Volatility Transmission of Overnight Rate along the Yield Curve in Pakistan

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Abstract

'This paper presented the empirical results of the volatility transmission of overnight rate along the yield curve in case of Pakistan. The results indicate that the volatility transmission of overnight repo rate is higher at the shorter end of the yield curve while lower at the longer end. These results are in line with both theoretical and empirical underpinning of the interest rates volatility transmission process found in other countries. Moreover, the results also suggest that the pass-through level of overnight volatility transmission to other market interest rates decreased after State Bank of Pakistan (SBP) adopted the interest rate corridor framework in August 2009. This indicates the enhancement of effective and smooth transmission of SBP policy rate changes to other market interest rates under the current framework. However, absence of any explicit desired level of operational target in the monetary policy framework of SBP still imparts higher volatility in interest rates when compared to other countries following the similar interest rate corridor framework.'

Keywords: monetary policy, volatility, yield curve, GARCH

JEL Classification: E4, E5, G1

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1. Introduction

In modern economic world, central bank ability to control short-term interest rates with high precision is necessary for credible monetary policy implementation. Today, most of the central banks employ overnight rate – the starting point of the yield curve – as the operational target of monetary policy frameworks. Besides signaling the monetary policy stance, the overnight rates also help in anchoring the term structure of interest rates. Hence, central banks try to avoid excessive volatility in overnight rate because; (1) any erratic volatility in these rates may prove to be detrimental for efficient market functioning through ineffective policy signals; and (2) this detrimental volatility in overnight rates may be transmitted to long-term rates which are more relevant from the perspective of consumption and investment decisions in the economy.

State Bank of Pakistan (SBP), like most other central banks use short-term interest rates to provide monetary policy signals in the economy. However, given the uncertainties related to liquidity situation in the money market, at times short-term rates indicate undesirable volatility. This excessive volatility at the short end of the yield curve not only complicates the monetary policy implementation process but may also leads to volatility in other important macroeconomic variables in the economy. In August 2009, to counter this unwarranted volatility at the short end of the yield curve, SBP adopted the interest rate corridor (IRC) framework by introducing overnight deposit facility in addition to already available overnight lending facility for the money market. The foremost reason behind this change in SBP's operational framework is to avoid excessive volatility in overnight repo rate i.e. its operational target as this may create disconnect between short and long-term interest rates in the economy.[1] However, compared to international standards, the volatility in overnight repo rate is still very high within this new IRC framework.

In this backdrop, the rationale of this paper is to empirically investigate the transmission of volatility in SBP's operational target i.e. overnight repo rate to other short and long-term interest rates in the term structure. Since, no prior study available for Pakistan on this topic, taking a lead from international studies and because of its significance in analyzing the volatile financial series like interest rates, GARCH model is used in this study for empirical investigations. The results suggest that the volatility transmission of overnight repo rate is higher at the shorter end of the yield curve while lower at longer end in case of Pakistan. These results are in line with both theoretical and empirical underpinning of the volatility transmission process found in other countries. Nevertheless, the important thing is that the pass-through coefficients found in this study depict higher values even

[1] Monetary Policy Statement, July-September 2009.

at longer end of the yield curve when compared to results of other countries following the same IRC framework for monetary policy implementation.[2]

The rest of the paper is organized as follows. Section 2 briefly reviews the SBP's operational framework for monetary policy implementation. Section 3 provides the results of the empirical model for overnight repo rate. Section 4 presents the results of volatility transmission of overnight repo rate along the yield curve. Section 5 makes the conclusion on the basis of results obtained in the previous sections.

2. Operational framework of SBP for monetary policy implementation: a brief review

Like most other central banks, SBP implements monetary policy by steering very short-term interest rates in the interbank money market. In particular, being the operational target, the overnight repo rate plays a central role in signaling the stance of monetary policy. However, unlike many other central banks SBP do not explicitly announce any desired or target level for its operational target. In fact, SBP used one of the rates on its standing facilities i.e. reverse repo rate as policy rate to give overall direction of monetary policy in the economy.[3] Hence, prior to August 2009, there were periods where large deviations between overnight repo rate and SBP's policy rate could be observed. Also, these deviations were not only produced high volatility at the shorter end of the yield but also at the longer end, which is more important one from the view point of real economic decisions.

