



Cross-time-frequency analysis of volatility linkages in global currency markets: an extended framework

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Abstract

This research aims to detect cross-border volatility linkages among various currencies within the foreign exchange market with respect to different sampling frequencies. Eleven currency pairs are included in the sample, which covers a period from 2009 to 2020. Volatility linkages among these selected exchange rates were tested by utilizing a multivariate VAR-BEKK-GARCH model. Results indicate that volatility linkages among currencies sampled are far stronger in higher frequency terms. Strikingly, the results denote that the major currencies do not play a strong leading role in volatility transmission. This finding is more apparent when daily and intraday results are compared.

Keywords Volatility spillover · Exchange rates · Multivariate GARCH · Intraday data

JEL Classification G11 · G13 · G15

1 Introduction

Amongst the most critical matters for traders over and above for policymakers is the form of volatility transmission in global currency markets, because a strong volatility linkage among several markets may cause together benefits and drawbacks. Especially, the presence of volatility transmissions in currency markets is prone to bound hedging opportunities, however may correspondingly set the stage for probable speculative trading gains.

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Regarding a policymaker's perspective, there is an ongoing debate on the impact of Central Bank intervention on exchange rate volatility. Some studies claim that these interventions either augment, or have no impact on volatility (Dominguez, 2003; Fratzcher, 2006; Rogers & Siklos, 2003), whereas others document a decreasing volatility (Kim et al., 2000; Qiumin & Qian, 2017). In this respect, volatility transmission analysis between currencies is crucial for Central Bank authorities, as the results may be useful in formulating their decisions.

There are numerous studies on volatility spillovers in global currency markets, with various stories encapsulated (Kocenda & Moravcova, 2019; Panda et al., 2019; Salisu et al., 2018; Kenorgios et al., 2015; Bubak et al., 2011, Kitamura, 2010; Chang & Taylor 2003). Nevertheless, the sample datasets in the majority of these were confined to major currencies, and generally ignored interactions between major and minor currencies. In addition, in the majority of studies examining the volatility dynamics that utilized various frequencies, samples were limited to either single or a small number of currencies (Seemann et al., 2011; Gau & Hua, 2007; Melvin & Melvin, 2003). Contrarily, Baklaci et al. (2020) try to identify the impact of stock market trading on currency market volatility spillovers while taking interactions between major and minor currencies into consideration and analyzing the diversity of findings regarding to different sampling frequencies. However, since the study's sub-samples are based on operating and non-operating hours of three major stock markets (Tokyo, London and New York), volatility linkages among sample currencies are analyzed using discrete samples representing the stock market sessions. This approach distorts the continuous information flow between currencies but distinguishes the impact of stock market trading on currency market. In addition, as a result of discrete sub samples, higher sampling frequencies are employed to satisfy the required number of observations for a feasible estimation.

In this respect, the literature still lacks a combined study embracing the volatility spillover effects among various currencies with regard to different sampling frequencies.

This particular study aims to fill this gap by detecting volatility spillover patterns among eleven currency pairs, which, in our opinion, represents an extensive number of currency pairs. One other unique feature of the data set is that it is comprised of major, minor and exotic currencies. Furthermore, the volatility transmissions among eleven currency pairs are scrutinized by employing different sampling frequencies: namely daily, 30-min and 15-min data. The sample period spans from 1st January, 2009 to 31st December, 2020. Since the intraday data for the sample can be traced to the beginning of 2009, data availability is the main cause for defining this sample period. As a result, the data set contains sufficient numbers of observations to analyze inter-currency volatility spillovers.

The research questions of the study can briefly be summarized as follows:

- (a) What are the primary roles of major and minor currencies in volatility transmission process? Which of the sample currencies play the role of volatility transmitter in different sampling frequencies?

- (b) Is there a change in number of unilateral/bilateral volatility linkages when different intraday frequencies are employed?

The remainder of the paper is organized as follows: the next section includes a brief discussion of relevant literature. The third section includes the discussion on data and methodology, followed by the interpretation of empirical findings. The final section presents concluding remarks.

