Return, shock and volatility co-movements between the bond markets of Turkey and developed countries

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Abstract

In this study, we present a VAR-BEKK model to investigate the co-movements of long-term interest rates between Turkey and four developed (Germany, Japan, USA and UK) markets . We use weekly rates on the 5-year maturity government bonds for the period of February 10, 2006 to September 12, 2014 containing 448 observations. We empirically document that, while Turkish bond market is only correlated with Japanese and the US markets, there are strong ties between the returns and volatility of developed bond markets. Our findings indicate most of the movements in international government bond markets is a product of global risk factors rather than country specific factors.

JEL codes: C32; C51; G15

Keywords: Bond market co-movement; volatility spillover; BEKK-GARCH model

1 Introduction

There has been growing interest on studying the interconnections in international financial markets during last several years due to recent global financial crises of US sub-prime mortgage crisis and European sovereign debt crisis. Identifying the linkages among the international interest rates is of pivotal importance for both financial economics and macroeconomics aspects. As proposed by Yang (2005) studying co-movements of international interest rates may shed a light on the cost of fiscal deficit, monetary policy-making, forecasting interest rate movements and benefits of bond portfolio diversification.

Barassi et al. (2001) point out that bond rates can be treated as either financial assets or macroeconomic policy instruments. Bond rates as financial assets may tend to move together with the increasing globalization and capital flows across international financial markets. Conversely, if bond rates are seen as a macroeconomic instruments, the co-movement of bond rates are perplexed by the degree of national monetary and fiscal policy decisions. Therefore, it might be worthwhile to empirically test the co-movement dynamics of the international bond rates for a number of reasons. First of all, understanding the interdependence in international bond markets is important to know how economic and financial shocks are transmitted across the globe. Secondly, interconnectedness of international bond markets is vital in terms of managing monetary policies. Because, the domestic monetary policies are highly related to the degree of co-movement between domestic and foreign interest rates. Therefore, co-movements of bond rates across times and frequencies are crucial for both public and private economic agents as well as for international inverstors to build a well diversified portfolio.

In this study, we investigate the dynamics of the sovereign interest rate co-movements by applying VAR(1)-BEKK(1,1) model which will enable us to assess time-varying conditional correlations and spillover effects of return, shock and volatility dynamics. The rest of this paper is organized as follows. Literature review is given in 2. 3 presents the details of the methodological framework. Empirical results are presented and analysed in 4 and 5 concludes.

2 Literature review

There are several studies in the literature that carried out on exploring the linkages of international bond markets. There are mixed empirical results depending on sample period and econometric methodology used. While, some of them argue that bond yield and returns across different countries are positively correlated and move together. There are some studies contradict this argument as finding no significant evidence on the bond market integration. Furthermore, some researchers also assert that integration are more likely to increase during the turmoil periods or after the certain events (for example; introduction of Euro, September 11, Lehman Brothers collapse). In this part, we will summarize the results of some existing studies in the field.

Yang (2005) conducted a research to reconnoitre the government bond market linkages among the six European (Germany, France, Italy, the UK, Belgium and the Netherlands) with using co-integration, Granger causality and forecast error variance decomposition methods. The study reports the weak existence of a long-term relationship among the European bond markets. However, according to the results from the forecast error decomposition analysis there are generally co-movements among the markets without a distinctive leadership.

Kim et al. (2006) looked into integration dynamics of EU countries by utilizing Kalman filter and bivariate EGARCH models and found evidences of strong linkages between German and EU markets. The study also reveals that the relationship between the UK and German markets are weaker than those of the UK and other EU members.

Ciner (2007) explored interactions among the government bond markets of four major developed countries (US, Germany, Japan and the UK) between 1988 and 2005. He detects no empirical evidence of co-integration among the bond markets for the full period. However, he demonstrates that there are strong causal associations between markets for the period of 1996-2005.

Skintzi and Refenes (2006) conducted a research to shed a light on the integration dynamics and volatility spillover effects of European and US bond markets. They support the idea of spillover effect from the US to European bond markets. They also remark that integration among European bond markets has multiplied after the introduction of Euro. The empirical results of strong co-movements among European bond markets after the circulation of single currency were also documented in the studies of Cappiello et al. (2006) and Christiansen (2007).

Laopodis (2008) also studied the government bond market linkages among the European countries by using Granger causality tests. He posits several bi-directional linkages among the European bond markets. The results of the analysis also suggest unidirectional causal effects from the US bond market to the European markets. On the other hand, Abad et al. (2010) analysed the impact of single currency Euro on European bond market integration by utilizing CAPM based linear regression model and found EU and US sovereign bond markets display a weak level of integration for the period of 1999-2008. However, their result suggest that there is a strong link between the US and German bond yields.

