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The impact of domestic and global factors on individual public, domestic and foreign bank performances in Türkiye

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ABSTRACT

The Turkish economy has encountered significant shocks in interest rates and foreign exchange along with global risks in recent years. These shocks had an impact not only on the real sector but also on the banking sector's returns, depending on the ownership structure. This study examines the sensitivity of banking sector stock returns to the exchange rate, interest rate, and VIX index using data from January 4, 2005 to March 28, 2023. Using multivariate diagonal BEKK-GARCH methodology, the study found that (i) half of private banks experienced a mean spillover from the interest rate to their returns, but not from the exchange rate and VIX index, (ii) the returns of public banks, on the other hand, did not respond to any variable in the mean equations, (iii) the explanatory power of exchange rate and interest rate risks is higher than the power of the changes in these variables, (iv) the spillover of global risk in covariance equations is higher compared to exchange and interest rate risks, (v) the mean equations do not have an asymmetric structure, but the covariance equations exhibit structural breaks. These findings suggest that in the last decade, the interest rate policy has become the main variable affecting the stock returns in Türkiye, foreign exchange has become a safe haven due to this policy, and the relationship between the exchange rate and stocks that existed in the past has been disrupted.

1. Introduction

In the last two decades, there has been an improvement in the performance of the banking sector in Türkiye due to swift restructuring, advancements in technology and a succession of liberalisation reforms. The 2001 banking crisis, which caused bankruptcy of 24 banks and had a deep impact on the Turkish economy, was the key reason behind the restructuring. The BRSA (Banking Regulation and Supervision Agency) monitors and regulates the banking sector's activities closely following the crisis-driven legislation to restructure the sector.

The progress in technology worldwide has significantly contributed to enhancing the banking sector in Türkiye by enabling banks to integrate these advancements into their business areas (Kasman, 2012). The expansion of financial service activities has simultaneously increased competition in the banking sector and strengthened integration between banks. Whilst the increase in integration between banks increased competition in the sector and result in higher productivity (Tan and Floros, 2018), it equally exposed all banks to similar adverse shocks affecting the sector (Dungey et al., 2020). Moreover, the increase in the

degree of integration among banks has led to a banking system that is more vulnerable to the spillover of shocks (Forbes and Rigobon, 2002; Abreu and Mendes, 2010; Assidenou, 2011; Coeurdacier and Guibaud, 2011; Mun and Brooks, 2012; Dungey et al., 2020). Since shocks to the banking system have a profound impact on the competitiveness of banks, it is of great importance to investigate how the shocks that hit the banking system affect the performance of banks operating in the sector.

Possible impacts on the banking system can arise both from foreign and domestic sources. The negative impact of global developments leads to an increase in non-performing loans, which adversely may affect the real sector. The volume of credit may contract, while the cost of credit extended by banks rises. Non-financial sectors that cannot use bank loans may be adversely affected, leading to a contraction in the real economy. Shocks to the banking sector may spill over to the non-financial sector through two channels: the financial channel and the demand channel (Tong and Wei, 2015). In times of recession, the demand channel arises due to the low level of consumption, while the financial channel is related to the disruption in the flow of credit during a banking crisis (Peek et al., 2003; Laeven and Valencia, 2013).

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Empirical researches indicate that the performance of the banking industry is significantly influenced by foreign shocks, as revealed in previous studies by [Cetorelli and Goldberg \(2011\)](#), [Balcilar and Demirer \(2015\)](#), and [Tiwari et al. \(2022\)](#).¹ Several studies addressed particular shocks, such as [Cetorelli and Goldberg \(2011\)](#), who contended that global banks played a significant role in disseminating the impacts of global shocks, particularly during the global financial crisis. However, a significant number of studies concentrated on the influence of uncertainty or volatility indices on the stock returns of banks ([Hajilee and Nasser, 2017](#); [Aljarayesh et al., 2018](#); [Ferreira Martins et al., 2021](#)). Ultimately, analyses by both groups demonstrated that global impacts play a significant role in the returns on banks' stocks.

Domestic issues, in addition to global events, exert a significant impact on the banking sector. In recent years, in Türkiye, the policy rate has been set significantly below the inflation rate, and additional measures have also been implemented to minimize the excessive fluctuations in exchange rates. In addition, the Banking Regulation and Supervision Agency (BRSA) has issued several regulations for both the bond and foreign exchange markets, limiting the scope of banks in the economy. These recent developments have led to increased economic uncertainty since May 2018 ([Demiralp and Demiralp, 2019](#)). Given that sudden fluctuations in interest rates and exchange rates can severely harm banks' performance ([Lloyd and Shick, 1977](#); [Flannery and James, 1984](#); [Hancock, 1985](#); [Grammatikos et al., 1986](#): 671; [Demirguc-Kunt and Huizinga, 1999](#); [Den Haan et al., 2007](#); [Zeitun et al., 2007](#); [Kasman et al., 2011](#); [Hajilee and Al Nasser, 2014](#); [Aydemir and Demirhan, 2009](#)), studying and analysing the spillover effects of shocks caused by these variables on banks' stock returns is crucial.

Apart from the national developments, bank ownership could also lead to variations in the industry. Out of the banks operating in Türkiye, three are public banks, and two of them have publicly traded shares. Public banks, unlike private banks, are not profit-oriented institutions by nature. Consequently, these banks may react differently to interest rate and foreign exchange market fluctuations compared to private banks, i.e. the exchange rate and interest rate risks faced by public banks may be different from the risks faced by other banks. Thus, it is crucial to evaluate public banks separately. On the other hand, it is of utmost importance to examine the response of foreign banks to changes in the exchange rate and interest rate in the economy, as foreign banks are more likely to have access to external financing than private and public banks.

This study investigates the effect of interest rates, exchange rates, and global factors on individual bank returns in Türkiye. We focus on public banks, private domestic banks, and private foreign banks since these factors have seen significant changes recently. We use a four-variable diagonal BEKK-GARCH method to examine the mean and variance spillover coefficients. By doing so, we also examine whether exchange rate and interest rate variables as well as global risk factors have spillover effects on the performance of banks in Türkiye.

The number of studies investigating the effects of exchange rates and interest rates on the Turkish economy is quite limited and does not cover recent developments in the analysis periods. [Kandil Göker and Uysal \(2020\)](#) investigated the effects of interest and exchange rate risks on the Turkish tourism industry's returns, whereas [Kasman et al. \(2011\)](#) focused on banks traded in BIST and examined the effect of changes in the interest rate and the exchange rate on the stock returns of Turkish banks. In the study of [Kasman et al. \(2011\)](#), the authors used the univariate GARCH methods to analyse the effect of these variables. [Ekinci](#)

(2016a) used the same univariate methodology and investigated the effect of these factors on the banking sector, in addition to the industrial and services sectors. In another study, [Ekinci \(2016b\)](#) also investigated the effect of credit and market risk on bank performance, again using the univariate GARCH approach.

Our study differs from these studies in five ways. First, unlike these studies, we focused on both mean and variance spillover coefficients while their main focus was only on volatility spillover. Second, we focused on the volatility spillover effect for individual bank returns for the Turkish economy by using a diagonal BEKK-GARCH method, as it is widely stated in the literature that the multivariate methods for analysing the spillover effect provide better performance and more significant results. Third, we also included the global fear index (VIX) in our study, although these studies did not use a variable that takes into account the effects of global factors. In this way, we have made it possible for our equations to generate more robust error terms. And the fourth factor is the period of analysis of the study. Parallel to emerging markets, the turmoil experienced by the Turkish economy after May 2013 due to Fed tapering announcements and after the second half of 2018 due to geopolitical tensions, increased risk premiums had deteriorated financial stability. An understanding of the impact of these factors on the performance of banks is extremely important for investors in the sector. As our data cover the period in question, our study has the potential to shed light on a number of issues. And the last one is the grouping of the banks that are considered in the study. In our study, the individual banks that are part of the XBANK index in BIST were grouped into three different categories: domestic private banks, domestic public banks and foreign private banks, and it was analysed whether the results for these categories were different.

In the study, we first built a model based on the fundamentals of economic theory that searched for the volatility spillover between individual bank performances. In this model, we used (i) exchange rate changes, (ii) interest rate changes and (iii) the VIX index as factors affecting individual bank returns. Then, based on the volatility series of the variables considered as influencing individual bank returns, the impact of (i) exchange rate risk, (ii) interest rate risk variables and (iii) global risk variables was examined. Since the spillover effect may be temporarily strengthened or weakened, depending on various reasons,² we focused on whether the exchange rate, interest rate, and global risk have a more substantial impact, exceeding a specific threshold. Therefore, in the third step, taking into account the asymmetry that risk variables are more effective above a certain threshold, we used dummy variables in the mean equation and reproduced the error terms.

Only a few studies investigating the spillover effect have incorporated structural breaks in their models. The existence of structural breaks is universally acknowledged as a recurring issue in daily asset series - particularly for less resilient emerging markets. The ICSS algorithm was devised by [Sanso et al. \(2004\)](#) as an appropriate method for detecting structural breaks in unconditional variance, receiving endorsement as such from [Kumar and Maheswaran \(2013\)](#), [Kang et al. \(2009\)](#), and [Mensi et al. \(2014\)](#). [Zivkov et al. \(2015\)](#) incorporated structural breaks into the model and assessed volatility spillover in the Czech Republic, Hungary, Poland, and Russia using data from 2002 to 2014. The study employed the ICSS algorithm to detect multiple structural breaks. The study observed that the presence of structural breaks in GARCH models may lead to biased estimates of the volatility spillover effect. Additionally, the study discovered evidence supporting the existence of long-term volatility persistence in variance when structural breaks are present. [Mensi et al. \(2014\)](#) discovered that structural breaks have significant effects on the persistence of volatility within the data for

¹ The returns of the banking sector may be affected by sudden changes in some commodity prices, such as oil, natural gas, coal, gold, and silver, or by global factors such as the contraction of import and export volumes, resulting from an economic recession experienced in foreign trade partners, which negatively affects foreign trade relations ([Claessens et al., 2001](#); [Kim et al., 2000](#)).

² Several studies have analysed whether spillover effects differ before and after crisis periods ([Bekaert et al., 2005](#); [King et al., 1990](#); [Rigobon, 2003](#); [Kaminsky and Reinhart, 2000](#); [Jawadi et al., 2015](#); [Apostolakis et al., 2021](#)) and found that spillover effect differs during these periods.

Saudi Arabia. Kang et al. (2009) assessed structural breaks and the persistence of volatility in Japanese and Korean stock markets for the period of 1986–2008 by employing the ICSS algorithm and identified that effectively controlling sudden changes reduces volatility persistence. Therefore, in the last step, we included the Fourier approximation to the covariance equations, considering the possibility of structural breaks depending on the recent developments in the Turkish economy.

Contrary to the literature on the Turkish banking sector, our models revealed a mean spillover from changes in the interest rate to the performance of the banking sector for half of the private domestic and foreign banks, but not from changes in the exchange rate and the VIX index to the returns of the banking sector for all banks in the sector. We were able to obtain similar results when we used the risks of the exchange rate, the interest rate and the VIX index in the equations. We have also found that the average returns of the public banks do not react to any of the variables. Regarding the volatility spillover effect, we found that a shock to exchange rate, interest rate and global risk variables triggered the shock to stock returns and the effect is quite persistent. Specifically, we found that the volatility spillover is most related to global risk and least related to interest rates. The asymmetry analysis revealed no asymmetric structure in the mean equations, but structural breaks in the covariance equations, although the presence of structural breaks did not change the results.

The structure of the paper is as follows. Section 2 briefly reviews the main studies in the relevant literature. Section 3 is an introduction to the econometric methodology of VAR-DBEKK-GARCH. Section 4 provides a description of the data and some descriptive statistics. The empirical results and findings are presented in Section 5. And the final remarks are provided in section 6.

2. Methodology

In the financial economics literature, economists have generally preferred to use multivariate GARCH methods to model the spillover or contagion effect. The advantage of multivariate GARCH methods is that they specify equations regarding the movement of variances and covariances of underlying assets over time (Musunuru, 2014). Therefore, it is possible to find several multivariate GARCH methods in the literature, such as VEC-GARCH, BEKK-GARCH, their diagonal versions, DCC-GARCH and CCC-GARCH methods.

