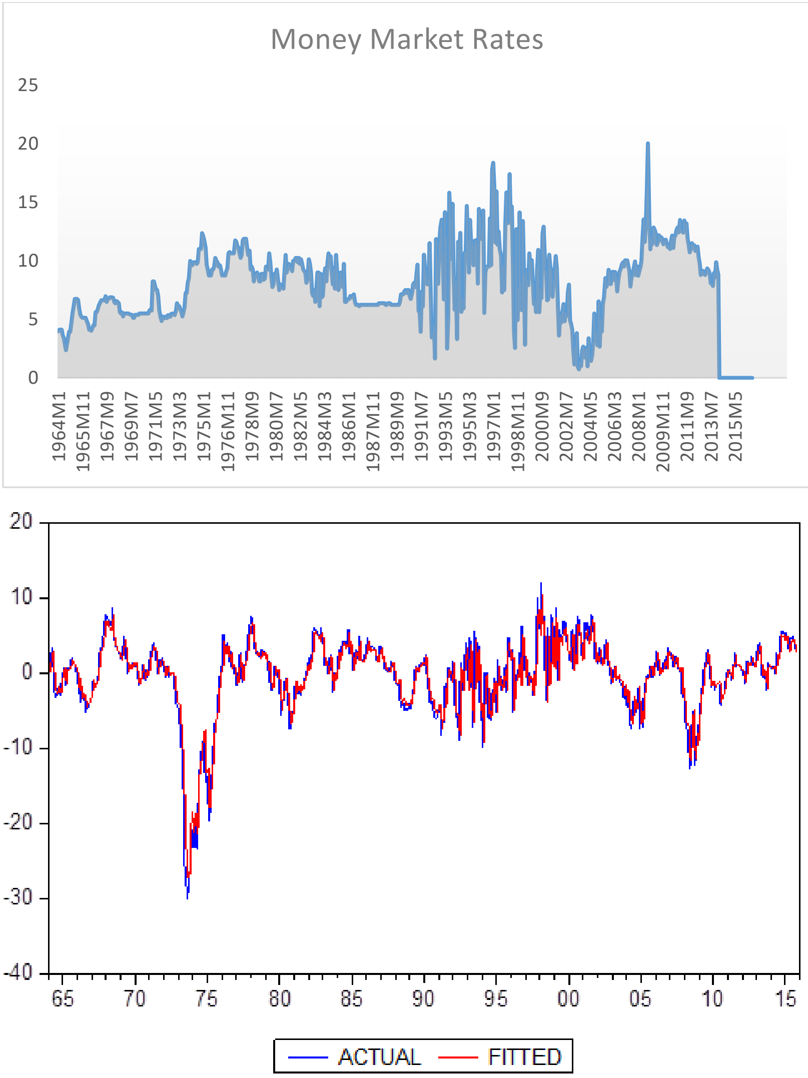

Fig1: Markov switching model: Pakistan Real Interest Rate Actual versus Fitted Plot

it is important that we understand and capture the dynamic behavior of real interest rate in Pakistan. No empirical work has been undertaken to estimate real interest rate volatility in Pakistan even though the behavior of real interest is significantly responsible for fluctuating policy implications. This study uses the most popular non-linear time series model known as Markov Switching model of Hamilton (1989) to assess interest rate volatility. This model involves multiple structures that can characterize the time series behavior of different regimes of real interest rate in contrast to linear models. It also exhibits many non-linear dynamic patterns such as asymmetry, amplitude dependence and volatility cluster.

The rest of the paper is organized such that section 2 presents the literature review, followed by econometric methodology and data in section 3. The results are discussed in section 4 followed by conclusion in section 5.

2 Literature review

Measuring the existence of unit root in real interest rate is stimulating in many aspects. Fama (1975) study which examined the efficiency of the T-bill market, rests on the assumption that the ex-ante real interest rate is constant. Discussing market efficiency, setting price of one-month T-bill at time t-1, making use of all available information of inflation rates, and if expected return remains constant through time, then variation in nominal rates reflects expected rate of change of inflation.

In contrast, Garbade and Wachtel (1978) and Nelson and Schwert (1977) criticized Fama's paper and found evidence against a constant real interest rate. They based their analysis on the assumption that the real rate follows an integrated process. Rose (1988) has shown that the viability of consumption-based asset pricing models rests on whether or not the time series properties of growth rate of consumption, which is known to be stationary, and the real interest rate are similar. Hansen and Singleton (1982) investigated the nonlinear rational expectation models based on Eulers stochastic equation. The sample is made equivalent to the population, such that orthogonality condition of the model approaches zero. An important advantage of this method is that the solution for dynamic function parameters can be obtained without solving for stochastic equilibrium related to stock market return and aggregate consumption.