A recent study of Matei (2013) employs multivariate Granger causality analysis to explore the bond market ties among EU countries for the period between

2003 and 2013. She argues that although, the bond market integration among EU countries became stronger after the initiation of Euro, not all the bond markets have strong relationship in the long-run. The results from the study show that "'core"' countries (Germany, France, and Italy etc.) are more integrated than the "'periphery"' countries (Ireland, Greece and Portugal). Overall, she found a weak degree of integration among the EU markets and direction of causality changes during the turbulent periods which can be interpreted as a contagion effect. Therefore, it is a difficult task for European Central Bank's monetary authorities to manage the long-term interest rates to maintain the price stability.

Apart from studies examining the relationship between developed bond markets, there are few studies that investigating the emerging and frontier markets. A study on the integration dynamics of emerging bond markets has been carried out by Cifarelli and Paladino (2006). They applied principal component analysis (PCA) and orthogonal GARCH (O-GARCH) methods to the daily spreads of the sovereign emerging bonds. They claim that conditional covariances among the emerging bond spreads tend to increase during the crisis times.

Thupayagale and Molalapata (2012) investigated the degree of interdependence among three emerging bond markets (Mexico, South Africa, and South Korea) and the US with vector autoregressive (VAR) and DCC-GARCH methods. They indicate that emerging market bonds are not co-integrated in the long-run. They also found no statistically significant short-run relationship among the markets. Moreover, impacts of the US bond rates on these emerging market bonds are limited.

Piljak (2013) assess the time-varying evolution of the correlations of the then emerging and four frontier bond returns with the US bond returns between October 2000 and December 2011 with DCC-GARCH model. His results validate that only Malaysian market returns show positive correlation with the US returns during the whole period. China, Mexico, Poland and South Africa have generally show positive correlation while Brazil, Russia, Turkey and Ecuador have predominantly negative correlations with the US.

Integration of Asian bond markets with the US and Australian markets has been studied by Vo (2009). Their empirical results do not show a high level of integration between the Asian bond markets with the US and Australian markets which can be accredited to home country bias in Asian markets.

3 Econometric Framework

In order to capture the joint process between international bond yield returns, we consider the following econometric model.

$$\begin{aligned} X_t &= \omega + \Theta_1 X_{t-1} + \Theta_2 X_{t-2} + ... + \Theta_p X_{t-p} + \varepsilon_t \\ \varepsilon_t | \Omega_{t-1} &\approx N(0, H_t) \end{aligned} \tag{1}$$

with X_t is an $(nx1)$ vector of daily returns at time t and Θ is a (nxn) matrix containing the coefficients related with the lagged returns. For the five variable VAR(1) model, which we apply in this study, the Eq.1 can be represented as;

$$\begin{bmatrix} x_{1,t} \\ x_{2,t} \\ x_{3,t} \\ x_{4,t} \\ x_{5,t} \end{bmatrix} = \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \\ \omega_5 \end{bmatrix} + \begin{bmatrix} \theta_{11} & \theta_{12} & \theta_{13} & \theta_{14} & \theta_{15} \\ \theta_{21} & \theta_{22} & \theta_{23} & \theta_{24} & \theta_{25} \\ \theta_{31} & \theta_{32} & \theta_{33} & \theta_{34} & \theta_{35} \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} & \theta_{45} \\ \theta_{51} & \theta_{52} & \theta_{53} & \theta_{54} & \theta_{55} \end{bmatrix} \begin{bmatrix} x_{1,t-1} \\ x_{2,t-1} \\ x_{3,t-1} \\ x_{4,t-1} \\ x_{5,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \end{bmatrix} \tag{2}$$

In the above VAR(1) model, $x_{i,t}$ for $i = 1, 2, 3, 4, 5$ represents the returns of the bond The diagonal elements θ_{ii} in matrix Θ measure the effect of respective bond's lagged own returns, while the off-diagonal elements $\theta_{i,j}$ represent the connections in terms of bond yield returns also known as return spillovers. The random errors $\varepsilon_{i,t}$ are the innovations of each return at time t with corresponding ($5x5$) conditional variance-covariance matrix H_t. The vector of c represent constant terms. Engle and Kroner (1995) showed that conditional variance matrix H_t can be modeled by a linear function of the past squared errors and cross products of errors and past values of the elements of variance-covariance matrix H_t, thus H_t can be represented as:

$$H_t = C^T C + A^T \varepsilon_{t-1}^T \varepsilon_{t-1} A + B^T H_{t-1} B \tag{3}$$

where **C** is a ($5x5$) lower triangular matrix (to induce the positive semi-definiteness of H_t) containing the constant terms. **A** is a ($5x5$) matrix of the coefficient corresponding to the lagged squared errors. The elements of matrix **A** measure the impacts of 'innovations' or shocks on the conditional variances. The ($5x5$) matrix **B** signifies the effects of past values of conditional variance-covariance matrix onto the current one. The matrices **A** and **B** capture the ARCH and GARCH effects of the volatility process. The diagonal coefficients $\alpha_{i,i}$ (for $i = 1, 2, 3, 4, 5$) of matrix **A** shows the dependence of current conditional variances $h_{i,i}$ on their lagged squared errors, whereas the effects of the past conditional variances of $h_{i,i}$ are indicated through significance of the parameters $\beta_{i,i}$. The effects of cross-shocks and cross-volatilities are measured with off-diagonal elements $\alpha i, j$ and $\beta_{i,j}$ of the matrices **A** and **B**.

The estimation of the BEKK(1,1) model can be utilized via the maximizing the conditional log likelihood function $L(\Phi)$ which has the following expression:

$$L(\Phi) = -Tlog(2\pi) - 0.5\sum_{t-1}^{N} log|H_t(\Phi)| - 0.5\sum_{t-1}^{N} \varepsilon_t(\Phi)^T H_t^{-1}\varepsilon_t(\Phi) \qquad (4)$$

where, N is the number of observations and Φ denotes the parameter set to be estimated.

4 Empirical Results

4.1 Initial data analysis and descriptive statistics

Bond yield data for Turkey and for the four developed economies, namely Germany, Japan, United States and the United Kingdom are retrieved from Bloomberg database. The sample period spans from February 10, 2006 to September 12, 2014 containing 448 weekly observations of the yields on the 5-year maturity government bonds. The log-returns of the bond yields are calculated as the growth rate of bond yields, $X_t = ln(R_t) - ln(R_{t-1})$, where R_t bond rate at time t. Figure 1 illustrates the time series plots of the yields (R_t) and returns (X_t) of the Turkish and international 5-year government bonds.

From the figures, we can spot that yields of the German, US and UK long-term government bonds have close relationship. Yields of the Japanese and Turkish bonds deviate from this relationship but have some similar moving tendency during several specific time periods (for example; sharp falls after the Lehman Brothers collapse). Since, world financial markets are experiencing harsh times due to recent global crises, investors tend to move from stock markets to bond markets. As a consequence, we witness a downward trend for the bond yields resulted from bond price increases.

Descriptive statistics of the log-returns are presented in Table 1. From these statistics, we notice that Turkish bond returns show lower unconditional risk as measured by the standard deviation of daily bond yield returns than the developed markets. The kurtosis and skewness statistics indicate that non-normality is a common phenomenon for bond market return distributions. Jarque-Bera statistics also recommend that bond market returns do not obey the normal law. We conclude that all return series are stationary as suggested by ADF test statistics.

4.2 Unconditional correlation analysis

Table 2 reports the pairwise unconditional correlation coefficients between the international bond markets. Overall, we observe high degree of co-movements between the UK, the USA, and Germany with correlation values range from 0.62 to 0.72. Japan has weaker degree of relationships with other markets as suggested by correlation coefficients lower than 0.5. Moreover, relationship between Turkish and Japanese markets is statistically insignificant. Overall, we find that developed markets seem to be more integrated and correlations between the Turkish and developed bond market returns are positive and statistically significant (except with Japan), but they are weak with coefficients lower than 0.5.

From the point of Turkish investors, low correlation coefficients enrich potential portfolio diversification benefits by investing in international bond markets. Reversely, Turkish bond markets might be attractive for the international investors in terms of diversifying their portfolio risks. However, as Graham et al. (2012) point out using simple correlation coefficients for analysing the co-movements between the financial markets and make portfolio allocation decisions could be deceptive due to temporal instability of such correlation coefficients. Therefore, we must turn to more advanced techniques to expose the integration dynamics of the international bond markets.

4.3 VAR-BEKK estimation results

In order to see the time-varying evolutions of conditional correlations between Turkish and international bond returns and spot the direction of spillovers, we applied a VAR(1)-BEKK(1,1). We present the estimated coefficients of the matrices Θ, $\mathbf{A}$ and $\mathbf{B}$ in Table 3.