[Insert **Figure 1**]

Furthermore, in absence of any desired level, it is evident from **Figure 1** that the occasional deviations in policy rate and overnight repo rate is largely explained by the movements in SBP's intervention rate in open market operations (OMOs).[4] Though dependent upon the market liquidity situation, however, these operations are mostly conducted once per week at the start of reserve maintenance period. So, any liquidity shock in the remaining weekdays that might be emanated from the developments in autonomous factors (includes; changes in government accounts, SBP's forex activities, public demand to hold currency over deposits, weekly reserve requirements, etc.) generates high fluctuations in overnight repo rate and hence increases its volatility. Importantly, in addition to period average reserve requirements, banks are also required to meet daily reserve requirements obligation in Pakistan. Hence, any shortfall or surplus in any individual bank's reserve position is also responsible for high volatility in overnight interest rates, particularly if it is a large bank.

[2] See, for example Alonso and Blanco (2005), Bartolini and Prati (2006), Prati et. al. (2003), etc.

[3] See **Table A1** in annexure for cross-country comparison of selected central banks' policy and target interest rates.

[4] Besides overnight rate, other interest rates also closely follow the changes in SBP's OMO rate (see **Figure A2** in annexure).

The interbank market in Pakistan, like other emerging markets, tends to deal mostly in shorter tenors, specifically in the overnight. Around 80 to 85 percent of the total transactions in both repos (secured) and call (unsecured) markets are being held on overnight basis only. Any erratic volatility in the prices of this market may prove to be detrimental for efficient functioning of this market segment, in general, and for overall monetary transmission mechanism, in particular. Therefore, with the rationale to reduce the excessive volatility in overnight repo rate SBP introduced the IRC approach in August 2009. Accordingly, in addition to already available discount or overnight lending facility, new overnight deposit facility for excess funds in the interbank money market was introduced. The spread between both the overnight standing facilities was 300 basis points (bps) initially which was further reduced to 250 bps from 11th February 2013 onwards. Though, this framework had 'automatically' reduced the volatility in overnight rates through binding it movements between ceiling and floor rates, nonetheless, **Figure 2** show that its movements within the corridor is still considered to be high compared to international standards.

[Insert **Figure 2**]

Is this volatility at the very short end of the yield curve is transmitting to other short-term and long-term rates or not? Given the objective of this paper, this is an important question and needs proper empirical investigations. Thus, next sections will discuss this issue in details.

3. Volatility in the overnight repo rate

The sample period for this study covers the daily of overnight repo rate, 1-month, 3-month, 6-month, 12-month, 1-year, 3-year, 5-year and 10-year Pak rupee revaluation rates (PKRV) from 3rd July 2006 to 31st October 2013 (2024 observations).[5] The major reason behind the selection of this data sample is the absence of credible data series for certain PKRV rates and more importantly overnight repo rate before July 2006. (Simple statistics for each data series are shown in **Table A2** in the annexure).

As with many financial series, money market interest rates display periods of volatility and periods of calm. This suggests the use of well-known generalized autoregressive conditional heteroskedasticity (GRACH) model to capture the volatility in overnight repo rates and other market interest rates.[6] Hence, taking a lead from Ayuso, Haldane and Restoy (1997), following GARCH (1,1) model is adopted to model the volatility in overnight repo rate in case of Pakistan;[7]

[5] Since the data for repo rates is not readily available, PKRV rates were used in this study. These rates are based on collateralized transactions, quoted as end day values for different tenors of the term structure.

[6] See Engle (1982) and Bollerslev (1986) for the seminal contribution. For the most recent empirical contribution see Demiralp et. al. (2006). Prati et. al. (2003) and Bartolini and Prati (2006) provide cross-country studies of the different behavior of overnight markets in several industrialized economies including the US and the euro area.