Moreover, a finding that the ex-ante real interest rate has a unit root has important implications for the suggestion that the real rate be used as a guide to the conduct of monetary policy Walsh (1984). For example, factors that produce persistent shifts in the real rate may call for a different policy response than factors that produce temporary changes in the real rate. Rose (1988) concludes that the ex-ante real interest rate must have a unit root. Walsh (1984) also fails to reject the presence of a unit root in the real interest rate by analyzing the ex-post real interest rate.

On the contrary, Perron (1990) rejects the unit root hypothesis by incorporating regime shifts in the ex post real interest rate. He argued that the unit root test is biased towards non-rejection of the unit root hypothesis when the series contains a sudden change in the mean.

Nelson and Schwert (1977) stated that the efficiency of the market for the US bill cannot be tested without modelling ex ante real interest rate. Fama (1975) used an autocorrelation model for ex post real rate and regression approach between inflation rate on market interest rate and preceding inflation rate. But Fama's hypothesis was rejected by Nelson and Schwert (1977) since their analysis emphasized that expected inflation rate is the most important factor in determining the fluctuation in short term market interest rate during the postwar period in USA. Further, expectation of purchasing power rates takes into account important information which is ignored in past inflation rates.

Perron (1990) investigated existence of unit root in the mean changing time series, following the Box and Tiao (1975) methodology known as the intervention analysis. Garcia and Perron (1991), take into account the pattern of US real interest through regime shifts. The authors used time series following statistical characteristics of Hamilton in the analysis and applied the three state model with changing mean and variance. The results confirmed that real interest rate is random around the mean in all three regimes, similarly variance is also different in all three regimes.

Rose (1988) discussed the stability of interest rates by employing a univariate time series model of nominal interest rates, prices and consumption. Grossman and Shiller (1980) investigated that the movements of past stock price indices are dependent upon new information involving future dividends and real interest rates discounting dividend to present value. Measuring stock price fluctuations using real interest rates is favored, similarly real interest rate movements are subject to marginal rate of substitution of consumption.

Walsh (1984) evaluated interest rate volatility and its impact upon monetary policy. A rational expectation aggregate model was adopted where the parameters of the money demand function followed the random probability distribution of bond prices. Monetary policy is impacted by bond prices, such that structural shifts cause changes in the equilibrium prices of bonds. High volatility in bond prices exist when monetary policy shifts to reserve aggregate method from interest rate, coinciding with Lucas monetary policy measures assessment.

Then Walsh (1984) covered real interest rates and overall stabilization, based on rational expectation assumptions assessing wider variety of shocks by incorporating the credit market. The analysis investigated that stabilization of interest rate, output and price level due to demand shocks is not possible, however in case of supply shocks output can be steadied by taking into account unanticipated interest rate fluctuations.

Aristei and Gallo (2014) investigated interest rate transit in the Euro region during the financial crisis by employing autoregressive Markov switching model. During a financial crisis the short run transmission between bank rates and money market rate displays a transition from normal to high volatility regime. This is in line with recent literature that retail banks adopted varied measures due to change in money market rates during economic distress, hence reducing the overall efficiency of the monetary policy.

Hamilton (1989) introduced an appropriate method to model changes in the regime. The discrete state Markov process is the outcome for autoregression parameters since a nonstationary time series involves seasonal and discrete movements. Rather than capturing the shifts directly, a probabilistic inference is drawn determining when the shifts have occurred based on the trend of the series. A non-linear iterative filter is developed that allows estimation of population parameters by MLE. It also permits forecasting of the time series. The author applied the new methodology on US real GNP capturing the shift from the positive growth rate to the negative growth rate regime studying the volatility and overall recession; business cycle follows a pattern denoted by lags in the autoregressive model.

Ahrens (2002) used the regime switching model to predict recessions due to interest rates spread, studying eight OECD economies. The interest rate spread is modelled using a two state Markov switching model introduced by Hamilton. The two regimes for each economy confirmed that they are linked to expansions and recessions respectively. Moreover, the model efficiently filters the term spread signals hence it allows to capture large un-clear signals that can cause significant errors.

Shen and Siu (2012) studied the optimal asset allocation problem using Markov's switching model modelling stochastic interest rate. The two state model plays an important role in determining optimal investment opportunities in shares and bonds, given that the short rate behavior is considered using Vasicek Markov switching model while the share price is evaluated by Markov switching Geometric Brownian motion through the programming approach.