The VEC-GARCH method cannot ensure that the conditional variance-covariance matrix is positive semidefinite. Therefore, it is not widely used in empirical applications. To solve the non-positivity problem, Engle and Kroner (1995) proposed the BEKK specification, which can ensure that the conditional variance-covariance matrix is positive semidefinite. Subsequently, the diagonal BEKK method was developed to reduce the number of parameters to be estimated. Since the CCC-GARCH method makes an unrealistic constant correlation assumption, the DCC-GARCH method is preferred in the literature. However, Caporin and McAleer (2010) argue that the BEKK method is the optimal method for estimating conditional covariances and conditional correlations. The reasons why this method is more useful can also be explained as follows. First, this model facilitates the analysis of multidimensional relationships. Many researchers in the literature have estimated the volatility analysis between several markets using the VAR-BEKK-GARCH model (Awartani and Maghyereh, 2013; Du and He, 2015; Jouini, 2013; among others). One of the advantages of this model is that it simultaneously estimates the interaction between the variables we use in the study. The second is that the number of estimated coefficients in the model is smaller than in other models, such as VEC, and therefore the parameters estimated by the model are more stable. For example, Schreiber and Müller (2012), Stelzer (2008), and Carpentier and Samkharadze (2013) found supporting evidence that VAR-BEKK-GARCH is more efficient than its counterparts. Following these arguments, we decided to use the four-variate diagonal BEKK-GARCH method proposed by Engle and Kroner (1995) to

investigate the volatility link between return series.

2.1. The models

We built four-variate diagonal BEKK-GARCH(1,1) models, since the main characteristics of the financial return series are that they have fat tails, strong kurtosis and volatility clustering, as indicated by the work of Bauwens and Lubrano (2002). The models that we have estimated in this study are presented in the following.

Model 1: The Model with Changes in the Exchange Rate, Changes in the Interest Rate and VIX index in the Mean Equation

In the study, we first examined the effect of the changes in the exchange rate (Δexc) and the changes interest rate (Δint) in order to capture the domestic developments, and the effect of the VIX index (vix) to have the global effects.

$$Y_t = \kappa_0 + \kappa_1 Y_{t-1} + \epsilon_t \quad (1)$$

In Eq. (1), the 4x1 dependent variable matrix is $Y_t = \{r_t^i, \Delta exc_t, \Delta int_t, vix_t\}$, r_t^i is the stocks returns of i bank institution under investigation where $i = \{1, 2, \dots, 12\}$, the 4x1 constant matrix is $\kappa_0 = \{\kappa_{10}, \kappa_{20}, \kappa_{30}, \kappa_{40}\}$, the lagged values matrix is $Y_{t-1} = \{r_{t-1}^i, \Delta exc_{t-1}, \Delta int_{t-1}, vix_{t-1}\}$, the 4x4 coefficient matrix of lagged values is κ_1 ,³ the error term matrix is $\epsilon_t = \{\epsilon_{1,t}, \epsilon_{2,t}, \epsilon_{3,t}, \epsilon_{4,t}\}$ and $U_t | \Omega_{t-1} \sim N(0, H_t)$, the 4x4 conditional variance-covariance matrix is $H_t = \{h_{1,t}, h_{2,t}, h_{3,t}, h_{4,t}\}$ and Ω_{t-1} is the information in the market at time $t - 1$. The diagonal BEKK-GARCH specification we employed in the study is shown in Eq. (2).

$$H_t = C'C + A'\epsilon_{t-1}\epsilon_{t-1}'A + B'H_{t-1}B \quad (2)$$

In Eq. (2), H_t is the variance-covariance matrix of Eq. (1), C is an upper triangular matrix, A and B are diagonal 4x4 parameter matrices. If we solve the matrices presented in Eq. (2), we can obtain the following covariance equations under investigation.⁴

$$\begin{aligned} h_{12,t} &= c_{11}c_{12} + a_{11}a_{22}\epsilon_{1,t-1}\epsilon_{2,t-1} + b_{11}b_{22}h_{12,t-1} \\ &= m_{12} + a_{12}\epsilon_{1,t-1}\epsilon_{2,t-1} + b_{12}h_{12,t-1} \end{aligned} \quad (3)$$

$$\begin{aligned} h_{13,t} &= c_{11}c_{13} + a_{11}a_{33}\epsilon_{1,t-1}\epsilon_{3,t-1} + b_{11}b_{33}h_{13,t-1} \\ &= m_{13} + a_{13}\epsilon_{1,t-1}\epsilon_{3,t-1} + b_{13}h_{13,t-1} \end{aligned} \quad (4)$$

$$\begin{aligned} h_{14,t} &= c_{11}c_{14} + a_{11}a_{44}\epsilon_{1,t-1}\epsilon_{4,t-1} + b_{11}b_{44}h_{14,t-1} \\ &= m_{14} + a_{14}\epsilon_{1,t-1}\epsilon_{4,t-1} + b_{14}h_{14,t-1} \end{aligned} \quad (5)$$

where $c_{11}c_{1s} = m_{1s}$, $a_{11}a_{ss} = a_{1s}$ and $b_{11}b_{ss} = b_{1s}$ when $s = \{2, 3, 4\}$. The conditional variance and covariance matrices cannot be defined negatively by its nature. To satisfy the mean reverting condition, the coefficients in Eqs. (3)–(5) are expected to be less than unity as following.

$$[a_{1s} + b_{1s}] < 1 \text{ where } s = \{2, 3, 4\} \quad (6)$$

³ The VAR type of coefficients in the κ_1 matrix denotes the mean spillover. The mean spillover effect is assumed to influence the values of variables under analysis based on their and other variables' past values, guided by economic theory. Economic theory guided the creation of the κ_1 matrix, supporting our assumption of interdependence between stock return, exchange rate changes, and interest rate changes, all affected by the VIX index, while the latter remains unaffected by them.

⁴ The coefficients of a_{xy} in the H_t matrix (where $x \neq y$) pertain to the transmission of volatility. Volatility spillover is premised on the impact of variance changes in one variable on the variance changes in other variables.

Model 2: The Model with Square Root of the Exchange Rate Volatility, Square Root Interest Rate Volatility and VIX Index in the Mean Equation

The second objective of the study is to measure the impact of exchange rate risk, interest rate risk and global risk on the returns of individual banks. To this end, we first calculated the volatility of the exchange rate and interest rate variables using the GARCH(1,1) method, and then derived the exchange rate risk ($\sqrt{\Delta exc^{vol}}$) and interest rate risk ($\sqrt{\Delta int^{vol}}$) variables by taking the square root of these variables. We have also included the global risk variable (vix) in the analysis:

$$Y_t = \kappa_0 + \kappa_1 Y_{t-1} + \varepsilon_t \quad (7)$$

where

$$Y_t = \left\{ r_t^j, \sqrt{\Delta exc^{vol}}, \sqrt{\Delta int^{vol}}, vix \right\}$$

Model 3: The Model with Square Root of the Exchange Rate Volatility, Square Root of Interest Rate Volatility, VIX Index and Dummy Variables in the Mean Equation

Another objective of our study is to determine whether individual bank returns respond asymmetrically to risk factors. There are a number of studies, such as Kaminsky and Reinhart (2000), Rigobon (2003) and Bekaert et al. (2005), which suggest that financial variables respond to risk factors in an asymmetric manner. Accordingly, we believe that once the risk variables exceed a certain threshold, the likelihood of individual bank returns responding to risk factors would be high. For this purpose, we determined the thresholds after calculating the risk variables as described above. The thresholds were determined by adding one standard deviation to the mean of each risk. Dummy variables were then created by assigning a value of 1 to the values where the risk value exceeds this threshold and a value of 0 to the values below. Finally, the dummy variables are included in the mean equations as interaction variables.

$$Y_t = \kappa_0 + \kappa_1 Y_{t-1} + \tau_1 D_t Y_{t-1} + \varepsilon_t \quad (8)$$

where

$$\tau_1 = \begin{bmatrix} 0 & t_{12} & t_{13} & t_{14} \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \text{ and } D_t = \begin{bmatrix} 0 \\ dum_{\sqrt{\Delta exc^{vol}}} \\ dum_{\sqrt{\Delta int^{vol}}} \\ dum_{vix} \end{bmatrix}$$

Model 4 and 5: Models Considering Structural Breaks in the Variance Equations

Some studies, such as Mensi et al. (2019) and Begiazi and Katsiampa (2019), have stated that there are likely to be structural breaks in the variance equations of financial variables, and that these breaks have a serious impact on the significance level of the estimated coefficients. Therefore, we re-estimate models 1 and 2 by adding the Fourier approximation to the variance equations, rather than using dummy variables to capture exogenous structural breaks.

The use of the Fourier approximation has several advantages. First, it allows the structural break to be estimated endogenously. Second, it allows us to capture multiple unknown structural break dates. And third, it allows us to avoid the difficult procedure of estimating the break date (Banerjee et al., 2017). Becker et al. (2006) show that the Fourier approximation works quite well in the presence of unknown breaks in the series. The variance-covariance equations associated with the Fourier approximation are as follows.

$$H_t = C' C + A' \varepsilon_{t-1} \varepsilon_{t-1}' A + B' H_{t-1} B + \sum_{k=1}^n D' \cos(2\pi kt / T) D + \sum_{k=1}^n E' \sin(2\pi kt / T) E \quad (9)$$

Where $n < T/2$, k is the particular frequency, t is the trend and T is the number of observations under investigation. D and E matrixes are diagonal.

Model 6: Model Considering Structural Breaks in the Variance Equations and Dummy Variables in the Mean Equation

Finally, we simultaneously analysed the effect of structural breaks and the asymmetric response of individual bank returns to risk factors. In this way, we have tried to ensure that the error terms in the study reflect both the asymmetric effect and the structural break together. In this analysis, the mean equation is determined as in Equation (8), and the variance equation is determined as in Equation (9).

3. Data

The stock returns of individual banks (r_t) are calculated by taking the logarithmic difference of the closing price (P) at time [$r_{i,t} = (\ln P_{i,t} - \ln P_{i,t-1}) * 100$]. The individual banking indices used in the study are private domestic banks [Akbank (AKBNK), Türkiye İşbank A Ord Shs (ISATR), Türkiye İşbank B Ord Shs (ISBTR), Türkiye İşbank C Ord Shs (ISCTR), Şekerbank (SKBNK), Türkiye Sınai Kalkınma Bank (TSKB), and Yapı Kredi Bank (YKBNK)], public domestic banks [Halkbank (HALKB) and Vakıfbank (VAKBN)] and private foreign banks [Albaraka Türk Bank (ALBRK), Garanti Bank (GARAN), ICBC Türkiye Bank (ICBCT)]. Change in the nominal exchange rate (Δexc) computed as the log difference of basket rate (exc) over the previous day obtained by weighting 50%–50% for USD/TRY and EUR/TRY rates [$\Delta exc_t = (\ln exc_t - \ln exc_{t-1}) * 100$].⁵ The interest rate is the interest rate of a 2-year government bonds (TR2) and the changes in interest rate (Δint) are calculated by the first difference over the previous working day ($\Delta int_t = int_t - int_{t-1}$). The data used in the study are in daily frequency and covers the period between January 4, 2005 and March 28, 2023. However, the sample period varies for some of the variables due to data availability.⁶ Data are obtained from the electronic data delivery system of the Central Bank of the Republic of Türkiye (CBRT) and Bloomberg.

4. Estimation results

4.1. Calculating the conditional covariance equation

This section presents the estimation results for the above models. In order to make the following tables easier to follow, the return of a bank (AKBNK) has been taken as an example and detailed information on one of the predicted models has been presented. In the first step, we set up the mean equation as in equation (1) and estimated the coefficients of the VAR(1,1) model with the κ_1 matrix. In the second step, we performed the four-variate diagonal BEKK-GARCH(1,1) method to obtain the diagonal coefficients. In the third step, we multiplied the diagonal coefficients as in equations (3)–(5) to obtain the volatility spillover coefficients to search for the existence of a spillover effect between bank returns and the variables under investigation. The significance of the cointegration coefficients is tested using the Wald test. Table 1 shows the

⁵ Alternative exchange rates other than 50%–50% were also used in the study, but since it was determined that the results did not differ, the results regarding other exchange rates were not reported. These results are available upon request.

⁶ Descriptive statistics and unit root test results are presented in Appendix B.

Table 1

The results of VAR(1,1)-DBEKK-GARCH(1,1) model for the returns of AKBNK.