[7] The exponential (EGARCH) model used by Ayuso, Haldane and Restoy (997) was also experimented and found not to add much to what is presented in this paper.

$$\Delta r_t = \alpha + \beta(r - o)_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta r_{t-j} + \sum_{j=1}^{q} \eta_j \Delta o_{t-j} + \varepsilon_t \quad \ldots. (1)$$

$$\varepsilon_t \sim N(0, \sigma^2)$$

$$\sigma_t^2 = \pi + \delta\varepsilon^2{}_{t-1} + \rho\sigma^2{}_{t-1} + \omega DX_t \quad \ldots. (2)$$

In the mean equation (1) r_t denotes the nominal overnight repo rate, o_t is the SBP's OMO intervention rate and Δ is the first difference operator since each series turned out to be an I(1) variable.[8] In the variance equation (2) DX_t is consists of several dummies to get an effect of end of reserve maintenance period, end month, end quarter and corridor implementation period on volatility of overnight repo rate.[9] Moreover, an error correction term (ECT) i.e. the spread between the overnight repo rate and OMO rate is also introduced in equation (1). Though, SBP do not formally target the overnight repo rate in order to converge it to OMO rate. However, the ECT helps to understand the earlier highlighted behavior of market participants which closely follows the changes in SBP's OMO rate while transacting in the overnight money market.

[Insert **Table 1**]

Table 1 presents the estimation results for modeling overnight repo rate volatility in case of Pakistan. In the mean equation, the coefficient value of ECT i.e. spread between overnight repo rate and OMO rate suggests that only 0.06 points of the adjustment occurred in overnight repo rate in one day after a 1 percentage point increase in OMO rate. Statistically, this value is quite low when compared to other countries following the IRC approach and explains the absence of any effective interest rate targeting in the operational framework at SBP.[10] However, provided the magnitude of daily change in spread between overnight repo rate and OMO rate, still the coefficient is economically quite significant. Similar is the explanation about coefficients of both overnight repo rate (γ values) and OMO rate (η values). Importantly, in the variance equation, the value for persistence of volatility (δ+ρ) is 0.96. This indicates that due to relatively higher volatility, the variance process of overnight repo rate does not tend towards a mean value in a predictable way in the current SBP's framework.

It is also evident from **Table 1** that interestingly all the dummies that included in the variance equation for overnight repo rate found to be highly significant. The results suggest that on the last day of reserve maintenance period (EMP) and at the end of quarter (EQ) volatility in overnight repo rate declined. This pattern may reflect the high certainty about flows on that particular day. However, in

[8] In the initial estimations, all the dummies were also included in the mean equation. However, all were found to be insignificant. This may again reflects the absence of any explicit benchmark target interest rate in SBP's framework which creates high volatility in overnight repo rate in case of any change in liquidity position due to change in autonomous factors.

[9] While end month dummy basically captures the impact of outflows, particularly of tax related, the end quarter dummy is used to capture adjustments in government budgetary accounts and banks deposits. The dummy for corridor takes value of 0 for the period before the adoption of IRC framework and 1 otherwise.

[10] See, for example Alonso and Blanco (2005), Bartolini and Prati (2006), Prati et. al. (2003), etc.

the process of securing the reserves averaging position by financial institutions, the dummy for day before the end of reserve maintenance period (EEMP) show that volatility in overnight repo rate on average increased. Importantly, the coefficient for corridor dummy (CORR) is found to be significant with negative sign. This simply indicates the decline in levels of volatility in overnight repo rate after the introduction of IRC framework at SBP.

4. Volatility transmission of overnight rate along the yield curve

Although, the fluctuations in overnight rates are mostly influenced by liquidity conditions in the money market, nonetheless, central bank's operational framework and its communication strategies also plays important role in this regard. Today, most of the central banks try to stabilize the undesirable volatility at the very short end of the yield curve. This is because any transmission of this undesirable volatility in overnight rates to other short and long-term market interest rates may impact the consumption and investment decisions in the economy.