In order to examine the relationship in terms of bond yield returns; we inspect the elements of matrix Θ of the 2 captured by the coefficients $\theta_{i,j}$ in the panel A of Table 3. We notice that diagonal elements $\theta_{1,1}$, $\theta_{4,4}$ and $\theta_{5,5}$ are statistically insignificant meaning that bond yield returns of Turkey, USA and the UK do not depend on their lagged values. On the other hand, German and Japanese bond yields have dependence on their past returns as indicated with significant parameters $\theta_{2,2}$ and $\theta_{3,3}$.

When we look at the off-diagonal elements of the matrix Θ; we observe following patterns for the cross-market linkages among bond yield returns. First of all, the significant $\theta_{1,5} = 0.117$ parameter suggests that Turkish bond yield returns respond positively to the changes in the UK bond returns. While we observe a uni-directional return spillover from US market to Japanese market with parameter $\theta_{3,4} = 0.199$, Japanese bond market has bidirectional relationship with German and the UK markets as exposed with statistically significant coefficients of $\theta_{2,3} = 0.105$, $\theta_{3,2} = -0.101$, $\theta_{3,5} = 0.167$ and $\theta_{5,3} = 0.067$. The estimation results of the mean equation reveal that Japanese bond market are sensitive to changes originated from other developed markets.

To see the cross-market shock and volatility transmissions, we look into estimated parameters of BEKK model given as $\alpha_{i,j}$ and $\beta_{i,j}$ in the panel B of Table 3. As stated earlier, the diagonal elements of matrix $\mathbf{A}$ measure the own past shock or ARCH effects, while the diagonal elements of matrix **B** measure own past volatility or GARCH effects. As presented in Table 3, the statistically significant diagonal parameters α_{11}, α_{22}, α_{33} and α_{55} are implying the existence of ARCH effect in the bond returns of Turkey, Germany, Japan and the UK. Furthermore, the diagonal coefficients β_{11} through β_{55} are all statistically significant showing a strong presence of GARCH effects. Thus, conditional variances of all bond returns are driven by a strong GARCH(1,1) process.

We inspect the off-diagonal elements of matrix **A** and **B** to understand the cross-market linkages in terms of shock spillover and volatility spillover among international bond markets. Firstly, we document a two-way negative shock transmission between Turkey and Japan at 1% significance level. News on Turkish bond market have also moderate impact on the conditional volatility of the US bond returns at 5% level. There also exists a bidirectional shock spillover between Japanese and US bond markets. While, the shocks on Japanese bond returns have positive effect over the US bond returns, Japanese bond return volatility respond negatively to the news from the US market.

Moreover, we found evidence of unidirectional negative shock transmission from German and the UK markets to Japan. The significant α_{24}, α_{42} and α_{25}, α_{52} and α_{45}, α_{54} indicate strong bidirectional shock spillover between Germany and US; between Germany and UK; and between US and UK at 1% significant level. There are strong bidirectional volatility spillovers between Turkish and Japanese market as shown with parameter $\beta_{13} = 0.338$ and $\beta_{31} = -0.107$. The past volatility shocks in Japanese bond market have also negative effects on the future volatility in the UK bond market. The bidirectional volatility transmission mechanisms are also present between Germany and US; Germany and UK; US and UK.

Our empirical finding for this part advocate that; Japan is the main return and shock spillover receiver, and future volatility of the UK bond market heavily depend on past volatility shock from other markets, specifically UK is the main volatility receiver. It is also interesting that there is a strong bidirectional shock and volatility linkages between Turkish and Japanese bond markets which can be attributed to the carry-trade phenomenon.

5 Conclusion

For this study, we implemented VAR-BEKK model, for empirical purposes, to investigate the co-movements among the international bond markets at returns, shock and volatility level. Our empirical results for this chapter have some implications from the point of macroeconomic perspective. First, the higher degree of co-movement indicate greater shock transmission exist in world bond market with possible adverse consequences of the monetary policy stability. Central banks of the developed markets have more difficult tasks of implementing and controlling monetary policy (as their aim is to control interest rates and maintain price stability).

Moreover, higher degree of bond market integration has important implications for the fiscal policy maintenance. As suggested by Claeys et al. (2010), with the increasing glabalization, capital mobility and trade flows among countries have profilarated in last decade driving both domestic and foreign agents to seek out diversification benefits across borders. As a consequence, budget deficits of one economy are not solely financed by domestic resources. Fiscal policies of governments heavily depend on international capital markets. Reversely, fiscal decisions of one goverment has impact on all other capital markets in an integrated economic environment.