Coefficients in Mean Equation $i = \{1, 2, 3, 4\}$ and $j = \{1, 2, 3, 4\}$						
		κ_1				κ_0
		k_{i1}	k_{i2}	k_{i3}	k_{i4}	k_{i0}
<i>AKBNK</i>	k_{1j}	-0.0156	0.0213	-0.5732***	-0.0034	0.1575**
<i>Δexc</i>	k_{2j}	-0.0435***	0.0619***	0.9416***	0.0022***	-0.0152
<i>int</i>	k_{3j}	-0.0058***	0.0066***	-0.0089	-0.0005**	0.0035
<i>vix</i>	k_{4j}	-	-	-	0.9798***	0.3149***

Coefficients of Covariance Equations $s = \{2, 3, 4\}$					Stability Conditions $s = \{2, 3, 4\}$
		m_{1s}	a_{1s}	b_{1s}	$a_{1s} + b_{1s}$
	h_{12}	0.0001	0.0496***	0.9206***	0.9702***
	h_{13}	-0.0025***	0.0463***	0.9405***	0.9867***
	h_{14}	-0.0399***	0.0638***	0.8579***	0.9216***

*, ** and *** indicates significance at 10%, 5% and 1% level, respectively.

estimated results obtained from the VAR(1,1)-DBEKK-GARCH(1,1) method using the returns of AKBNK.

There are three parts to Table 1. The first part shows the coefficients of the mean equation. Since one of the objectives of the study is to determine the effect of exchange rate, interest rate and VIX index on the return of individual banks, the coefficients k_{12} , k_{13} and k_{14} in the mean equation provide crucial information about their effects. In Table 1, the values of k_{12} , k_{13} and k_{14} are 0.0213, -0.5732 and -0.0034 respectively. As can be seen from the table, changes in interest rates have a negative effect on the returns of AKBNK, which is significant at the 1% level, while changes in interest rates and the global risk factor have no effect on the returns of the individual banks studied. On the other hand, we found that, in line with financial theory, AKBNK's returns have a strong negative effect on changes in exchange rates and interest rates. However, since our aim in this study is only to try to determine the effects of exchange rates and interest rates on stocks, the effects of stock returns on exchange rates and interest rates are not mentioned in the following parts of the study.

We used the DBEKK-GARCH (1,1) method to collect the coefficients of the M , A and B matrices from the second part of Table 1, since the aim of our study is to examine the volatility spillover. After the analysis of the coefficients, we found that all the coefficients in the M , A and B matrices are statistically significant, with the exception of m_{12} . This indicates that these coefficients can be used to obtain the equations of variance and covariance, which are shown in equations (4)–(6). The calculated ARCH coefficients of 0.0496, 0.0463 and 0.0638 are statistically significant and imply a spillover effect in the return of AKBNK and changes in the exchange rate, interest rate and VIX index, respectively. Furthermore, the calculated GARCH coefficients of 0.9206, 0.9405 and 0.8579 are statistically significant and demonstrate a strong persistence in the GARCH terms. In other words, the GARCH terms suggest that the volatility spillover persists even after the initial spillover period.

The effect of the volatility spillover lasts longer when the GARCH term gets closer to 1. The stability condition holds equal significance to the values and significance of the covariance coefficients. In Table 1, we found that the sum of ARCH and GARCH terms are less than one (0.9702, 0.9867, 0.9216) which indicates that the provided conditional covariance coefficients are guaranteed to be stationary. Fig. 1 demonstrates the covariance graphs derived from our model.

4.2. Effects of the exchange rate changes, interest rate changes and VIX index on individual bank returns

4.2.1. Mean spillover

Table 2 also contains the values from Table 1, making it easier for readers to understand the underlined numbers. Bold coefficients indicate statistical significance. As per Table 2, Model 1 shows mean

spillover effects from interest rate changes to the returns of five specific banks. Although the expected sign for seven other banks is in question, no significant relationship could be identified. An assessment, differentiating domestic private, domestic public and foreign private banks, has found that only domestic public bank returns remain unaffected by interest rate changes. Separating the two aforementioned banks, half of the remaining banks were found to respond to interest rate changes.

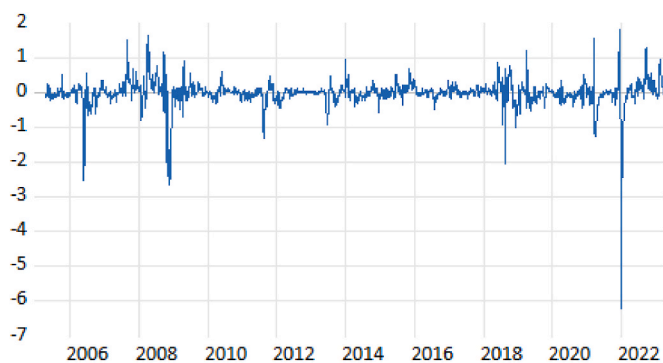
The situation becomes even more intriguing when changes in exchange rates are taken into account. The analysis revealed that bank returns, except for ISCTR, do not respond to changes in exchange rates. This implies that investors who invest in stocks do not consider exchange rate changes as theorized. The possible reason for this could be that policymakers have implemented various measures to affect the volatility and changes in exchange rates. Hence, some economic agents have turned to alternative investment instruments such as real estate or gold.

It is crucial to compare the results of our study with previous studies in the literature. Kasman et al. (2011) studied the effects of changes in exchange rates and interest rates on the individual banks' performance in Türkiye. The study found that the effect of the exchange rate change was more significant than the effect of the change in the interest rate. In other words, both variables affect the returns, but the effect of exchange rate changes is more pronounced. However, our study found that the effect of changes in exchange rates does not exist, and the effect of changes in interest rates is not questionable for all individual banks. According to Ekinci (2016a and 2016b), who used the same methodology and analysed the more stable period of 2002–2015, the exchange rate had a significant impact on the banking sector's performance, whereas changes in interest rates had no notable effects. When we evaluated the reason for the divergence between the findings, we considered that the key factor was the rise in geopolitical tensions and risk premiums in Türkiye. Partially starting in 2013, and more evidently after 2018, increased in risk premiums resulted in interest rate decisions affecting several economic variables in addition to stock returns. As a result, these developments have a significant impact on banks' profitability, with changes in interest rates having a pronounced effect on bank returns.

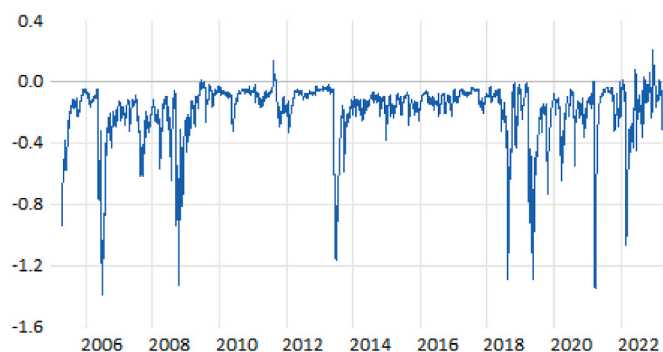
Upon examining the impact of the global risk factor, it has been found that there is no mean spillover effect on the VIX index returns. This indicates that the returns of the banks included in the banking index in Türkiye are wholly determined by domestic factors. As previous literature did not account for the global risk factor for Turkish individual banks, it was not feasible to match these findings with those of other studies.

4.2.2. Volatility spillover

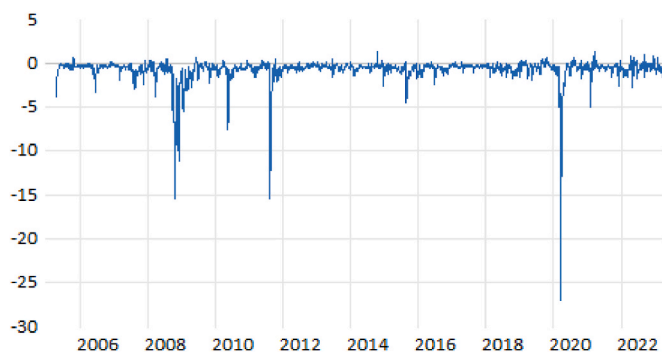
The main objective of our research is the investigation of volatility spillover between variables. Analysis of Table 2 determined the presence



Covariance of AKBNK and Change in Exchange Rate (h_{12})



Covariance of AKBNK and the Interest Rate (h_{13})



Covariance of AKBNK and the VIX Index (h_{14})

Fig. 1. Covariance of AKBNK and series under investigations.

of volatility spillover in all three covariance equations. The coefficients were statistically significant and strong. The study found that SKBNK's individual bank returns had the strongest volatility spillover (0.2123, 0.1668, 0.2431) compared to the change in the exchange rate, the change in the interest rate and the VIX index, whereas ISCTR's returns had the weakest spillover (0.0416, 0.0386, 0.0535). Focusing on the average of the volatility spillover, we observed that the volatility spillover of the global risk factor was stronger (0.1107) than the change in the interest rate (0.0788).⁷ An additional notable finding pertains to the

⁷ The average volatility spillover coefficients have been calculated for all banks.

exchange rate variation. While the shift in exchange rate lacks statistical significance in the mean equation of local banks, spillover of volatility has been found to have a substantial impact. This suggests that the volatility of the exchange rate is more significant than changes in the exchange rate concerning stock transactions. All the findings are consistent with the research of Kasman et al. (2011) and Ekinçi (2016a, 2016b), indicating that bank returns are impacted by exchange rates. The findings demonstrate that a movement in the exchange rate, interest rate or global risk factor has a spillover effect on the returns of all banks within the Turkish economy. Focusing on persistence in GARCH coefficients, we note that the figures are quite high, suggesting that the volatility spillover takes longer among the changes in the variables and individual bank returns.

4.3. Effects of the exchange rate, interest rate and global risks on individual bank returns

The previously conducted model results provide us with information on the volatility spillover between individual bank performances and critical economic variables. Clearly, the risk factors associated with the investigated variables, as well as their variations, affect the individual banks' performance. Hence, we established the mean equation shown in Eq. (7) and proceeded to re-estimate the model. The estimation outcomes are presented in Table 3.

While Table 2 confirmed that changes in the interest rate had a partial impact on the average returns of the bank, Table 3 revealed that this effect was not significant for the interest rate. The situation changes for volatility spillover. The covariance equations revealed that all three explanatory variables are responsible for triggering volatility spillover. The findings exhibit that a change in foreign exchange, bond, and stock markets leads to action in association with one another, but it is not substantial enough to impact the mean returns. These findings are consistent with those of previous studies conducted by Kasman et al. (2011) and Ekinçi (2016a, 2016b), which had shown a robust volatility spillover among variables under evaluation. It is also essential to note that as in the earlier model, the coefficients of volatility persistence are high.

4.3.1. Asymmetry analysis

As mentioned above, the asymmetric pattern of financial data is well documented in the literature (Razzaq et al., 2021; Lee and Lee, 2022, among others). The lack of addressing asymmetry in previous studies on the Turkish economy was considered a significant drawback. The second model was redesigned using dummy variables to set the threshold per this reality. We assumed that if the risk exceeds a specific threshold, it will have a more significant impact on individual bank returns. Table 4 shows the results obtained from the model defined in Equation (8).

Due to space limitations, Table 4 omits the κ_1 coefficients and instead presents the coefficients of the threshold variables ($\tau_1 = \{t_{12}, t_{13}, t_{14}\}$). The coefficients obtained from the analysis were not significantly different from those obtained in the Model 2 of Table 3. In other words, the model's findings do not indicate significant changes in the mean equations, as coefficients for dummy variables are statistically insignificant (except ISCTR which was already significant in Table 3).⁸ These findings indicate that no asymmetrical effect is present in the mean equation when taking risk factors into account. However, examining the covariance equations revealed that there is still a strong spillover effect between individual bank returns and the variables examined. The spillover of volatility between individual bank returns, exchange rate,

⁸ Searching for the asymmetric effect for the model including exchange rate changes, interest rate changes and VIX index, we reached the same result: no asymmetric effect. We conducted alternative calculations while deriving the dummy variables, but none of them showed significant effect. We didn't report these findings due to space limitations, but we can provide them upon request.

Table 2
Estimation results of the model that includes changes in exchange rates, changes in interest rates and volatility index.