As discussed earlier that SBP, unlike most other central banks do not announce any explicit level for its operational target. Hence, provided the obligation of meeting daily reserves requirements – in addition to weekly reserves requirement – higher volatility in overnight repo rate is obvious, particularly in case of any liquidity shock. However, is this volatility in overnight repo rate is transmitting to other interest rates in the term structure or not? To answer this question, similar to the model for overnight repo rate with exclusion of error correction term (ECT), GARCH (1,1) model is estimated for 1-month, 3-month, 6-month, 12-month, 3-year, 5-year and 10-year PKRV rates. Specifically, following model for each maturity is regressed;

$$\Delta r_t^i = \alpha^i + \sum_{j=1}^{p} \gamma_j^i \Delta r_{t-j}^i + \sum_{j=1}^{q} \eta_j^i \Delta o_{t-j} + \varepsilon_t^i \quad \text{…. (3)}$$

$$\varepsilon_t^i \sim N(0, \sigma^{2,i})$$

$$\sigma_t^{2,i} = \pi^i + \delta^i \varepsilon^{2,i}{}_{t-1} + \rho^i \sigma^{2,i}{}_{t-1} + \omega^i DX_t + \lambda^i \sigma_t^{2,ON} \quad \text{…. (4)}$$

In the mean equation (3) r_t^i denotes the nominal interest rate with maturity i = 1-month, 3-month, 6-month, 12-month, 3-year, 5-year and 10-year PKRV rates. In the variance equation (4) the fitted GARCH variance ($\sigma_t^{2,ON}$) from the overnight repo rate model is used as an explanatory variable for other market interest rates. The coefficient values for parameter λ^i captures the pass-through effect of volatility in overnight repo rate along the yield curve, the main objective of this study. Positive values for the coefficient confirm the translation of higher volatility in overnight repo rate to other interest rates of the term structure.

[Insert **Table 2**]

It is evident from the **Table 2** that in the mean equation, the impact of changes OMO rate is found to be significant for all maturities but with different magnitudes at different tenors. In the initial estimations, the conditional variance of overnight repo rate obtained from the equation (2) is also included in equation (3) as an explanatory variable. However, the coefficient at each maturity is found to be insignificant which simply implies no role of conditional volatility in the overnight repo rate in determining the other short and longer term interest rates of the term structure.

However, the main focus of this study is the results of the variance equation for the selected market interest rates. In line with expectations, the dummies for calendar dates effects found to be mostly insignificant at longer tenors. Moreover, corridor implementation effect is quite visible at all tenors with high level of significance. Importantly, as evident from **Table 2** that the pass-through coefficient of overnight repo rate volatility along the yield curve (i.e. λ values) is found to be significant for all tenors. The results suggest that magnitude of overnight volatility transmission decreases for each high tenor on the yield curve (i.e. λ values). These results are in line with both theoretical and empirical underpinning of the interest rates volatility transmission process found in other countries.

Due to relatively higher volatility in overnight rates compared to other market rates, however, the estimated λ values are not considered as good measure for overnight volatility transmission along the yield curve.[11] Hence, two other adjusted measures were also calculated for getting the pass-through effect of overnight volatility transmission. The first calculates the average impact elasticity of overnight repo rate volatility and volatility of any particular tenor, computed as $\mathrm{ELAST_{SR}} = \lambda^{i} \frac{\bar{\sigma}^{2,ON}}{\bar{\sigma}^{2,i}}$. The second measure calculates the average equilibrium elasticity and computed as $\mathrm{ELAST_{LR}} = \frac{\lambda^{i}}{1-\rho^{i}} \frac{\bar{\sigma}^{2,ON}}{\bar{\sigma}^{2,i}}$.