2 Literature review

In parallel with the apparently increasing importance of the foreign exchange market, currency volatility has become an issue of concern, particularly for monetary authorities and international investors seeking risk diversification. Recently, voluminous studies have been devoted to exploring integration and the spillover effect of the foreign exchange market for developed as well as for emerging economies (Apergis & Christou, 2017; Greenwood-Nimmo et al., 2016; Kocenda & Moravcova, 2019; Panda et al., 2019; Salisu et al., 2018).

Previous studies on volatility spillovers in currency markets made diverse conclusions. There is evidence on significant exchange rate spillovers (Black & McMillan, 2004; Kearney & Patton, 2000) as well as asymmetric spillovers among selected currencies (Boero et al., 2011). Especially, there is strong evidence for prolonged volatility increases in post-crisis periods (Kole, 2006; Le & David, 2014; Groby, 2015). The results of some recent studies on volatility spillover can be summarized as follows:

Ozer-Imer and Ozkan (2014) consider daily data of 16 currencies during the 2008–2009 global financial crisis by applying two-step estimations; the results indicate at least a twofold increase in volatilities with the outbreak. Kenourgios et al. (2015) examine the impact of Central Bank announcements on volatility spillover between the Euro, British Pound and Japanese Yen. Their results indicate an increased volatility transmission from Euro to Yen during ECB announcements and an increased volatility from Pound to the Euro during BoE announcements. Bekiros (2014), Lau and Sheng (2018), and Jain and Sehgal (2019) all argue that major FX and stock markets become more nonlinearly integrated after financial crises.

Some studies document that various factors may be explanatory for volatility transmission in FX markets. Scheduled news announcements are found to explain volatility transmissions partially (Gau & Hua, 2004); whereas quarterly earnings announcements by central banks (Kenourgios et al., 2015), order flows as buyer-initiated trades net of seller-initiated trades in FX markets (Kitamura, 2010), exchange rate uncertainties (Caporale et al., 2015), and verbal interventions in FX markets (Dewachter et al., 2014) significantly affect volatility transmission. Lastly, Laakkonen (2014) highlights the importance of filtering out the intraday periodicity of volatility to prevent biased results, as well as the importance of selectivity filtering method in analyzing the impact of news on currency markets.

Most recent studies (Laborde & Olmo, 2021; Hung & Vo, 2021; Zhang & Hamori, 2021; Balcilar & Usman, 2021) have investigated the volatility spillover among financial markets and instruments during Covid-19 pandemic by employing Diebold-Yilmaz approach (2012).

Diebold and Yilmaz (2012) have developed a volatility spillover index to examine the transmission mechanism between various financial markets and instruments. Although regarded as a variant of BEKK-GARCH model, forecast-error variance decompositions are invariant to the variable ordering in Diebold and Yilmaz approach. Thus, their approach is considered to be a better framework in capturing asymmetric volatility spillovers.

Considering the frequency of data, deployment of intraday data is valuable not only to understand patterns within the day, but also to improve the estimation of volatility over different horizons (Andersen et al., 2000). In other words, high frequency data can result in more accurate volatility measurements, and hence in efficiency gains (Bollerslev & Wright, 2000). In various studies (Bubák et al., 2011; Melvin & Melvin, 2003), very high-frequency data is employed to support the evidence for significant volatility spillovers in FX markets.

This study aims to detect global volatility linkages among eleven currencies within the foreign exchange market with respect to different sampling frequencies, while accounting for both volatility persistence within currencies, and also volatility spillover effects between currencies.

Consistent with the research questions discussed above, this study contributes to current literature in two major aspects: Firstly, it utilizes an extensive dataset to compare and contrast the volatility transmission mechanism among major and minor currencies simultaneously. This approach has been largely ignored in previous studies as most studies have predominantly used major currencies in their sample. Secondly, both daily and intraday data are utilized to detect if switching from lower to higher frequency data yield distinct results in volatility spillover mechanisms.