In conclusion, the results documented in this chapter are in line with some of the earlier literature (Driessen et al., 2003; Barr and Priestley, 2004; Engsted and Tanggaard, 2004, 2007) suggest that most of the movements in international government bond markets is a product of global risk factors rather than country specific factors. A further study will be needed to uncover the precise reasons and risk factors behind the bond rate co-movements in the international markets.

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6 Appendix: Tables and Figures

Table 1 Summary statistics of the bond yield returns

	Germany	Japan	Turkey	UK	USA
Mean	-0.0062	-0.0042	-0.0008	-0.0020	-0.0022
Maximum	0.6090	0.3331	0.2349	0.3446	0.3313
Minimum	-0.5897	-0.2092	-0.1682	-0.2281	-0.2669
Std. Dev.	0.1077	0.0721	0.0373	0.0656	0.0710
Skewness	0.5660	0.6149	0.3760	0.7665	0.4143
Kurtosis	9.8270	5.0314	8.1314	6.9145	5.0463
Jarque-Bera	893.94	105.27	502.08	329.90	90.98
ADF	-23.211	-21.044	-20.808	-22.182	-22.793

Table 2 Unconditional correlations between bond yield returns

	Turkey	Japan	Germany	UK	USA
Turkey	1				
Japan	0.0127	1			
Germany	0.1458**	0.2587**	1		
UK	0.1158**	0.3027**	0.7252**	1	
USA	0.1898**	0.3479**	0.6245**	0.6407**	1

** denotes 5% significance level

Table 3 Estimated coeffcients for VAR(1)-BEKK(1,1) model

Panel A										
	Turkey (i=1)	t-stat	Germany (i=2)	t-stat	Japan (i=3)	t-stat	US (i=4)	t-stat	UK (i=5)	t-stat
$\theta_{i,1}$	0.032	0.65	0.008	0.14	0.036	0.43	0.098	1.50	0.040	0.74
$\theta_{i,2}$	-0.044	-1.88	*-0.166*	-2.71	*-0.101*	-2.15	*-0.107*	-2.54	-0.070	-1.84
$\theta_{i,3}$	-0.047	-1.79	**0.105**	2.90	*-0.124*	-2.35	0.045	1.14	*0.067*	2.00
$\theta_{i,4}$	0.035	1.01	0.017	0.32	**0.199**	3.13	-0.079	-1.40	0.088	1.75
$\theta_{i,5}$	**0.117**	3.00	0.081	1.05	*0.167*	2.10	0.116	1.61	-0.058	-0.95

Panel B										
	Turkey (i=1)	t-stat	Germany (i=2)	t-stat	Japan (i=3)	t-stat	US (i=4)	t-stat	UK (i=5)	t-stat
$\alpha_{i,1}$	*0.148*	2.51	0.016	0.76	**-0.124**	-4.83	*0.090*	2.69	-0.026	-0.84
$\alpha_{i,2}$	-0.023	-0.49	**0.575**	9.55	**-0.126**	-3.41	**0.217**	4.59	**-0.525**	-5.59
$\alpha_{i,3}$	**-0.329**	-4.51	-0.025	-0.60	**-0.272**	-4.70	**0.255**	4.38	0.098	1.38
$\alpha_{i,4}$	-0.059	-1.26	**0.132**	3.24	**-0.162**	-4.86	-0.008	-0.17	*-0.140*	-2.59
$\alpha_{i,5}$	-0.099	-2.61	0.050	1.27	**-0.164**	-5.78	**0.311**	8.38	*-0.146*	-2.66
$\beta_{i,1}$	**0.874**	14.93	0.017	1.47	**-0.107**	-6.03	0.004	0.21	-0.023	-1.56
$\beta_{i,2}$	0.002	0.03	**0.945**	44.97	-0.016	-0.64	**0.098**	5.43	**-0.202**	-7.44
$\beta_{i,3}$	**0.338**	3.55	0.049	1.99	**0.890**	33.14	0.014	0.50	**-0.135**	-4.05
$\beta_{i,4}$	0.093	1.66	**0.047**	2.92	-0.043	-1.60	**0.990**	76.94	**-0.098**	-5.15
$\beta_{i,5}$	0.035	0.95	**0.084**	5.52	-0.031	-1.61	**0.042**	3.21	**0.830**	42.32

Note: $i = 1, 2, 3, 4, 5$ stands for Turkey, Germany, Japan, US, and UK respectively.
Coefficients, θ, α, and β represent return, shock and volatility effects.
Significant coefficients at 1% and 5% levels are presented in **bold** and *italic* fonts respectively

Figure 1 International 5-year government bond yields and returns