[Insert **Figure 3**]

The results obtained from the computations of aforementioned two adjusted measures of pass-through effect are presented in **Figure 3**. The figure depicts that according to average impact elasticity approach, 1 percent increase in the variance of overnight repo rate increases the variance of 1-month PKRV rate by 1.54 percent when both variances are at the average level. Similarly, equilibrium elasticity approach suggest that due to a 1 percent increase in the variance of overnight repo rate, the variance of 1-month PKRV rate will increase by 2.82 percent. The pass-through impact decreases at longer maturities. Nonetheless, the impact remains significant, particularly according to more important equilibrium approach. This is because the latter approach also captures the impact of permanent shift in the volatility of overnight repo rate that observed after the implementation of IRC in August 2009.

[11] For instance, see Colarossi and Zaghini (2009)

[Insert **Figure 4**]

Moreover, given the high significance of corridor implementation on the volatility of overnight repo rate and other interest rates, **Figure 4** depicts the pattern of volatility before and after the IRC framework. The figure depicts that volatility in market interest rates has declined significantly after the corridor framework introduced in August 2009 (dark green bars). In addition, the results after the reduction of IRC width from 300 bps to 250 bps in February 2013 also indicates further decline in volatility in interest rates along the yield curve (light green bars). Though needs further empirical investigation, these results suggest the effective and smooth transmission of interest rates changes at shorter end of the yield curve to longer end, for the period within the IRC framework.

5. Concluding remarks

Like most other central banks, SBP steers the short-term interest rates to give the monetary policy signals in the economy. To achieve this objective smoothly, the bank try to keep these short-term rates stable and minimize their undesirable volatility by using its monetary policy instruments. In line with international best practices, SBP adopted the interest rate corridor framework for its monetary policy implementation in August 2009 and stated overnight repo rate as its operational target. The key rationale behind the introduction of this new framework was to avoid excessive volatility in overnight repo rates. This is because excessive volatility in overnight rates may be transmitted to other short and longer term rates which in turn effect the real decisions in the economy.

In this backdrop, this paper presented the empirical results of the volatility transmission of overnight rate along the yield curve. Simple GARCH model used to estimate the conditional volatilities of overnight rate and other market interest rates, and also test the volatility spillovers of the former to the latter.

The results indicate that the volatility transmission of overnight repo rate is higher at the shorter end of the yield curve while lower at the longer end. These results are in line with both theoretical and empirical underpinning of the interest rates volatility transmission process found in other countries. Moreover, the results also suggest that the pass-through level of overnight volatility transmission to other market interest rates decreased after SBP adopted the interest rate corridor framework in August 2009. This indicates the enhancement of effective and smooth transmission of SBP policy rate changes across the yield curve under the current framework. However, absence of any explicit desired level of operational target in the monetary policy framework of SBP still imparts higher volatility in interest rates when compared to other countries following the similar interest rate corridor framework.

Therefore, with an aim to make monetary policy more effective in achieving its desired results, SBP should focus on minimizing the still existing unwarranted volatility in its operational target. One simple way to attain this objective is to make SBP more transparent about its operational framework by explicitly announce the desired level of overnight repo rate along with the commitment to keep its deviations as small as possible from the chosen path.

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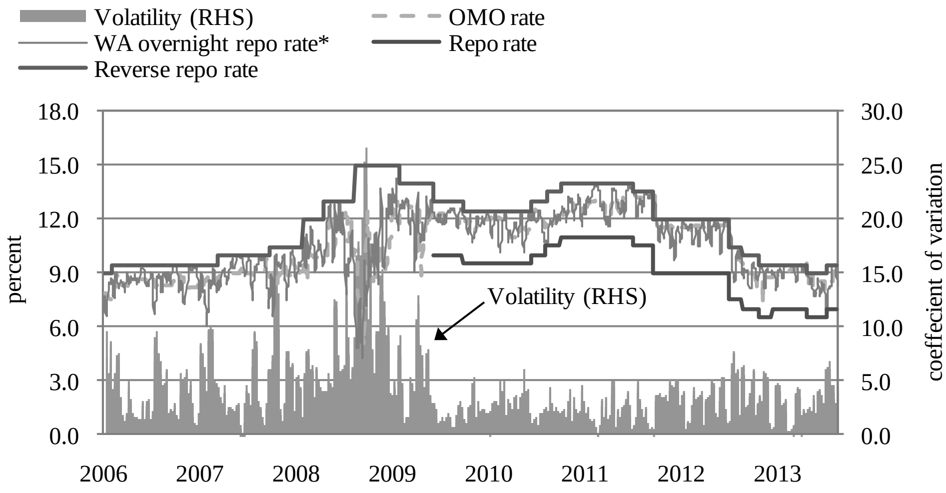
Appendices