3 Data

In order to understand the cross-border volatility linkages within the foreign exchange market, a total of eleven currencies, including major, minor and exotic currencies, were utilized in the dataset. The sample period spans from 1st January, 2009 to 31st December, 2020. As indicated in the Introduction, since intraday data for all sample currencies begin from January 2009, the sample window does not include data before 2009. Besides, this defined sample period allows us to avoid the turmoil of global crisis in 2007 and 2008, evidenced by exuberant volatility in all financial markets, which would distort results. Commensurate with the research question to detect whether volatility transmission increases with higher frequency data, daily, 30-min and 15-min observations are chosen. The rationale for the selection of 30- and 15-min frequencies for intraday sampling is their popularity among investment banks and professionals. The highest data frequency including 15-min observations yield 3,009,622 data points, which is sufficiently large to conduct the required analyses.

As indicated above, the sample includes major, minor and exotic currencies. Major currency sample pairs are: Euro/US Dollar (EURUSD), British Pound/US Dollar (GBPUSD), US Dollar/Japanese Yen (USDJPY), US Dollar/Swiss Franc (USDCHF), and US Dollar/Canadian Dollar (USDCAD). Minor currency sample pairs are: Australian Dollar/US Dollar (AUDUSD), New Zealand Dollar/US Dollar (NZDUSD), US Dollar/Norwegian Krona (USDNOK) and US Dollar/Swedish Krona (USDSEK), whereas exotic currency sample pairs are US Dollar/Hong Kong Dollar (USDHKD), and US Dollar/Mexican Peso (USDMXN).

Even though there are some minor differences of opinion in currency type classifications, the currency classifications used in the study are done in consistent with the classifications from majority of the prominent FX web sources including *finance.yahoo.com*, *Forextraders.com*, and *Continental Currency*. Furthermore, our currency classification is consistent with the ranking of currencies by Bank for International Settlements (BIS) based on their trading volume.

The primary reason for selection of these particular currencies is that these currencies are among the currencies with the highest FX turnover in global currency markets (Table 1).¹ FX turnover figures in Table 1 indicate that the sample currencies are reliable representatives of global currency markets.

The rationale behind the sample selection process is based not only on turnover, but also on regional variety in order to achieve an understanding of global outcomes. The study aims to identify the impact of frequency differences on the volatility transmission mechanism, and to identify any differences with respect to the direction of the volatility spillovers.

The price series are directly converted into return series. This, in turn, eliminates the possible impact of direct or indirect quotation of price series on analysis. Likewise, Seemann et al. (2011) and Salisu et al. (2018) only use return series as input in their empirical analyses.

Data is collected via Reuters and cross-checked with Bloomberg to confirm the accuracy of data. Furthermore, price quotations are gathered from real-time transaction data to ensure that they represent actual trading data. In addition, since global currency markets are 24-h open markets, the data is continuous and convenient for high-frequency analysis.

Descriptive statistics as well as the results of the unit root and ARCH effect tests² for sample currencies at daily frequency,³ are provided in Table 2.

Table 2 figures reveal that the average daily percentage changes in sample currencies are within close proximity, possibly due to the high number of observations. On the other hand, standard deviation figures show some disparity: as expected,

¹ The FX turnover figures by currency classifications are obtained from Bank for International Settlements 2016 FX survey.

² ADF (Augmented Dickey Fuller), ERS (Elliot et al., 1996), PP (Phillips and Perron, 1988) and KPSS (Kwiatkowski et al., 1992) unit root tests are used to confirm and check the robustness of results. All tests indicate that all currency series are stationary at levels.

³ Descriptive statistics and other test results for intraday frequencies are not reported for brevity purposes but are available from the authors upon request.

Table 1 FX turnover by currency classifications (2010–2019)

Currency	2010	2013	2016	2019	Change in percentage (2019–2010)
	Amount (Billion \$)	Amount (Billion \$)	Amount (Billion \$)	Amount (Billion \$)	
USD	3,371	4,662	4,438	5,819	72.62
EUR	1,551	1,790	1,591	2,219	43.07
JPY	754	1,235	1,096	1,108	46.95
GBP	512	633	649	844	64.84
AUD	301	463	348	445	47.84
CAD	210	244	260	332	58.10
CHF	250	276	243	327	30.80
CNY	34	120	202	284	735.29
SEK	87	94	112	134	54.02
MXN	50	135	97	114	128.00
NZD	63	105	104	136	115.87
SGD	56	75	91	119	112.50
HKD	94	77	88	233	147.87
NOK	52	77	85	119	128.85
KRW	60	64	84	131	118.33
TRY	29	71	73	71	144.83
INR	38	53	58	113	197.37
RUB	36	86	58	72	100.00
BRL	27	59	51	71	162.96