MODEL 1	Changes in Exchange Rates				Changes in Interest Rates				VIX Index				Stability Conditions		
	Mean eq.		Variance eq. (h_{12})		Mean eq.		Variance eq. (h_{13})		Mean eq.		Variance eq. (h_{14})		$a_{12} + b_{12}$	$a_{13} + b_{13}$	$a_{14} + b_{14}$
	k_{12}	m_{12}	a_{12}	b_{12}	k_{13}	m_{13}	a_{13}	b_{13}	k_{14}	m_{14}	a_{14}	b_{14}			
Domestic Private Banks in XBANK Index															
AKBNK	0.0213 (0.0346)	0.0001 (0.0012)	0.0496 (0.0019)	0.9206 (0.0026)	-0.5732 (0.0981)	-0.0025 (0.0003)	0.0463 (0.0018)	0.9405 (0.0015)	-0.0034 (0.0038)	-0.0399 (0.0058)	0.0638 (0.0023)	0.9206 (0.0026)	0.9702	0.9868	0.9844
ISATR	-0.0455 (0.0199)	0.0003 (0.0024)	0.1100 (0.0019)	0.8379 (0.003)	-0.1589 (0.1171)	0.0002 (0.0003)	0.0850 (0.0013)	0.9057 (0.0009)	-0.0010 (0.0026)	-0.0031 (0.0045)	0.1231 (0.0019)	0.8379 (0.003)	0.9479	0.9907	0.9610
ISBTR	0.0501 (0.0305)	0.0012 (0.0017)	0.0757 (0.002)	0.9063 (0.0026)	-0.3411 (0.0921)	-0.0011 (0.0003)	0.0713 (0.0018)	0.9246 (0.0015)	0.0031 (0.0038)	-0.0172 (0.0059)	0.0973 (0.0023)	0.9063 (0.0026)	0.9820	0.9959	1.0036
ISCTR	0.1234 (0.0143)	0.0013 (0.0022)	0.0416 (0.0033)	0.8774 (0.008)	-0.4793 (0.0993)	-0.0087 (0.0008)	0.0386 (0.0031)	0.8946 (0.0079)	-0.0018 (0.0046)	-0.0513 (0.0072)	0.0535 (0.004)	0.8774 (0.008)	0.9190	0.9332	0.9309
SKBNK	0.0029 (0.0223)	0.0006 (0.0023)	0.2123 (0.0047)	0.7423 (0.0044)	-0.1718 (0.0769)	-0.0002 (0.0006)	0.1668 (0.0032)	0.7994 (0.0037)	-0.0079 (0.0026)	-0.0063 (0.0072)	0.2431 (0.0048)	0.7423 (0.0044)	0.9546	0.9662	0.9854
TSKB	-0.0202 (0.0338)	-0.0001 (0.0011)	0.0500 (0.002)	0.9235 (0.0025)	-0.3614 (0.1066)	-0.0019 (0.0003)	0.0473 (0.0018)	0.9401 (0.0014)	0.0006 (0.0037)	-0.0401 (0.0053)	0.0643 (0.0024)	0.9235 (0.0025)	0.9735	0.9874	0.9878
YKBNK	-0.0103 (0.0331)	0.0004 (0.0013)	0.0489 (0.0021)	0.9198 (0.0027)	-0.5879 (0.0931)	-0.0029 (0.0003)	0.0463 (0.002)	0.9380 (0.0017)	-0.0003 (0.0037)	-0.0461 (0.0057)	0.0636 (0.0025)	0.9198 (0.0027)	0.9687	0.9843	0.9834
Domestic Public Banks in XBANK Index															
HALKB	0.0038 (0.0364)	0.0010 (0.0015)	0.0475 (0.0022)	0.9212 (0.0028)	-0.2956 (0.1383)	-0.0032 (0.0003)	0.0444 (0.002)	0.9381 (0.002)	0.0058 (0.0043)	-0.0556 (0.0081)	0.0634 (0.0027)	0.9212 (0.0028)	0.9687	0.9825	0.9846
VAKBN	0.0186 (0.0376)	0.0015 (0.0013)	0.0491 (0.0021)	0.9215 (0.0026)	-0.2868 (0.1151)	-0.0031 (0.0003)	0.0465 (0.002)	0.9381 (0.0017)	-0.0015 (0.004)	-0.0484 (0.0062)	0.0637 (0.0026)	0.9215 (0.0026)	0.9706	0.9846	0.9852
Foreign Private Banks in XBANK Index															
ALBRK	-0.0006 (0.0321)	0.0006 (0.0016)	0.0871 (0.0026)	0.8979 (0.0028)	-0.4859 (0.0975)	-0.0024 (0.0003)	0.0879 (0.0025)	0.9071 (0.0023)	-0.0042 (0.0036)	-0.0356 (0.0073)	0.1218 (0.0033)	0.8979 (0.0028)	0.9850	0.9950	1.0197
GARAN	0.0551 (0.0387)	0.0006 (0.0013)	0.0460 (0.0018)	0.9189 (0.0027)	-0.5603 (0.1051)	-0.0025 (0.0003)	0.0411 (0.0016)	0.9440 (0.0013)	-0.0035 (0.0037)	-0.0438 (0.006)	0.0585 (0.0022)	0.9189 (0.0027)	0.9649	0.9851	0.9774
ICBCT	0.0181 (0.0569)	0.0020 (0.0063)	0.0783 (0.004)	0.7659 (0.0144)	-0.3760 (0.1821)	-0.0127 (0.0016)	0.0737 (0.0037)	0.7799 (0.0145)	-0.0063 (0.0066)	-0.0781 (0.0177)	0.1003 (0.0048)	0.7659 (0.0144)	0.8442	0.8536	0.8662

(i) a_{1s} indicates volatility spillover where $a_{11} * a_{ss}$ and ($s= 2, 3, 4$) (ii) b_{1s} indicates persistence in volatility spillover where $b_{11} * b_{ss}$ and ($s= 2, 3, 4$) (iii) Values in parentheses give standard errors., (iv) Bold in mean variance equations means that the coefficient is significant at 1% level. (v) Bold in stability conditions mean the stability condition is hold.

Table 3
Estimation results of the model that includes exchange rate risk, interest rate risk and global risk.

MODEL 2	Exchange Rate Risk				Interest Rate Risk				Global Risk				Stability Conditions		
	Mean eq.		Variance eq. (h_{12})		Mean eq.		Variance eq. (h_{13})		Mean eq.		Variance eq. (h_{14})		$a_{12} + b_{12}$	$a_{13} + b_{13}$	$a_{14} + b_{14}$
	k_{12}	m_{12}	a_{12}	b_{12}	k_{13}	m_{13}	a_{13}	b_{13}	k_{14}	m_{14}	a_{14}	b_{14}			
Domestic Private Banks in XBANK Index															
AKBNK	0.0013 (0.0606)	-0.0007 (0.0012)	0.0488 (0.0019)	0.9253 (0.0021)	-0.0220 (0.2047)	-0.0026 (0.0003)	0.0461 (0.0018)	0.9401 (0.0015)	-0.0024 (0.0038)	-0.0390 (0.0055)	0.0624 (0.0023)	0.8623 (0.0033)	0.9741	0.9862	0.9247
ISATR	-0.0280 (0.0399)	0.0003 (0.0016)	0.0780 (0.0013)	0.9093 (0.0017)	-0.0153 (0.2091)	-0.0001 (0.0003)	0.0673 (0.0011)	0.9297 (0.0009)	0.0038 (0.003)	0.0060 (0.0048)	0.0945 (0.0015)	0.8533 (0.003)	0.9873	0.9970	0.9478
ISBTR	0.0499 (0.0856)	0.0011 (0.0017)	0.0763 (0.002)	0.9106 (0.0021)	0.0513 (0.2456)	-0.0011 (0.0003)	0.0714 (0.0018)	0.9242 (0.0015)	0.0020 (0.0038)	-0.0150 (0.0056)	0.0966 (0.0023)	0.8509 (0.0031)	0.9869	0.9956	0.9475
ISCTR	0.4739 (0.0194)	-0.0006 (0.0025)	0.0526 (0.0033)	0.8677 (0.0077)	-0.7255 (0.1913)	-0.0094 (0.0008)	0.0492 (0.0031)	0.8814 (0.0078)	-0.0046 (0.0045)	-0.0530 (0.0076)	0.0669 (0.0039)	0.8112 (0.0073)	0.9203	0.9306	0.8781
SKBNK	-0.0975 (0.052)	0.0007 (0.0022)	0.2015 (0.0043)	0.7580 (0.0042)	0.1971 (0.1538)	-0.0001 (0.0006)	0.1673 (0.0033)	0.7995 (0.0038)	-0.0075 (0.0025)	-0.0062 (0.0069)	0.2429 (0.0048)	0.7086 (0.0044)	0.9595	0.9668	0.9515
TSKB	-0.0940 (0.0658)	0.0002 (0.0017)	0.1404 (0.004)	0.8274 (0.0034)	0.2126 (0.161)	-0.0002 (0.0004)	0.1165 (0.0031)	0.8744 (0.0025)	-0.0019 (0.0027)	-0.0014 (0.0051)	0.1661 (0.0042)	0.7761 (0.0037)	0.9678	0.9909	0.9422
YKBNK	-0.0102 (0.0605)	-0.0011 (0.0012)	0.0487 (0.0021)	0.9226 (0.0023)	-0.0432 (0.1976)	-0.0030 (0.0003)	0.0454 (0.0019)	0.9385 (0.0017)	0.0004 (0.0037)	-0.0452 (0.0054)	0.0619 (0.0024)	0.8588 (0.0034)	0.9713	0.9839	0.9207
Domestic Public Banks in XBANK Index															
HALKB	-0.0548 (0.0623)	-0.0005 (0.0027)	0.1607 (0.0053)	0.7846 (0.0051)	0.1064 (0.1802)	0.0002 (0.0005)	0.1321 (0.0042)	0.8308 (0.0049)	0.0018 (0.003)	-0.0006 (0.0086)	0.1986 (0.0062)	0.7203 (0.0054)	0.9453	0.9629	0.9189
VAKBN	-0.0764 (0.0772)	0.0007 (0.0013)	0.0492 (0.0021)	0.9236 (0.0023)	-0.1270 (0.212)	-0.0031 (0.0003)	0.0460 (0.002)	0.9383 (0.0018)	0.0000 (0.0041)	-0.0471 (0.006)	0.0625 (0.0026)	0.8579 (0.0035)	0.9728	0.9843	0.9204
Foreign Private Banks in XBANK Index															
ALBRK	-0.0425 (0.0737)	-0.0008 (0.0016)	0.0842 (0.0024)	0.9029 (0.0025)	0.0009 (0.2083)	-0.0023 (0.0003)	0.0865 (0.0024)	0.9083 (0.0022)	-0.0030 (0.0036)	-0.0353 (0.007)	0.1172 (0.0031)	0.8165 (0.0043)	0.9871	0.9948	0.9337
GARAN	-0.0138 (0.068)	-0.0004 (0.0012)	0.0450 (0.0018)	0.9250 (0.0021)	0.0858 (0.2047)	-0.0026 (0.0003)	0.0410 (0.0016)	0.9436 (0.0014)	-0.0030 (0.0037)	-0.0422 (0.0057)	0.0571 (0.0022)	0.8621 (0.0033)	0.9700	0.9846	0.9192
ICBCT	-0.0288 (0.1038)	-0.0023 (0.0062)	0.0816 (0.0041)	0.7607 (0.0148)	0.0700 (0.3069)	-0.0135 (0.0016)	0.0762 (0.0039)	0.7713 (0.015)	-0.0077 (0.0067)	-0.0773 (0.0178)	0.1022 (0.0049)	0.7121 (0.0139)	0.8423	0.8475	0.8143

(i) a_{1s} indicates volatility spillover where $a_{11} * a_{ss}$ and ($s= 2, 3, 4$) (ii) b_{1s} indicates persistence in volatility spillover where $b_{11} * b_{ss}$ and ($s= 2, 3, 4$) (iii) Values in parentheses give standard errors., (iv) Bold in mean variance equations means that the coefficient is significant at 1% level. (v) Bold in stability conditions mean the stability condition is hold.

Table 4
Estimation results of the asymmetric model.