Figure 1: Movements in SBP's Key Interest Rates



* 7 days moving average

Figure 2: Volatility in Operational Targets

(17th August 2009 to 31st October 2013)

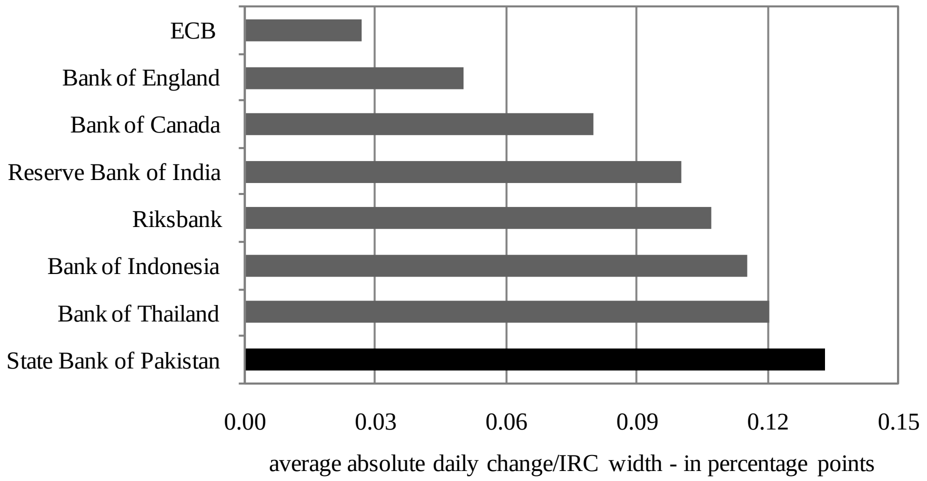


Figure 3: Volatility Transmission of Overnight Repo Rate along the Yield Curve - Pass-through Coeffecient