USD US Dollar, *EUR* Euro, *JPY* Japanese Yen, *GBP* British Pound Sterling, *AUD* Australian Dollar, *CAD* Canadian Dollar, *CHF* Swiss Franc, *CNY* Chinese Yuan, *SEK* Swedish Krona, *MXN* Mexican Peso, *NZD* New Zealand Dollar, *SGD* Singapore Dollar, *HKD* Hong Kong Dollar, *NOK* Norwegian Krona, *KRW* Korean Won, *TRY* Turkish Lira, *INR* Indian Rupee, *RUB* Russian Ruble, *BRL* Brazilian Real

standard deviations for minor and exotic currencies are large compared to major currencies.

Unit root test results illustrate that first differences of all currencies are stationary. Furthermore, ARCH test results clearly point to the existence of an ARCH effect in percentage change series of the sample currencies.

4 Methodology

In this study, the VAR-BEKK-GARCH model (Engle & Kroner, 1995), a multivariate volatility specification model, is employed to measure the dynamics of conditional volatility and volatility interdependence among sample currencies. This specification accounts for both volatility persistence of each currency, as well as own- and cross-volatility spillover effects between the currencies. The full BEKK model has three main advantages over VEC-GARCH and other alternative specifications of

Table 2 Descriptive statistics (Daily frequency)

	μ	$\tilde{\mu}$	σ	γ	κ	JB	N	ADF	PP	KPSS	ERS	ARCH
AUDUSD	0.00%	0.00%	0.84%	-0.01	5.77	*613	2572	*-57.35 [0]	*-105.56 [12]	0.04 [15]	*-103.63 [0]	*175.54 [1]
EURUSD	-0.01%	0.00%	0.64%	0.14	4.74	*264	2572	*-51.84 [0]	*-104.95 [5]	0.01 [8]	*-104.65 [0]	*36.41 [1]
GBPUSD	0.00%	-0.01%	0.58%	-0.39	6.12	*814	2572	*-53.13 [0]	*-103.53 [5]	0.03 [3]	*-5.97 [8]	*245.13 [1]
NZDUSD	0.00%	0.00%	0.86%	-0.14	4.73	*248	2572	*-50.51 [0]	*-106.19 [18]	0.07 [20]	*-27.82 [5]	*67.32 [1]
USDCAD	0.00%	0.00%	0.62%	0.11	5.68	*568	2572	*-51.53 [0]	*-105.15 [7]	0.04 [4]	*-9.21 [9]	*57.75 [1]
USDCHF	-0.01%	0.01%	0.84%	-5.72	16.39	*2009	2572	*-53.81 [0]	*-103.09 [1]	0.05 [4]	*-102.48 [0]	*75.94 [1]
USDHKD	0.00%	0.00%	0.03%	-1.68	26.97	*4633	2572	*-54.09 [0]	*-169.98 [17]	0.04 [19]	*-3.85 [9]	*55.87 [1]
USDJPY	0.01%	-0.01%	0.61%	0.08	6.61	*1048	2572	*-51.23 [0]	*-103.87 [12]	0.06 [14]	*-17.41 [8]	*129.34 [1]
USDMXN	0.02%	0.00%	0.92%	7.32	17.65	*2375	2572	*-50.10 [0]	*-112.94 [9]	0.07 [6]	*-3.71 [8]	*122.34 [1]
USDNOK	0.01%	-0.01%	0.87%	0.06	5.13	*391	2572	*-50.19 [0]	*-104.81 [9]	0.01 [12]	*-29.33 [6]	*122.12 [1]
USDSEK	0.00%	0.01%	0.84%	-0.18	5.84	*685	2572	*-48.32 [0]	*-103.22 [11]	0.04 [12]	*-102.49 [0]	*108.11 [1]

Numbers in square brackets correspond to lags for ADF (Augmented Dickey Fuller), ERS (Elliot et al., 1996) unit root tests and ARCH (Engle, 1982) test, bandwidth for PP (Phillips and Perron, 1988) and KPSS (Kwiatkowski et al., 1992) unit root tests. Maximum lags are set to 10, and lag length is determined using the modified Schwarz Information Criterion. Bandwidths are determined using the Newey-West Bandwidth. All auxiliary unit root regressions involve a constant and a trend