MODEL 3	Exchange Rate Risk				Interest Rate Risk				Global Risk				Stability Conditions		
	Mean eq.		Variance eq. (h_{12})		Mean eq.		Variance eq. (h_{13})		Mean eq.		Variance eq. (h_{14})		$a_{12} + b_{12}$	$a_{13} + b_{13}$	$a_{14} + b_{14}$
	t_{12}	m_{12}	a_{12}	b_{12}	t_{13}	m_{13}	a_{13}	b_{13}	t_{14}	m_{14}	a_{14}	b_{14}			
Domestic Private Banks in XBANK Index															
AKBNK	-0.0366 (0.0508)	-0.0007 (0.0012)	0.0482 (0.0019)	0.9257 (0.0021)	0.0996 (0.1649)	-0.0027 (0.0003)	0.0458 (0.0018)	0.9398 (0.0015)	-0.0017 (0.0027)	-0.0390 (0.0056)	0.0619 (0.0023)	0.9257 (0.0021)	0.9739	0.9856	0.9876
ISATR	-0.0610 (0.0278)	0.0003 (0.0017)	0.0787 (0.0013)	0.9086 (0.0017)	-0.0637 (0.1414)	-0.0002 (0.0003)	0.0677 (0.0011)	0.9294 (0.0009)	0.0017 (0.002)	0.0062 (0.0049)	0.0951 (0.0015)	0.9086 (0.0017)	0.9873	0.9971	1.0037
ISBTR	0.0662 (0.0701)	0.0011 (0.0017)	0.0762 (0.002)	0.9108 (0.0021)	0.1646 (0.2021)	-0.0011 (0.0003)	0.0714 (0.0018)	0.9243 (0.0015)	0.0016 (0.0027)	-0.0150 (0.0057)	0.0967 (0.0023)	0.9108 (0.0021)	0.9870	0.9957	1.0075
ISCTR	0.0756 (0.0166)	0.0001 (0.0049)	0.1180 (0.0062)	0.6990 (0.0135)	0.0469 (0.1546)	0.0004 (0.0013)	0.0943 (0.0049)	0.7556 (0.0145)	-0.0033 (0.0028)	0.0085 (0.0103)	0.1368 (0.0066)	0.6990 (0.0135)	0.8170	0.8499	0.8358
SKBNK	-0.0517 (0.0381)	-0.0007 (0.0022)	0.2020 (0.0043)	0.7572 (0.0042)	0.0495 (0.1131)	-0.0001 (0.0006)	0.1677 (0.0033)	0.7988 (0.0038)	-0.0024 (0.0018)	0.0049 (0.0069)	0.2436 (0.0048)	0.7572 (0.0042)	0.9592	0.9665	1.0008
TSKB	-0.0469 (0.0621)	-0.0010 (0.0012)	0.0516 (0.0021)	0.9232 (0.0023)	0.0750 (0.1633)	-0.0020 (0.0003)	0.0481 (0.0018)	0.9395 (0.0015)	0.0006 (0.0026)	-0.0375 (0.0049)	0.0640 (0.0023)	0.9232 (0.0023)	0.9748	0.9876	0.9872
YKBNK	-0.0234 (0.0503)	-0.0011 (0.0012)	0.0491 (0.0021)	0.9221 (0.0023)	0.1506 (0.1586)	-0.0030 (0.0003)	0.0457 (0.002)	0.9384 (0.0018)	-0.0003 (0.0026)	-0.0450 (0.0054)	0.0623 (0.0025)	0.9221 (0.0023)	0.9712	0.9841	0.9844
Domestic Public Banks in XBANK Index															
HALKB	-0.0212 (0.068)	0.0002 (0.0015)	0.0464 (0.0021)	0.9235 (0.0025)	-0.0520 (0.1909)	-0.0032 (0.0003)	0.0432 (0.002)	0.9387 (0.0019)	0.0027 (0.0028)	-0.0551 (0.0078)	0.0606 (0.0026)	0.9235 (0.0025)	0.9699	0.9819	0.9841
VAKBN	-0.1180 (0.0545)	-0.0002 (0.0021)	0.1395 (0.0042)	0.8184 (0.0038)	0.1704 (0.1371)	0.0001 (0.0004)	0.1150 (0.0035)	0.8690 (0.0034)	-0.0025 (0.0019)	-0.0060 (0.0062)	0.1667 (0.0049)	0.8184 (0.0038)	0.9579	0.9840	0.9851
Foreign Private Banks in XBANK Index															
ALBRK	0.0183 (0.0614)	-0.0008 (0.0016)	0.0843 (0.0024)	0.9028 (0.0025)	-0.0559 (0.166)	-0.0024 (0.0003)	0.0867 (0.0025)	0.9081 (0.0022)	-0.0046 (0.0024)	-0.0355 (0.007)	0.1176 (0.0031)	0.9028 (0.0025)	0.9871	0.9948	1.0204
GARAN	-0.0839 (0.0522)	-0.0004 (0.0018)	0.1251 (0.0038)	0.8319 (0.0036)	0.2929 (0.1356)	0.0000 (0.0003)	0.1014 (0.003)	0.8894 (0.0027)	-0.0018 (0.0021)	0.0003 (0.0054)	0.1470 (0.0042)	0.8319 (0.0036)	0.9570	0.9908	0.9789
ICBCT	-0.0020 (0.0865)	-0.0021 (0.0064)	0.0828 (0.0042)	0.7557 (0.0151)	0.0583 (0.2436)	-0.0138 (0.0017)	0.0772 (0.0039)	0.7666 (0.0153)	-0.0056 (0.0045)	-0.0789 (0.0181)	0.1035 (0.005)	0.7557 (0.0151)	0.8385	0.8438	0.8592

(i) a_{1s} indicates volatility spillover where $a_{11} * a_{ss}$ and ($s= 2, 3, 4$) (ii) b_{1s} indicates persistence in volatility spillover where $b_{11} * b_{ss}$ and ($s= 2, 3, 4$) (iii) Values in parentheses give standard errors., (iv) Bold in mean variance equations means that the coefficient is significant at 1% level. (v) Bold in stability conditions mean the stability condition is hold.

and global risk is still high, while the spillover with the interest rate is relatively low, has been determined.

4.3.2. Structural breaks

As previously noted in the literature, there is a high likelihood of structural breaks occurring in the variance equations of financial variables. In this study, we have modelled the possibility of a structural break in the variance-covariance equations, which was not considered in the earlier studies. These breaks can significantly impact the significance level of the estimated coefficients; therefore, we have re-estimated the first two models by adding the Fourier approximation to the variance equations. The results of these estimations are presented in Appendix C - Tables 5 and 6.⁹

Table 5 presents the results with changes to the model, whereas Table 6 presents the results with the *risk factors* included. The results from Tables 5 and 6 demonstrate that the structural break coefficients had no significant statistical impact on changes in exchange rate and exchange rate risks; however, cosine coefficients are significant in both h_{13} covariance equations. These coefficients indicated the presence of structural breaks in the covariance equations whenever changes occurred in interest rates and interest risk rates. Comparing the coefficients of Tables 5 and 6 with Tables 2 and 3, respectively, reveals an increase in the k_{13} values. This result concurs with the outcomes reported at the start of the research. In recent years, in particular, the policy interest rate has caused interest rate decisions to have an effective impact on stock returns. Either investors are not inclined to look at foreign exchange as an alternative mode of investment, or the connection between the foreign exchange market and the stock market has weakened over time, as an alternative policy has repressed the exchange rate. Even though the study revealed evidence of a structural break, the conclusions from the structural break model remain in Kasman et al. (2011) and Ekinci (2016a, 2016b) and may not be entirely consistent with the obtained data. The previous sections have explained the reasons for this discrepancy.

4.3.3. Structural breaks with dummy

Finally, estimates were conducted using models that incorporated both structural breaks and asymmetry. To some extent, the asymmetric model presented in Table 1 was retested to determine if it contains structural breaks. The results in Table 7 indicate the presence of a structural break in the covariance equations related to interest rate risk. However, these structural breaks did not cause a significant change in the asymmetry coefficients.

When evaluating the study's results as a whole, the following conclusions can be drawn. Regardless of whether change or risk variables were used, no significant effect of exchange rate on stock returns was found. However, we determined that the interest rate has a significant effect on the average returns of half of the private banks, irrespective of whether they are domestic or foreign banks. Moreover, we observed that public banks' returns did not significantly respond to exchange rate or interest rate variables. This discrepancy is possibly related to the asset structure of public banks. Public sector banks, by nature, do not have as strong a profit motive as the private sector. In some periods, aligned with economic policy preferences, they may adopt a zero profit or short-term

loss policy in line with public interest, and thus change their asset structure accordingly. It is probable that public sector banks have adapted to the pro-growth policies that have gained prominence in Türkiye in recent years, resulting in a change of their asset positions that reduced their profitability. Consequently, the return on assets of public sector banks decreased and has been lower than that of the private sector since 2018. (BRSA, 2023: 13). As this situation was anticipated by the investors, the performance of the public banks remained unaffected by the changes in interest rates during the investigated period.

It has been determined that stock investors do not significantly react to the change in the exchange rate or its risk. This suggests that exchange rate variables are not explicitly considered by investors. This finding is different from previous literature on the subject. Kasman et al. (2011) and Ekinci (2016a, 2016b) discovered that the exchange rate has a direct impact on individual stock returns. However, our study did not find similar effects. This suggests that the correlation between the exchange rate and stocks diminishes over time. It is believed that the weakening is due to the investor's inclination to guard against the exchange rate's volatility. In a country like Türkiye, where the exchange rate is of high instability, investors trying to protect themselves against changes or risks to exchange rates is perfectly understandable.

While the exchange rate and interest variables have no direct impact on the stock's returns, research has found that the shocks caused by these variables swiftly spillover to other markets and persist for a prolonged period of time. This is one of the most common characteristics of asset markets. Investors closely monitor the progress in other markets and modify their actions over time based on these changes, even if they do not make abrupt decisions.

5. Conclusion

The banking sector's performance has been positively impacted by technological advancements and sectoral reforms, while integration between the banks in Türkiye has been further strengthened. This intensified integration escalated the transmission of shocks to the banking sector among individual banks. This study investigates the impact of both internal and external shocks on individual banks in the Turkish banking sector. Shocks are categorised into two groups. The first subgroup pertains to changes in the exchange and interest rates, whereas the second subgroup includes risks associated with exchange and interest rates that supplement the VIX index.

The results of the study show that half of the returns of individual private banks in Türkiye are directly affected by interest rate fluctuations and risks, but not by changes in the exchange rate or the VIX index. These findings are in contrast to those in the Turkish economic literature, where other authors have noted exchange rates have an impact on average returns. The primary cause of this dissimilarity stems from the fact that other studies' analysis periods only include before 2013. Even though Türkiye has adopted an inflation targeting strategy, policies that prioritized economic growth have been enforced since 2013, particularly from mid-2018 onwards.

Although we may not observe the mean spillover among the variables, we have observed that shocks to the exchange rate and interest rate increase the shocks to the stocks. To put it differently, there is a spillover of volatility among the variables. This implies that investors closely monitor other markets when making their investment decisions and switch between markets, which is also consistent with finance theory. The global risk factor has a similar effect, suggesting that investors closely monitor both domestic and global issues.

The findings of the study indicate that public banks exhibit identical behaviour, whereas private banks differ in their behaviour regardless of whether they are domestic or foreign institutions. Public banks' returns do not respond to exchange or interest rate fluctuations.

This study also examined whether changes and risks have an asymmetrical nature in the Turkish markets. For this purpose, we investigated whether the results change when the values of change and risk exceed a

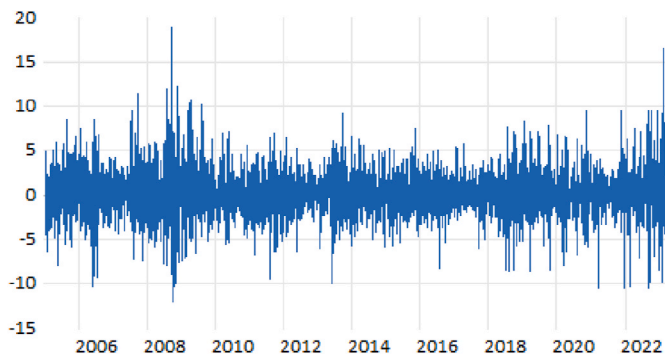
⁹ According to Becker et al. (2006) and Enders and Lee (2012), choosing the value $k=1$ is adequate to capture different breaks in economic analysis. They argued that using the low frequency often leads to a good estimation as to a model with structural changes. However, we still needed to choose the optimal frequency of k^* determined by data. To determine the optimal frequency, we followed Becker et al. (2006) and minimized the sum of squares residuals (SSE) from our models, with the maximum frequency being set at 3 ($k_{max}=3$). Our results suggest that the Fourier component with frequency $k=1$ can approximate the breaks accurately without explicit estimation of break number, break dates and break forms.

certain threshold. According to our findings, there is no asymmetry effect in the returns of the individual banks that we examined in the Turkish economy. These findings suggest that the magnitudes of change and risks have no significant impact on the returns of individual banks.

While the impacts of changes and risks have been found to be insignificant in the Turkish economy, we have explored the possibility of a structural break in the variance-covariance equations for financial variables. To investigate, we re-estimated the variance-covariance equations through Fourier convergence analysis. The results suggest that a structural break existed solely for interest rate covariance equations. We captured more robust results by slightly altering the covariance coefficients. Despite this change, the significance of the coefficients in the equations remained unaffected.

Appendix A

Returns of Individual Banks.



Authors' contributions

Serkan Çiçek: Writing, Data collection, Methodology, Software, Visualization.

Aynur Yıldırım: Writing, Investigation, Literature, Visualization.

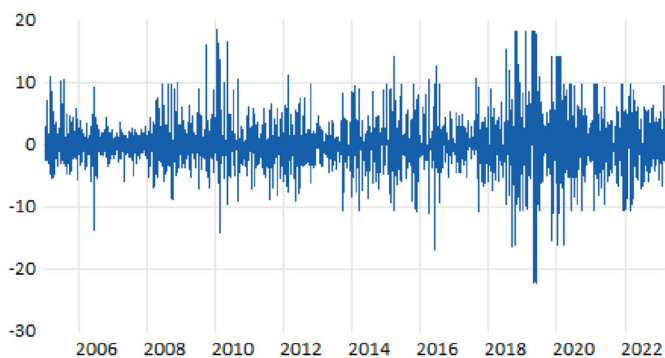
Declaration of interest

As the authors, we declare that we have no conflict of interest.