Kanas (2008) evaluated interest rate dynamics in USA and UK using the regime switching approach incorporating inflation and role of political regimes. For UK, in one regime strong mean reversion is identified, which did not hold true in case of the second regime due to large errors and high volatility, whereas, in USA, volatility differed in both regimes and transition probabilities were also significant. Bleaney (1997) explained fluctuations in real interest rates by permitting switching between inflationary regimes that provided a more accurate fit for relationship between interest rate and inflation. Neal et al (2000) used the cointegration model to evaluate the relationship between corporate and government bond rates and it was seen that corporate and government rates are cointegrated.

Ang and Bekaert (2002) applied regime switching models to conduct out-of-sample forecast using the data from US, Germany and UK. The authors focused upon short term international interest rates and term spread, revealing that interest rate regimes corresponded well with the business cycle. Dahlquist and Gray (2000) assessed how short-term interest rate varies by currency target zones. They discovered that volatility and overall speed of adjustment are faster in the regime that is going through a currency crisis or speculative operations. Interest rate is seen to have unit root, when there exists low volatility along with low interest rates.

Gray (1996) modelled the conditional distribution of interest rates by employing the generalized regime switching model, the interest rate displays mean reversion and conditional variance that led to application of GARCH technique. The GRS model takes into account the first order Markov process, while regime switching is determined by transition probabilities. Susmel et al (2001) used the RSV or regime switching stochastic volatility process to capture the shocks for modelling interest rates. The model is estimated based on Gibbs Sampling and its efficiency is compared with the GARCH model.

3 Econometric methodology and data

3.1 Data

The monthly data has been extracted from International Financial Statistics, IMF DATA from January 1964 to March 2016. Money market nominal interest rate and percentage of all CPI items corresponding to the past year have been collected, such that short-term real interest rate is calculated by subtracting CPI inflation rate from the money market rate. The short term real interest rate is calculated for Pakistan, to assess the volatility using Markov switching models.

3.2 Model specification and econometric methodology

In this study Hamilton (1989) Markov switching model is employed to capture the regime shifts by incorporating the autoregressive model. Garcia and Perron (1991) also used the same model to investigate the shifts through an AR (2) process with Markov switching mean and variance three state model similar to Nelson and Schwert (1977).

$$(y_t - \mu_{S_t}) = \varphi_1(y_{t-1} - \mu_{S_{t-1}}) + \varphi_2(y_{t-2} - \mu_{S_{t-2}}) + e_t \tag{1}$$

$e_t \sim N(0, \sigma^2_{S_t})$

$$\sigma^2_{S_t} = \sigma^2_1 S_{1t} + \sigma^2_2 S_{2t} + \sigma^2_3 S_{3t} \tag{2}$$

$S_{jt} = 1, if \quad S_t = j, and \quad S_{jt} = 0, otherwise, j = 1, 2, 3.$

$$p_{ij} = Pr(S_t = j|S_{t-1} = i), \sum p_{ij} = 1 \tag{3}$$

where y_t denotes short term real interest rate, the mean μ, σ is the standard deviation that is the time dependent process of the regime indexed by discrete variable S_t and e_t of N(0, 1) random variables. An autoregressive model is also employed to make the model; the appropriate lag order is that beyond which partial autocorrelation is zero. The autoregressive model of order ρ is defined as:

$$y_t = \mu_1 + \sum \varphi_1 y_{t-1} + e_t \tag{4}$$

where φ_1, φ_2,...φ_p are the parameters of the autoregressive model, with constant or drift μ_1 and e_t is the white noise.

4 Empirical results

The model has been estimated for the sample from January 1964 to March 2016 (table 1). An AR(4) model has been employed that allowed to make the residuals into a white noise process. The first column provides the estimates of the Linear model without regime shifts. All the AR terms are significant and the sum of their coefficients is 0.92. Conditional variance exists that fluctuates over the time, alternating between periods of high volatility followed by low variance states. This is viewed as volatility clustering highlighted by Bollerslev (1988), therefore not only mean models are estimated but variance models as well. After conducting unit root tests and correlograms, AR(4) model is found to be the most suitable unconditional mean model, since the real interest rate fluctuates around its mean.