$\mu, \tilde{\mu}, \sigma, \gamma, \kappa, JB$ and N refers to Mean, Median, Standard Deviation, Skewness, Kurtosis, Jarque-Bera and Number of observations respectively
 * ** * *** Indicate statistical significance at the 1%, 5% and 10% level respectively

the MGARCH models: First, the VAR-BEKK-GARCH model allows for cross-sectional dynamics. More specifically, VAR-BEKK-GARCH not only defines volatility spillover but also indicates the detailed directions within revealed spillovers, which fits best to our research objective. In this respect, other widely used specifications, including VEC-GARCH or DCC-GARCH, do not serve our purposes since both models reveal information only about the magnitude and not the direction of volatility interdependencies. Secondly, by construction, VAR-BEKK-GARCH model guarantees a positive estimated variance–covariance matrix. Finally, VAR-BEKK-GARCH is more parsimonious, allowing the reduction of the number of estimated parameters by enforcing restrictions both within and across equations.

Thus, the study employs multivariate VAR-BEKK-GARCH model to analyze volatility spillovers among sample currencies.

The VAR-BEKK-GARCH model is conducted using the quasi-maximum likelihood estimation procedure. The log-likelihood function for a given sample of T observations is given by:

$$\log L = -\frac{1}{2} \sum_{t=1}^T [k \log(2\pi) + \ln |H_t| + \varepsilon_t' H_t^{-1} \varepsilon_t], \tag{1}$$

where L is the parameter vector to be estimated, k is the number of the variables, T is a sample of organizations and H_t is the conditional variance–covariance matrix and ε_t is assumed to follow a joint Gaussian log-likelihood function.

The expansion through matrix multiplication resulting in h_{ii} , h_{jj} and h_{ij} of the unrestricted model is presented by Eqs. (2), (3):

$$H_t = C_0' C_0 + \begin{vmatrix} a_{ii} & a_{ij} \\ a_{ji} & a_{jj} \end{vmatrix} \begin{vmatrix} \varepsilon_{i,t-1}^2 & \varepsilon_{i,t-1} \varepsilon_{j,t-1} \\ \varepsilon_{i,t-1} \varepsilon_{j,t-1} & \varepsilon_{j,t-1}^2 \end{vmatrix} + \begin{vmatrix} b_{ii} & b_{ij} \\ b_{ji} & b_{jj} \end{vmatrix} H_{t-1} \begin{vmatrix} b_{ii} & b_{ji} \\ b_{ji} & b_{jj} \end{vmatrix}, \tag{2}$$

$$h_{ii,t} = c_{ii}^2 + a_{ii}^2 \varepsilon_{i,t-1}^2 + 2a_{ii} a_{ij} \varepsilon_{i,t-1} \varepsilon_{j,t-1} + a_{ji}^2 \varepsilon_{j,t-1}^2 + b_{ii}^2 h_{ii,t-1} + 2b_{ii} b_{ij} h_{ij,t-1} + b_{ji}^2 h_{ji,t-1}, \tag{3}$$

$$h_{jj,t} = c_{jj}^2 + a_{jj}^2 \varepsilon_{j,t-1}^2 + 2a_{ij} a_{jj} \varepsilon_{i,t-1} \varepsilon_{j,t-1} + a_{ii}^2 \varepsilon_{i,t-1}^2 + b_{ij}^2 h_{ij,t-1} + 2b_{ij} b_{jj} h_{jj,t-1} + b_{ii}^2 h_{ii,t-1}, \tag{4}$$

$$h_{ij,t} = c_{ij} c_{ji} + a_{ii} a_{ij} \varepsilon_{i,t-1}^2 + (a_{ji} a_{ij} + a_{ii} a_{jj}) \varepsilon_{i,t-1} \varepsilon_{j,t-1} + a_{ji} a_{jj} \varepsilon_{j,t-1}^2 + b_{ii} b_{ij} h_{ii,t-1} + (b_{ji} b_{ij} + b_{ii} b_{jj}) h_{ij,t-1} + b_{ji} b_{jj} h_{jj,t-1} \tag{5}$$

In analyses, Eqs. (2) and (3) represent conditional variances for individual currencies that include cross-currency impacts, whereas Eq. (5) expresses the cross-currency conditional covariance ($h_{ij,t}$), derived from Eqs. (3) and (4).