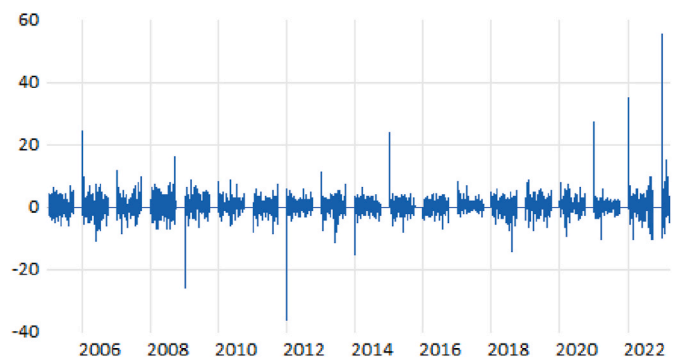
Declaration of competing interest

As the authors, we declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Returns of AKBNK



Returns of ISATR

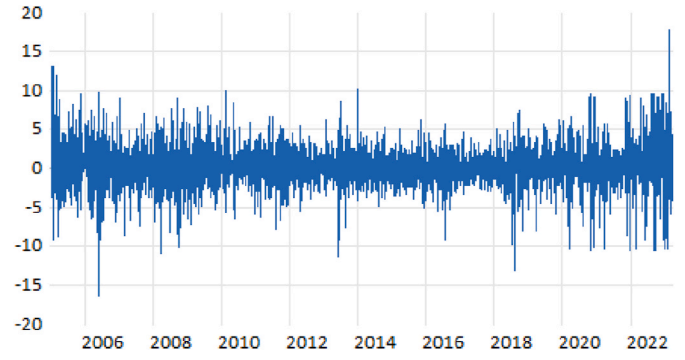
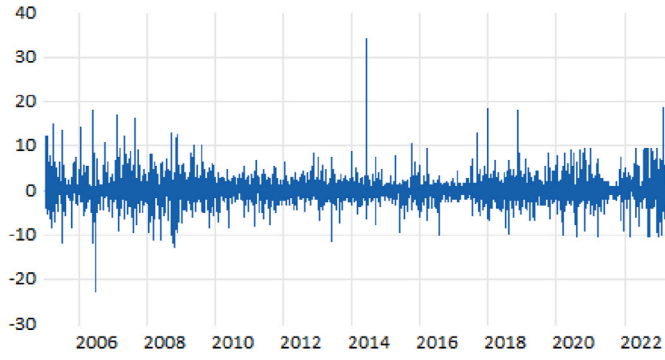


Returns of ISBTR

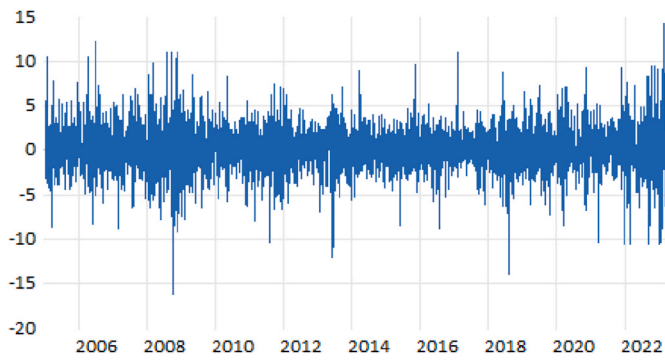
Returns of ISCTR

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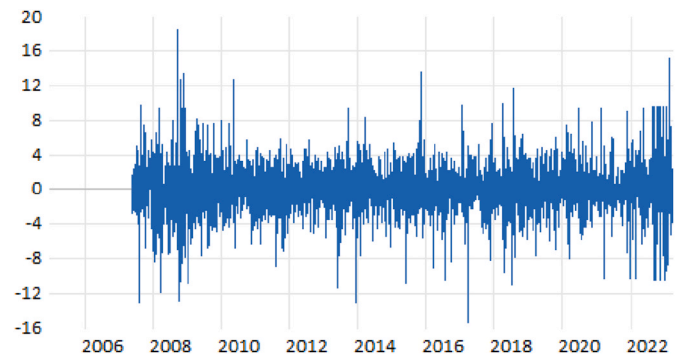
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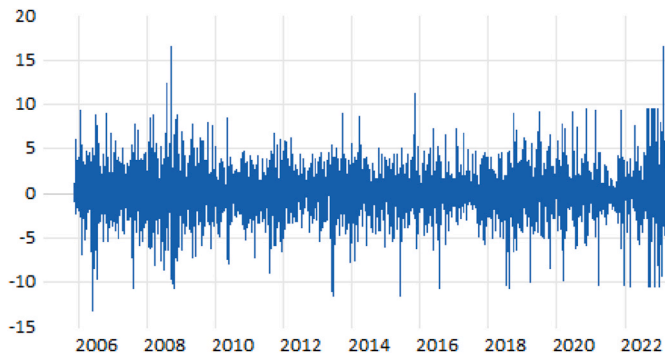
Returns of SKBNK



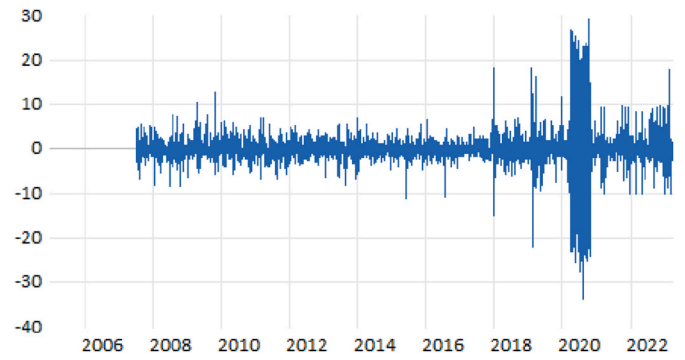
Returns of TSKB



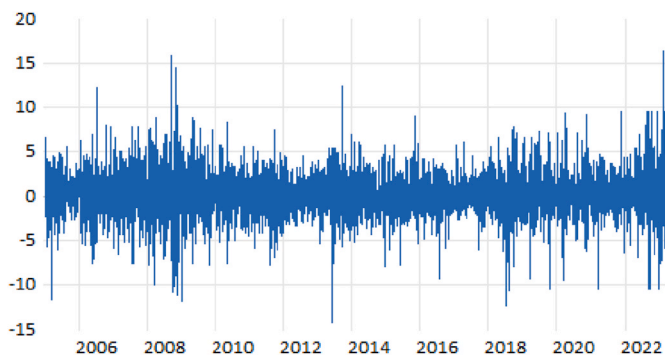
Returns of YKBNK



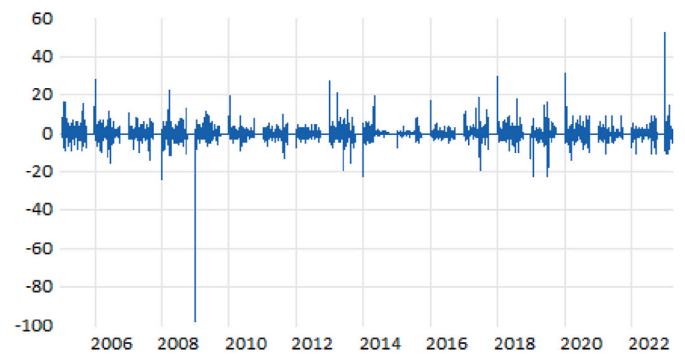
Returns of HALKB



Returns of VAKBN



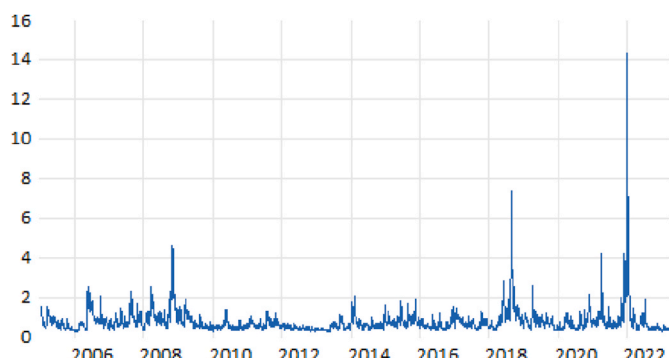
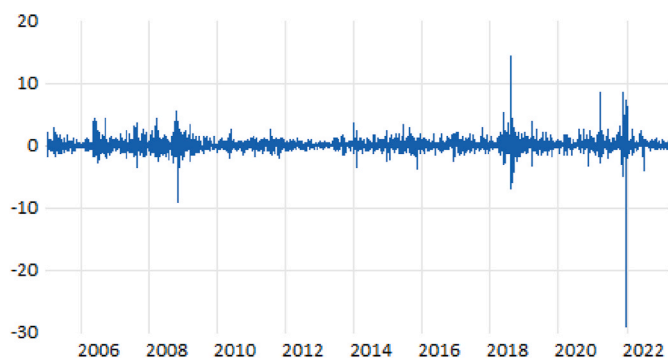
Returns of ALBRK



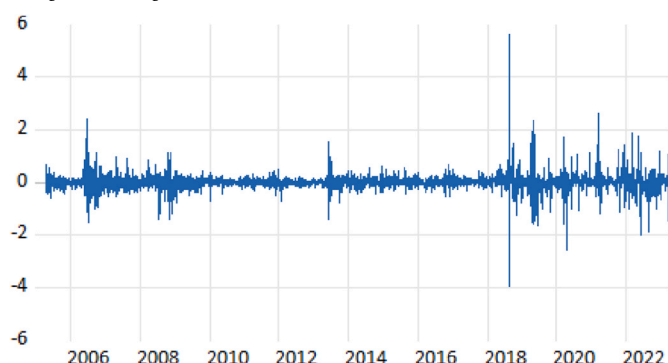
Returns of GARAN

Returns of ICBCT

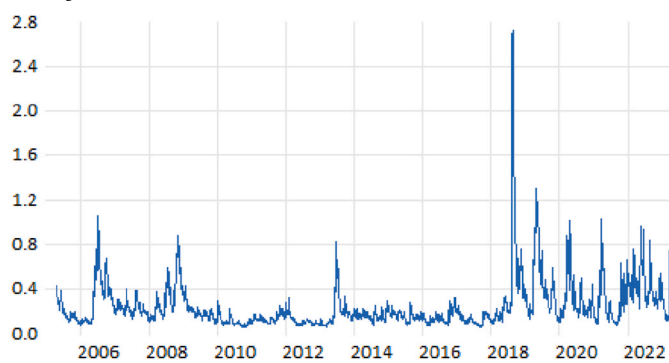
Changes and Risks of Explanatory Variables



Changes in Exchange Rates

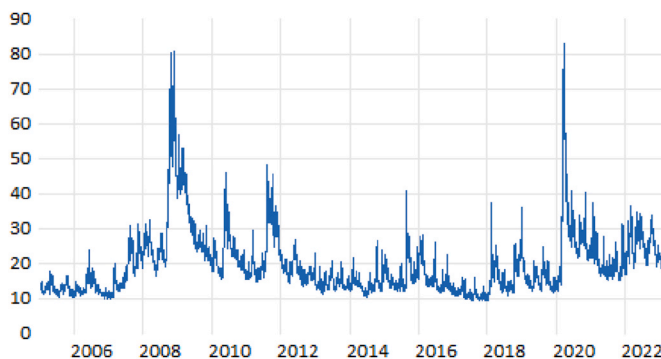


Exchange Rate Risk



Changes in Interest Rates

Interest Rate Risk



VIX Index (Global Risk)

Appendix B

Descriptive Statistics

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	JB Test	Obs.
Private Domestic Banks								
AKBNK	0.0461	18.9101	-11.9392	2.5192	0.1759	6.2081	2064.01*	4756
ISATR	0.0614	25.4417	-22.3148	2.8362	0.5789	30.5792	150993.40*	4756
ISBTR	0.0775	18.3849	-22.3143	3.2689	0.7663	12.6880	19064.94*	4756
ISCTR	0.0591	55.1988	-36.1790	2.5187	2.4786	78.4255	1132240.00*	4756
SKBNK	0.0509	34.1688	-22.7731	2.7921	0.6523	13.5026	22195.82*	4756
TSKB	0.0911	17.6850	-16.4875	2.5880	0.0210	6.6869	2694.02*	4756
YKBNK	0.0508	14.2843	-16.0773	2.4883	-0.0677	6.1029	1911.59*	4756
Public Domestic Banks								

(continued on next page)

(continued)

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	JB Test	Obs.
HALKB	0.0120	18.5921	-15.3719	2.6842	0.0271	6.9180	2649.83*	4142
VAKBN	0.0285	16.5156	-13.2316	2.6261	0.0012	5.9645	1657.30*	4526
Private Foreign Banks								
ALBRK	0.0232	29.0383	-33.5939	3.4674	-0.0872	28.2100	108736.30*	4106
GARAN	0.0661	16.3332	-14.2372	2.5577	0.0193	5.9712	1749.67*	4756
ICBCT	0.0724	52.6093	-97.7748	3.3349	-3.8393	181.5938	6332354.00*	4756
Related Variables								
Δexc	0.0531	14.3398	-29.2680	0.9689	-4.6691	198.8506	7618447.00*	4756
$\sqrt{\Delta exc^{vol}}$	0.7627	14.3344	0.2781	0.6651	8.3625	117.5741	2656253.00*	4755
Δint	-0.0015	5.6400	-3.9500	0.2895	1.3515	61.0902	660151.90*	4685
$\sqrt{\Delta int^{vol}}$	0.2389	2.7290	0.0621	0.2064	4.0430	32.5280	182927.10*	4684
vix	19.4672	82.6900	9.1400	9.0427	2.3814	11.4112	18515.30*	4756

* indicates significant at 1% level.