The second column of the table 2 specifies estimates of three state Markov

Table 1: Estimates: Real interest rate Linear Model and Markov Switching Model

	Linear Model	Markov Switching Model
φ_1	0.764	0.879
	(0.040)	(0.030)
φ_2	0.078	0.018
	(0.049)	(0.031)
φ_3	0.194	-
	(0.049)	
φ_4	-0.116	-
	(0.040)	
σ_1^2	-	0.284
		(0.039)
σ_2^2	-	1.359
		(0.065)
σ_3^2	-	-1.31
		(0.436)
μ_1	-0.374	0.083
	(1.121)	(0.065)
μ_2	-	-0.323
		(0.318)
μ_3	-	-0.680
		(0.197)
Log likelihood	-1377.85	-1255.51

Standard errors are in parentheses

switching model in which variance periods are categorized in terms of low, medium and high periods. The low variance state probability p33 is 9.59E-06, while the medium variance period probability p11 is 0.991 and the high volatility period probability p22 is 0.916. The variance of medium and high volatility states is significant whereas, the variance of low volatility period is insignificant. The sum of AR coefficients is close to 0.9 and the high variance state is over time higher than the medium volatility state. These results are consistent with existing literature. Figure 2, displays medium, high and low volatility periods, using structural breaks while modelling the real interest rates, indicating a different state at each point in time.

From 1980s till early 1990s, the fluctuations in interest rate are high, particularly due to the perpetual and high budget deficit. The government had adopted a restrictive interest rate policy in response to federal budget deficits and recessionary pressures. The variance is significantly small for the low volatility period, mainly due to constantly changing monetary policy. Different monetary tools were implemented with short term goals that prevented stability in the behavior of interest rates. Further the shifts in mean and variance led to exclusion of autocorrelation from the series.

The real interest rate follows a random path around its mean, showing un-

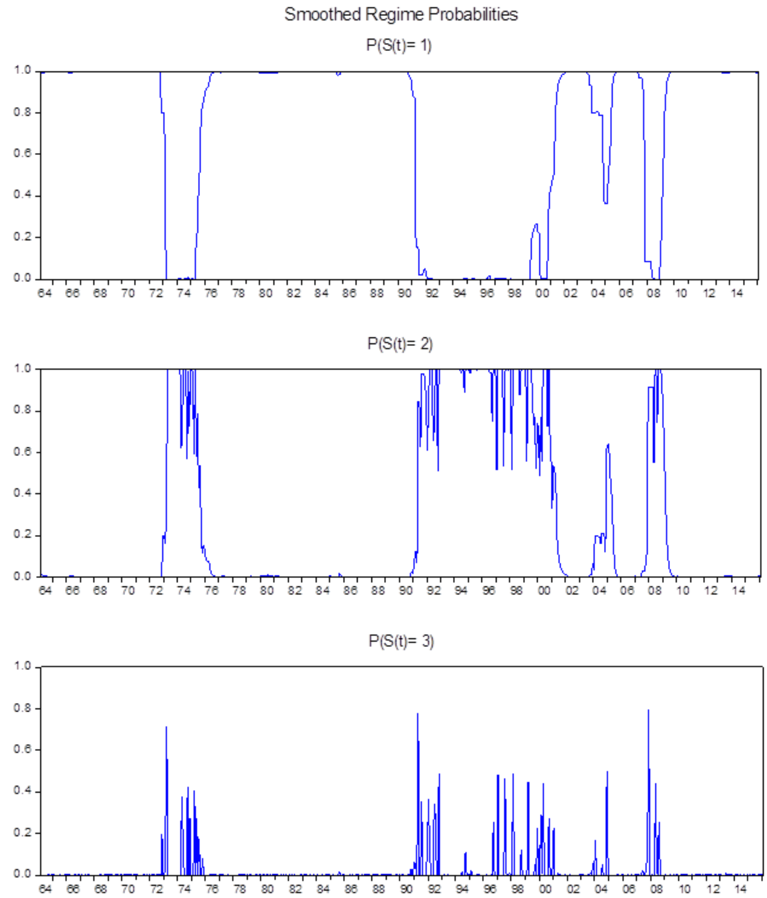

Fig2: Markov switching model Filtered probability Pakistan Real Interest Rate

common but significant fluctuations and moves parallel with the findings of Fama (1975). Moreover, there is an existence of Fischer effect, since the real interest rate follows i.i.d. process, such that nominal interest rate cannot infer much about the real interest rate trend. The period mid-1990s onwards is a medium volatility state, the probability of being in this condition is greater than other regimes; there is a high chance of a low variance regime followed by a high variance period. There was a medium rate short term fluctuation in interest rate during 2008, after the deployment of a variety of monetary tools that led to stability in the real interest rate. Overall, interest rate movement in Pakistan is largely categorized by high volatility followed by medium variance regime.