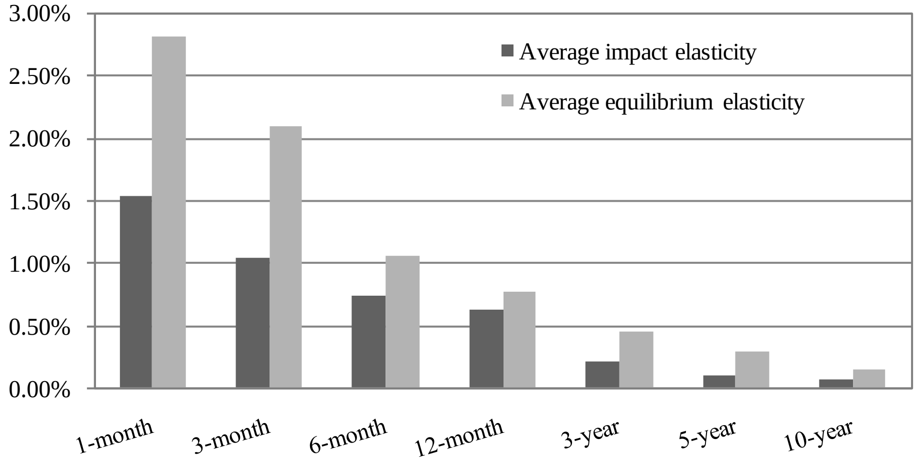


Figure 4: Mean of Conditional Variance

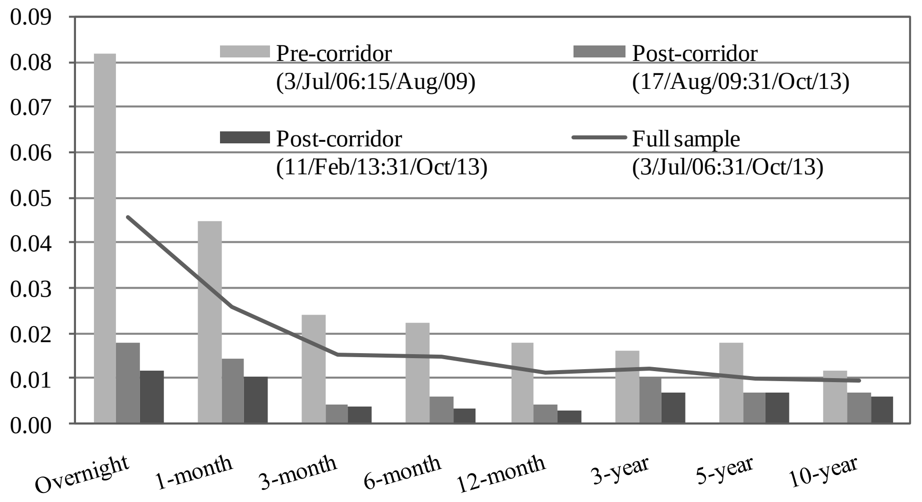


Table 1: Estimation Results for Overnight Repo Rate					
Mean equation			**Variance equation**		
Parameter	**Coefficient**		**Parameter**	**Coefficient**	
α	0.0034	*	π	0.0014	***
β	-0.0574	***	δ	0.1357	***
γ_1	0.6469	***	ρ	0.8288	***
γ_2	-0.0499	**	ω_{EMP}	-0.0030	***
η_1	0.1490	**	ω_{EEMP}	0.0036	***
η_2	-0.0586	**	ω_{EQ}	-0.0062	**
			ω_{CORR}	-0.0010	***

Note: Sample period is based on daily data from 3rd July 2006 to 31st October 2013; one, two and three asterisks denote statistical significance at 90, 95 and 99 percent respectively.

Table 2: Estimation Results for Other Interest Rates in the Term Structure														
	1-month		**3-month**		**6-month**		**12-month**		**3-year**		**5-year**		**10-year**	
Mean equation														
α	0.0046	***	0.0040	***	-0.0007	***	-0.0015	***	0.0018	***	0.0003	*	0.0020	*
γ_1	0.1068	***	0.0812	**	0.1781	**	0.2292	**	0.2235	**	0.1157	**	0.0940	**
γ_2	-0.2182	***	-0.2817	***	-0.0959	***	-0.1030	***	0.0445	**	-0.0393	***	0.0178	**
η_1	0.1166	**	0.1297	***	0.0158	***	0.1097	***	0.0207	**	0.0514	**	0.1028	**
η_2	-0.0216	*	-0.0232	***	0.0284	***	-0.0204	***	0.0540	**	-0.0063	**	0.0084	**
Variance equation														
π	0.0014	***	0.0001	***	0.0002	***	0.0036	***	0.0006	***	0.0002	**	0.0001	***
δ	0.7081	***	0.8746	***	0.6893	***	0.3167	***	0.9875	***	0.5806	***	0.1828	***
ρ	0.4548	***	0.5047	***	0.4562	***	0.5088	**	0.1368	**	0.6086	***	0.8107	***
ω_{EMP}	0.0059	*	-0.0025	*	-		-		-		-		-	
ω_{EEMP}	0.0038	*	0.0024	*	-		-		-		-		-	
ω_{EQ}	-		-0.0002	*	-		-0.0323	*	-		-		-	
ω_{CORR}	0.0002	***	0.0001	**	0.0005	***	-0.0006	**	0.0010	**	-0.0001	**	-0.0001	***
λ	0.0076	***	0.0039	**	0.0034	***	0.0022	***	0.0016	***	0.0015	***	0.0010	***
$\delta+\rho$	1.1628		1.3793		1.1456		0.8255		1.1243		1.1892		0.9935	

Note: Sample period is based on daily data from 3rd July 2006 to 31st October 2013; one, two and three asterisks denote statistical significance at 90, 95 and 99 percent respectively.