Unit Root Test Results

Data	ADF			PP		
	None	Intercept	Intercept & Trend	None	Intercept	Intercept & Trend
Private Domestic Banks						
AKBNK	-67.2027*	-67.2185*	-67.2124*	-67.3101*	-67.3596*	-67.3543*
ISATR	-41.7784*	-41.7965*	-41.8136*	-57.7992*	-57.7900*	-57.7812*
ISBTR	-65.9342*	-65.9631*	-65.9888*	-66.3014*	-66.3041*	-66.3001*
ISCTR	-69.2898*	-69.3217*	-69.3325*	-69.2949*	-69.3320*	-69.3429*
SKBNK	-30.5489*	-30.5651*	-30.5647*	-64.4446*	-64.4275*	-64.4226*
TSKB	-43.2612*	-43.3268*	-43.3250*	-64.2627*	-64.2608*	-64.2560*
YKBNK	-67.5273*	-67.5481*	-67.5451*	-67.5269*	-67.5465*	-67.5501*
Public Domestic Banks						
HALKB	-61.2216*	-61.2154*	-61.2080*	-61.2176*	-61.2110*	-61.2036*
VAKBN	-43.8856*	-43.8877*	-43.8844*	-63.7441*	-63.7934*	-63.7879*
Private Foreign Banks						
ALBRK	-26.4041*	-26.4079*	-26.4165*	-81.9013*	-81.9047*	-81.9182*
GARAN	-68.7309*	-68.7684*	-68.7612*	-68.7435*	-68.7942*	-68.7868*
ICBCT	-68.0001*	-68.0245*	-68.0185*	-68.0044*	-68.0380*	-68.0320*
Related Variables						
Δexc	-34.0290*	-34.2558*	-32.0916*	-62.4566*	-62.5656*	-62.6377*
$\sqrt{\Delta exc^{vol}}$	-8.3688*	-13.0083*	-13.0349*	-6.5081*	-11.1460*	-11.1678*
Δint	-43.4845*	-43.4817*	-43.4794*	-72.5213*	-72.5148*	-72.5085*
$\sqrt{\Delta int^{vol}}$	-5.3831*	-8.5024*	-8.7533*	-5.1782*	-7.8767*	-8.2320*
vix	-2.2372**	-5.5534*	-5.5520*	-2.1562**	-6.0580*	-6.0567*

*, ** indicates the significance at 1% and 5% level, respectively. The optimal lag is selected according to the AIC.

Appendix C

Table 5
Estimation Results for Changes with Structural Break

	Changes in Exchange Rates						Changes in Interest Rates						VIX Index					
	Mean eq.		Variance eq. (h_{12})				Mean eq.		Variance eq. (h_{13})				Mean eq.		Variance eq. (h_{14})			
	k_{12}	m_{12}	a_{12}	b_{12}	d_{12}	e_{12}	k_{13}	m_{13}	a_{13}	b_{13}	d_{13}	e_{13}	k_{14}	m_{14}	a_{14}	b_{14}	d_{14}	e_{14}
Home Private Banks in XBANK Index																		
AKBNK	0.0215 (0.0344)	0.0001 (0.0012)	0.0490 (0.0019)	0.9205 (0.0026)	0.0000 (0.0000)	0.0000 (0.0000)	-0.5894 (0.0972)	-0.0025 (0.0003)	0.0450 (0.0018)	0.9414 (0.0015)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0032 (0.0038)	-0.0397 (0.0061)	0.0639 (0.0024)	0.8553 (0.0038)	0.0000 (0.0000)	-0.0001 (0.0002)
ISATR	-0.0027 (0.0204)	0.0005 (0.0018)	0.0748 (0.0014)	0.9076 (0.0024)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0441 (0.122)	-0.0002 (0.0003)	0.0655 (0.001)	0.9322 (0.001)	0.0000 (0.0000)	0.0000 (0.0000)	0.0039 (0.0026)	0.0063 (0.0055)	0.0962 (0.0016)	0.8455 (0.0036)	-0.0001 (0.0002)	-0.0002 (0.0001)
ISBTR	0.0481 (0.0305)	0.0012 (0.0017)	0.0756 (0.002)	0.9061 (0.0026)	0.0000 (0.0000)	0.0000 (0.0000)	-0.3420 (0.0927)	-0.0010 (0.0003)	0.0701 (0.0017)	0.9257 (0.0015)	0.0000 (0.0000)	0.0000 (0.0000)	0.0029 (0.0039)	-0.0176 (0.006)	0.0986 (0.0024)	0.8450 (0.0036)	0.0001 (0.0001)	0.0004 (0.0003)
ISCTR	0.2259 (0.0119)	0.0007 (0.0021)	0.0464 (0.0033)	0.8804 (0.0074)	0.0000 (0.0000)	0.0003 (0.0001)	-0.5994 (0.0874)	-0.0073 (0.0007)	0.0428 (0.003)	0.8976 (0.0073)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0016 (0.0048)	-0.0481 (0.0074)	0.0616 (0.004)	0.8156 (0.0071)	0.0001 (0.0003)	-0.0115 (0.0016)
SKBNK	0.0126 (0.0332)	0.0021 (0.0018)	0.0783 (0.0024)	0.8871 (0.0034)	0.0000 (0.0000)	0.0000 (0.0000)	-0.3718 (0.111)	-0.0036 (0.0005)	0.0791 (0.0023)	0.8954 (0.0031)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0021 (0.0038)	-0.0411 (0.0079)	0.1085 (0.003)	0.8131 (0.0045)	0.0002 (0.0002)	-0.0006 (0.0006)
TSKB	-0.0183 (0.0339)	-0.0002 (0.0012)	0.0503 (0.002)	0.9227 (0.0025)	0.0000 (0.0000)	0.0000 (0.0000)	-0.3779 (0.1081)	-0.0018 (0.0003)	0.0469 (0.0018)	0.9410 (0.0014)	0.0000 (0.0000)	0.0000 (0.0000)	0.0008 (0.0037)	-0.0395 (0.0055)	0.0657 (0.0024)	0.8573 (0.0036)	0.0000 (0.0000)	0.0002 (0.0001)
YKBNK	-0.0087 (0.0328)	0.0004 (0.0013)	0.0483 (0.0021)	0.9195 (0.0028)	0.0000 (0.0000)	0.0000 (0.0000)	-0.6090 (0.0931)	-0.0028 (0.0003)	0.0448 (0.0019)	0.9393 (0.0017)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0001 (0.0037)	-0.0457 (0.006)	0.0634 (0.0026)	0.8518 (0.0039)	0.0000 (0.0001)	0.0000 (0.0002)
Home Public Banks in XBANK Index																		
HALKB	0.0081 (0.036)	0.0010 (0.0014)	0.0454 (0.0021)	0.9225 (0.0028)	0.0000 (0.0000)	0.0000 (0.0000)	-0.3150 (0.1402)	-0.0031 (0.0004)	0.0420 (0.002)	0.9401 (0.0019)	0.0000 (0.0000)	0.0000 (0.0000)	0.0059 (0.0043)	-0.0574 (0.0086)	0.0614 (0.0028)	0.8360 (0.0048)	-0.0007 (0.0002)	-0.0001 (0.0002)
VAKBN	0.0195 (0.0373)	0.0015 (0.0013)	0.0487 (0.0021)	0.9214 (0.0027)	0.0000 (0.0000)	0.0000 (0.0000)	-0.3000 (0.1143)	-0.0030 (0.0003)	0.0456 (0.002)	0.9388 (0.0018)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0013 (0.0041)	-0.0481 (0.0066)	0.0643 (0.0027)	0.8518 (0.0039)	0.0000 (0.0000)	-0.0003 (0.0002)
Foreign Private Banks in XBANK Index																		
ALBRK	-0.0007 (0.0316)	0.0006 (0.0016)	0.0881 (0.0026)	0.8976 (0.0028)	0.0000 (0.0000)	-0.0001 (0.0000)	-0.5022 (0.099)	-0.0023 (0.0004)	0.0887 (0.0025)	0.9069 (0.0023)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0046 (0.0033)	-0.0359 (0.0078)	0.1262 (0.0035)	0.8040 (0.005)	-0.0019 (0.0004)	0.0023 (0.0005)
GARAN	0.0560 (0.039)	0.0006 (0.0013)	0.0462 (0.0018)	0.9180 (0.0028)	0.0000 (0.0000)	0.0000 (0.0000)	-0.5757 (0.1058)	-0.0025 (0.0003)	0.0407 (0.0013)	0.9447 (0.0013)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0036 (0.0037)	-0.0427 (0.0062)	0.0594 (0.0022)	0.8548 (0.0038)	0.0000 (0.0000)	0.0002 (0.0001)
ICBCT	0.0239 (0.0441)	0.0017 (0.0048)	0.0775 (0.0034)	0.7883 (0.0127)	-0.0002 (0.0004)	0.0007 (0.0007)	-0.4689 (0.1531)	-0.0087 (0.0013)	0.0729 (0.0031)	0.8028 (0.0128)	0.0001 (0.0000)	0.0000 (0.0000)	-0.0074 (0.0068)	-0.0690 (0.0148)	0.1008 (0.0041)	0.7341 (0.0120)	-0.0005 (0.0028)	-0.0591 (0.0065)

(i) a_{12} indicates volatility spillover where $a_{11} * a_{22}$ and ($s = 2,3,4$) (ii) b_{12} indicates persistence in volatility spillover where $b_{11} * b_{22}$ and ($s = 2,3,4$) (iii) d_{13} and e_{13} indicates the cosine and sine coefficients, respectively ($s = 2,3,4$) (iv) Values in parentheses give the standard errors. (v) Bold means that the coefficient is significant at 1% level.