Table 2: Estimates: Real interest rate transition probabilities and expected duration

Constant transition probabilities P(i k)=P(s(t)=k-s(t-1)=i)(row = i / column = j)			
	1	2	3
1	0.991	6.04E-08	0.0088
2	0.028	0.916	0.056
3	3.26E-06	0.999	9.59E-06
Constant expected duration			
	1	2	3
	114.185	11.925	1.000

5 Conclusion

Based on Garcia and Perron (1991), the existence of random walk behavior in the real interest rate has important implications. If the random walk pattern is not visible in real interest rate series, then fluctuation in the series is temporary and eventually it will be restored around the mean value. The real interest rate fluctuations occur because of a sudden structural event either in the global economy or the local economy. The filtered probability diagrams clarified that the real interest rate went through a high volatility period from1973 onwards due to the oil price shock. The interest rate continued to stay in the high variance regime, due to unstable economic conditions and high budget deficits.

Apart from these major causes, there were other reasons including the unstable political situation of the country that contributed towards the jumps in the real interest rates; leading to non-rejection of the hypothesis of random walk as performed by Rose (1988) and Bollerslev (1988). Discussing the theoretical aspects, the presence of random walk pattern leads to either jumps in the series or the unit root. The existence of the unit root has an impact upon the CAPM model, showing similar relation between the real interest rate and growth rate of capital consumption.

References

Ahrens R (2002) Predicting recessions with interest rate spreads: a multicountry regime-switching analysis. Journal of international Money and Finance 21(4):519–537

Ang A, Bekaert G (2002) International asset allocation with regime shifts. The Review of Financial Studies 15(4):1137–1187

Aristei D, Gallo M (2014) Interest rate pass-through in the euro area during the financial crisis: A multivariate regime-switching approach. Journal of Policy Modeling 36(2):273–295

Bleaney MM (1997) Can switching between inflationary regimes explain fluctuations in real interest rates? 97-131, International Monetary Fund

Bollerslev T (1988) Integrated arch and cointegration in variance. Unpublished manuscript (Northwestern University, Evanston, IL)

Box GE, Tiao GC (1975) Intervention analysis with applications to economic and environmental problems. Journal of the American Statistical association 70(349):70–79

Dahlquist M, Gray SF (2000) Regime-switching and interest rates in the european monetary system. Journal of International Economics 50(2):399–419

Fama EF (1975) Short-term interest rates as predictors of inflation. The American Economic Review 3:269–282

Fry MJ (1998) Assessing central bank independence in developing countries: do actions speak louder than words? Oxford Economic Papers 50(3):512–529

Garbade K, Wachtel P (1978) Time variation in the relationship between inflation and interest rates. Journal of Monetary Economics 4(4):755–765

Garcia R, Perron P (1991) An analysis of the real interest rate under regime shifts. Université de Montréal, Centre de recherche et développement en économique

Gray SF (1996) Modeling the conditional distribution of interest rates as a regime-switching process. Journal of Financial Economics 42(1):27–62

Grossman SJ, Shiller RJ (1980) The determinants of the variability of stock market prices

Hamilton JD (1989) A new approach to the economic analysis of nonstationary time series and the business cycle. Econometrica: Journal of the Econometric Society .:357–384

Hansen LP, Singleton KJ (1982) Generalized instrumental variables estimation of nonlinear rational expectations models. Econometrica: Journal of the Econometric Society .:1269–1286

Kanas A (2008) On real interest rate dynamics and regime switching. Journal of Banking & Finance 32(10):2089–2098

Neal R, Rolph D, Morris C (2000) Interest rates and credit spread dynamics

Nelson CR, Schwert GW (1977) Short-term interest rates as predictors of inflation: On testing the hypothesis that the real rate of interest is constant. The American Economic Review 67(3):478–486

Perron P (1990) Testing for a unit root in a time series with a changing mean. Journal of Business & Economic Statistics 8(2):153–162

Rose AK (1988) Is the real interest rate stable? The Journal of Finance 43(5):1095–1112

Shen Y, Siu TK (2012) Asset allocation under stochastic interest rate with regime switching. Economic Modelling 29(4):1126–1136

Susmel R, Kalimipalli M, et al (2001) Regime-switching stochastic volatility and short-term interest rates. Tech. rep., Universidad del CEMA

Walsh CE (1984) Interest rate volatility and monetary policy. Journal of Money, Credit and Banking 16(2):133–150