Table A1: Cross-country Comparison of Selected Central Banks' Policy Interest Rate and Target Interest Rate		
Central bank	**Policy rate**	**Target rate**
Reserves Bank of Australia	Interbank cash rate	Interbank cash rate
Central Bank of Brazil	Selic rate	Selic rate - interest rate on overnight interbank loans collateralized
Bank of Canada	Overnight rate	Overnight rate on collateralized transactions
European Central Bank (ECB)	Minimum bid rate in MRO*	No formal operational target
Reserve Bank of India	Repo rate	Weighted average call money rate
Bank of Japan	Uncollateralized overnight call rate	Uncollateralized overnight call rate
Bank of Korea	Base rate	Overnight call rate
Bank of Mexico	Interbank overnight rate	Interbank overnight rate
Riksbank	Repo rate	Interbank overnight rate
Swiss National Bank	CHF 3-month Libor	Target range for 3-month Libor
Bank of England	Bank rate	Overnight rate
Federal Reserve System	Federal Funds rate	Federal funds rate – uncollateralized
Bank of Thailand	1-day repurchase rate	1-day repurchase rate

* main refinancing operations

Source: Central banks' websites, BIS

Table A2: Simple Statistics of Selected Interest Rates						
Series	**Mean**	**Median**	**Maximum**	**Minimum**	**Standard Deviation**	**Coefficient of Variation**
OMO rate	10.48	10.56	13.51	4.88	1.75	16.73
Overnight repo rate	10.45	10.49	14.28	4.26	1.84	17.62
Spread (ONR-OMO)	-0.03	0.03	3.24	-5.21	0.81	-
1-month	10.90	11.63	13.53	7.88	1.64	15.04
3-month	11.05	11.75	13.83	8.24	1.71	15.51
6-month	11.17	11.83	14.22	8.41	1.76	15.78
12-month	11.30	11.91	14.48	8.75	1.77	15.63
3-year	11.76	12.22	15.62	9.25	1.69	14.36
5-year	12.01	12.35	16.11	9.48	1.65	13.76
10-year	12.33	12.48	16.65	9.82	1.54	12.45

Data sample: 2024 observations (3rd July 2006 to 31st October 2013)

Source: SBP, Financial Markets Association of Pakistan

Figure A1: Overnight Repo Rate - Conditional Varaince

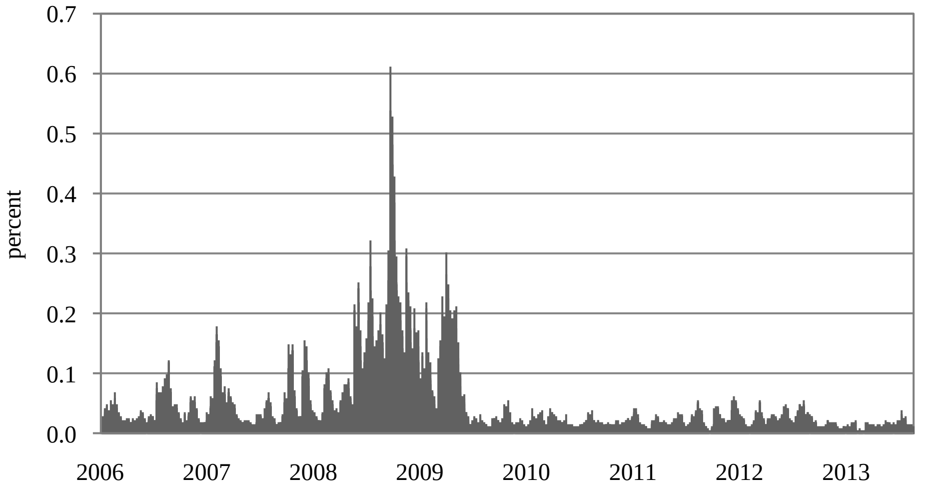


Figure A2: SBP's Key Interest Rates and PKRV Rates