Table 6
Estimation Results for Risks with Structural Break

	Exchange Rate Risk						Interest Rate Risk						VIX Index						
	Mean eq.		Variance eq. (h_{12})				Mean eq.		Variance eq. (h_{13})				Mean eq.		Variance eq. (h_{14})				
	k_{12}	m_{12}	a_{12}	b_{12}	d_{12}	e_{12}	k_{13}	m_{13}	a_{13}	b_{13}	d_{13}	e_{13}	k_{14}	m_{14}	a_{14}	b_{14}	d_{14}	e_{14}	
Home Private Banks in XBANK Index																			
AKBNK	-0.0014 (0.0609)	-0.0008 (0.0012)	0.0472 (0.0019)	0.9262 (0.0022)	0.0000 (0.0000)	0.0000 (0.0000)	0.0088 (0.2065)	-0.0026 (0.0003)	0.0446 (0.0018)	0.9407 (0.0015)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0026 (0.0038)	-0.0381 (0.0058)	0.0616 (0.0023)	0.8606 (0.0036)	0.0000 (0.0000)	-0.0001 (0.0001)	
ISATR	-0.0665 (0.0393)	0.0005 (0.0016)	0.0770 (0.0013)	0.9104 (0.0017)	0.0000 (0.0000)	0.0000 (0.0000)	0.0134 (0.1902)	-0.0001 (0.0003)	0.0657 (0.0021)	0.9322 (0.0009)	0.0000 (0.0000)	0.0000 (0.0000)	0.0047 (0.0027)	0.0057 (0.0053)	0.0951 (0.0015)	0.8523 (0.0032)	0.0001 (0.0001)	-0.0002 (0.0001)	
ISBTR	0.0500 (0.0858)	0.0011 (0.0017)	0.0759 (0.002)	0.9106 (0.0021)	0.0000 (0.0000)	0.0000 (0.0000)	0.0147 (0.2397)	-0.0010 (0.0003)	0.0703 (0.0017)	0.9252 (0.0015)	0.0000 (0.0000)	0.0000 (0.0000)	0.0022 (0.0039)	-0.0149 (0.0057)	0.0976 (0.0023)	0.8490 (0.0033)	0.0000 (0.0001)	0.0003 (0.0003)	
ISCTR	0.5809 (0.0163)	-0.0008 (0.0021)	0.0647 (0.0029)	0.8729 (0.0055)	0.0002 (0.0001)	0.0003 (0.0002)	-0.8380 (0.1629)	-0.0067 (0.0007)	0.0615 (0.0027)	0.8844 (0.0056)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0054 (0.0046)	-0.0461 (0.0074)	0.0856 (0.0034)	0.8086 (0.0057)	-0.0009 (0.0007)	-0.0127 (0.0013)	
SKBNK	-0.1093 (0.0683)	0.0011 (0.002)	0.0828 (0.0024)	0.8826 (0.0036)	0.0001 (0.0000)	0.0000 (0.0000)	0.2523 (0.205)	-0.0039 (0.0006)	0.0841 (0.0024)	0.8874 (0.0033)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0017 (0.0038)	-0.0402 (0.0076)	0.1121 (0.003)	0.8125 (0.0044)	-0.0002 (0.0003)	-0.0002 (0.0006)	
TSKB	-0.0731 (0.0778)	-0.0011 (0.0012)	0.0517 (0.0021)	0.9234 (0.0023)	0.0000 (0.0000)	0.0000 (0.0000)	0.0168 (0.2113)	-0.0019 (0.0003)	0.0478 (0.0018)	0.9402 (0.0014)	0.0000 (0.0000)	0.0000 (0.0000)	0.0017 (0.0038)	-0.0363 (0.0051)	0.0652 (0.0024)	0.8650 (0.0033)	0.0001 (0.0000)	0.0002 (0.0001)	
YKBNK	-0.0080 (0.0614)	-0.0012 (0.0012)	0.0483 (0.0021)	0.9227 (0.0023)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0550 (0.2001)	-0.0029 (0.0003)	0.0446 (0.0019)	0.9394 (0.0017)	0.0000 (0.0000)	0.0000 (0.0000)	0.0008 (0.0037)	-0.0439 (0.0057)	0.0621 (0.0025)	0.8579 (0.0036)	0.0000 (0.0000)	0.0000 (0.0001)	
Home Public Banks in XBANK Index																			
HALKB	-0.0295 (0.0838)	0.0002 (0.0014)	0.0441 (0.0021)	0.9257 (0.0025)	0.0000 (0.0000)	0.0000 (0.0000)	-0.1046 (0.2434)	-0.0031 (0.0003)	0.0410 (0.002)	0.9406 (0.0022)	0.0000 (0.0000)	0.0000 (0.0000)	0.0065 (0.0044)	-0.0562 (0.0082)	0.0585 (0.0026)	0.8430 (0.0046)	-0.0006 (0.0002)	-0.0001 (0.0002)	
VAKBN	-0.0767 (0.0776)	0.0006 (0.0013)	0.0487 (0.0021)	0.9239 (0.0023)	0.0000 (0.0000)	0.0000 (0.0000)	-0.1209 (0.2132)	-0.0031 (0.0003)	0.0453 (0.002)	0.9389 (0.0018)	0.0000 (0.0000)	0.0000 (0.0000)	0.0001 (0.0041)	-0.0460 (0.0062)	0.0627 (0.0027)	0.8575 (0.0037)	0.0001 (0.0000)	-0.0002 (0.0002)	
Foreign Private Banks in XBANK Index																			
ALBRK	-0.0407 (0.0761)	-0.0008 (0.0016)	0.0848 (0.0024)	0.9031 (0.0025)	0.0000 (0.0000)	-0.0001 (0.0000)	0.0072 (0.2154)	-0.0023 (0.0004)	0.0874 (0.0025)	0.9081 (0.0022)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0034 (0.0034)	-0.0352 (0.0075)	0.1209 (0.0032)	0.8111 (0.0047)	-0.0014 (0.0003)	0.0020 (0.0004)	
GARAN	-0.0153 (0.0694)	-0.0004 (0.0012)	0.0438 (0.0018)	0.9253 (0.0021)	0.0000 (0.0000)	0.0000 (0.0000)	0.1059 (0.2062)	-0.0026 (0.0003)	0.0396 (0.0016)	0.9444 (0.0013)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0034 (0.0037)	-0.0399 (0.0058)	0.0560 (0.0021)	0.8626 (0.0035)	0.0000 (0.0000)	0.0002 (0.0001)	
ICBCT	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)	NA (NA)

(i) a_{11} indicates volatility spillover where $a_{11} * a_{33}$ and ($s = 2,3,4$) (ii) h_{13} indicates persistence in volatility spillover where $b_{11} * b_{33}$ and ($s = 2,3,4$) (iii) d_{13} and e_{13} indicates the cosine and sine coefficients, respectively ($s = 2,3,4$) (iv) Values in parentheses give the standard errors. (v) Bold means that the coefficient is significant at 1% level.

Table 7
Estimation Results for Risks with Structural Break and Dummy

	Exchange Rate Risk						Interest Rate Risk						VIX Index					
	Mean eq.		Variance eq. (h_{12})				Mean eq.		Variance eq. (h_{13})				Mean eq.		Variance eq. (h_{14})			
	t_{12}	m_{12}	a_{12}	b_{12}	d_{12}	e_{12}	t_{13}	m_{13}	a_{13}	b_{13}	d_{13}	e_{13}	t_{14}	m_{14}	a_{14}	b_{14}	d_{14}	e_{14}
Home Private Banks in XBANK Index																		
AKBNK	-0.0371 (0.051)	-0.0008 (0.0011)	0.0473 (0.0019)	0.9262 (0.0022)	0.0000 (0.0000)	0.0000 (0.0000)	0.1069 (0.1666)	-0.0026 (0.0003)	0.0446 (0.0018)	0.4251 (0.0057)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0016 (0.0027)	-0.0381 (0.0058)	0.0617 (0.0023)	0.8605 (0.0036)	0.0000 (0.0000)	-0.0001 (0.0001)
ISATR	-0.0936 (0.0252)	0.0005 (0.0017)	0.0773 (0.0013)	0.9103 (0.0017)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0649 (0.1253)	-0.0002 (0.0003)	0.0660 (0.0011)	0.4247 (0.0056)	0.0000 (0.0000)	0.0000 (0.0000)	0.0021 (0.0017)	0.0057 (0.0054)	0.0954 (0.0015)	0.8525 (0.0032)	0.0001 (0.0001)	-0.0002 (0.0001)
ISBTR	0.0657 (0.0709)	0.0012 (0.0017)	0.0758 (0.002)	0.9107 (0.0021)	0.0000 (0.0000)	0.0000 (0.0000)	0.1643 (0.1998)	-0.0010 (0.0003)	0.0703 (0.0017)	0.4229 (0.0055)	0.0000 (0.0000)	0.0000 (0.0000)	0.0014 (0.0027)	-0.0148 (0.0057)	0.0975 (0.0023)	0.8492 (0.0033)	0.0000 (0.0001)	0.0003 (0.0003)
ISCTR	0.4782 (0.0151)	-0.0010 (0.0021)	0.0637 (0.0029)	0.8745 (0.0055)	0.0002 (0.0001)	0.0003 (0.0002)	-0.3527 (0.1344)	-0.0067 (0.0007)	0.0605 (0.0028)	0.4326 (0.0059)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0036 (0.0031)	-0.0458 (0.0073)	0.0841 (0.0035)	0.8106 (0.0057)	-0.0008 (0.0006)	-0.0126 (0.0013)
SKBNK	-0.0545 (0.0536)	0.0011 (0.002)	0.0828 (0.0024)	0.8829 (0.0036)	0.0001 (0.0000)	0.0000 (0.0000)	0.1300 (0.1542)	-0.0039 (0.0006)	0.0841 (0.0024)	0.4270 (0.0058)	0.0000 (0.0000)	0.0000 (0.0000)	0.0014 (0.0026)	-0.0401 (0.0077)	0.1122 (0.003)	0.8128 (0.0044)	-0.0002 (0.0003)	-0.0001 (0.0006)
TSKB	-0.0486 (0.063)	-0.0011 (0.0012)	0.0517 (0.0021)	0.9234 (0.0023)	0.0000 (0.0000)	0.0000 (0.0000)	0.0815 (0.1684)	-0.0019 (0.0003)	0.0478 (0.0018)	0.4211 (0.0056)	0.0000 (0.0000)	0.0000 (0.0000)	0.0008 (0.0026)	-0.0362 (0.0051)	0.0651 (0.0024)	0.8650 (0.0033)	0.0001 (0.0000)	0.0002 (0.0001)
YKBNK	-0.0242 (0.0506)	-0.0012 (0.0012)	0.0483 (0.0021)	0.9227 (0.0023)	0.0000 (0.0000)	0.0000 (0.0000)	0.1586 (0.1606)	-0.0029 (0.0003)	0.0445 (0.0019)	0.4285 (0.0057)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0003 (0.0026)	-0.0438 (0.0057)	0.0621 (0.0025)	0.8579 (0.0036)	0.0000 (0.0000)	0.0000 (0.0001)
Home Public Banks in XBANK Index																		
HALKB	-0.0244 (0.0692)	0.0002 (0.0014)	0.0440 (0.0021)	0.9257 (0.0025)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0329 (0.1964)	-0.0031 (0.0003)	0.0409 (0.002)	0.4327 (0.0068)	0.0000 (0.0000)	0.0000 (0.0000)	0.0026 (0.0028)	-0.0562 (0.0082)	0.0583 (0.0026)	0.8431 (0.0046)	-0.0006 (0.0002)	-0.0001 (0.0002)
VAKBN	-0.0670 (0.0627)	0.0006 (0.0013)	0.0487 (0.0021)	0.9239 (0.0023)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0778 (0.1683)	-0.0031 (0.0003)	0.0452 (0.002)	0.4235 (0.0057)	0.0000 (0.0000)	0.0000 (0.0000)	0.0008 (0.0027)	-0.0461 (0.0062)	0.0627 (0.0027)	0.8574 (0.0037)	0.0001 (0.0000)	-0.0002 (0.0002)
Foreign Private Banks in XBANK Index																		
ALBRK	0.0175 (0.0630)	-0.0008 (0.0016)	0.0850 (0.0024)	0.9030 (0.0025)	0.0000 (0.0000)	-0.0001 (0.0000)	-0.0557 (0.1701)	-0.0023 (0.0004)	0.0877 (0.0025)	0.4430 (0.0069)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0047 (0.0023)	-0.0353 (0.0075)	0.1213 (0.0033)	0.8107 (0.0048)	-0.0014 (0.0004)	0.0020 (0.0004)
GARAN	-0.0399 (0.0575)	-0.0004 (0.0012)	0.0438 (0.0018)	0.9252 (0.0021)	0.0000 (0.0000)	0.0000 (0.0000)	0.1825 (0.165)	-0.0026 (0.0003)	0.0396 (0.0016)	0.4262 (0.0056)	0.0000 (0.0000)	0.0000 (0.0000)	-0.0023 (0.0026)	-0.0399 (0.0058)	0.0560 (0.0021)	0.8625 (0.0035)	0.0000 (0.0000)	0.0002 (0.0001)
ICBCT	-0.0096 (0.0655)	-0.0027 (0.0047)	0.0834 (0.0035)	0.7726 (0.0135)	0.0004 (0.0004)	-0.0004 (0.0008)	0.0667 (0.1961)	-0.0098 (0.0014)	0.0780 (0.0033)	0.4177 (0.0054)	0.0001 (0.0000)	0.0000 (0.0000)	-0.0059 (0.0046)	-0.0712 (0.0154)	0.1051 (0.0041)	0.7238 (0.0126)	-0.0048 (0.0028)	-0.0574 (0.0062)

(i) a_{11} indicates volatility spillover where $a_{11} * a_{33}$ and ($s = 2,3,4$) (ii) h_{13} indicates persistence in volatility spillover where $b_{11} * b_{33}$ and ($s = 2,3,4$) (iii) d_{13} and e_{13} indicates the cosine and sine coefficients, respectively ($s = 2,3,4$) (iv) Values in parentheses give the standard errors. (v) Bold means that the coefficient is significant at 1% level.

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