ARCH effect (i.e., the effect of a previous shock on the volatility of the same variable,) is shown by the parameters (a_{ii} , a_{jj}), and the degree of volatility persistence is represented by the GARCH parameters (b_{ii} , b_{jj}).

The off-diagonal elements of γ_i matrix in Eq. (1) capture spillover effects in mean. Particularly, the coefficients $\gamma(1)_{ij}$ and $\gamma(1)_{ji}$ measure the bi-directional spillover effects in mean. Off-diagonal elements of A matrix, a_{ij} and a_{ji} , measure the bi-directional

spillover effects of previous shocks. Similarly, the off-diagonal elements of B matrix, b_{ij} and b_{ji} , measure the bi-directional spillover effects of variances. In particular, the parameters, a_{ij} and a_{ji} capture bi-directional shock transmission effects whereas b_{ij} and b_{ji} capture volatility spillover effects among the selected currencies.

5 Empirical results

The estimation results gathered from the VAR-BEKK-GARCH model are reported in Tables 6, 7, and 8 in the Appendix for daily, 30-min and 15-min observations. Before moving to the interpretation of the findings, it is noted that the estimation output provides robust coefficients. To elaborate, the statistical significance and persistence parameters of individual coefficients as well as the model validate the estimation quality.

In order to ensure that the results are not sensitive to sample selection bias, a structural break analysis is conducted on 30-min and 15-min frequencies through modified augmented Dickey-Fuller tests (Perron, 2006), which allow for levels and trends that differ across a single break date, since structural break is widely considered as a major source of nonlinearity in currency markets. The unit root tests are conducted with a single break, where the break consists of a level shift, a trend break, or both a shift and break. The results obtained from unit root tests are provided in Table 3.

From the structural break test, it is found that all the currencies' price change series contain no structural break point for the full sample period since there is not any statistical significance among the results provided in Table 3. The rationale behind this outcome may be the frequency of the data. Consequently, analyses were conducted for the full sample period.

Tables 4, 5 and 6 report the summarized results for short-term shock transmission and volatility spillover effects in three sampling frequencies. The shape of the arrows in the tables denote the direction of the interdependencies between sample currencies, if any.

The findings from the analyses can briefly be interpreted as follows:

The findings clearly point to the presence of volatility spillover effect among the sample currencies. Moreover, it can also be observed that, in most cases, the effect is bi-directional, indicating a strong volatility interaction among the selected currencies.

Volatility spillover among sample currencies is far stronger in the higher frequency data (30 min and 15 min). Interestingly, in 30- and 15-min intervals, all analyses indicated at least one unilateral volatility transmission among sample currencies.

Analyses provide unorthodox results indicating that major currencies do not play a strong leading role in volatility transmission. This finding is more distinct when daily and intraday results are compared. In particular, the majority of minor currencies (particularly the Norwegian Krona and Swedish Krona) transform from volatility receivers to volatility transmitters with the movement towards higher sampling frequencies. Likewise, as the observation frequencies increase, major currencies lose their volatility-transmitter role. Specifically, at the daily level they unilaterally

Table 3 Dickey–fuller structural break test results

	30 Minute frequency			15 Minute frequency		
	t	b_c	b_t	t	b_c	b_t
AUDUSD	− 0.496 [0]	0.999 [0]	− 1.157 [0]	0.051 [0]	0.857 [0]	− 0.938 [0]
EURUSD	1.241 [0]	− 1.008 [0]	0.041 [0]	0.256 [0]	− 0.175 [0]	− 0.259 [0]
GBPUSD	− 0.284 [0]	− 0.416 [0]	1.020 [0]	− 0.834 [0]	0.679 [0]	0.425 [0]
NZDUSD	0.494 [0]	− 0.135 [0]	− 0.511 [0]	− 1.151 [0]	1.148 [0]	1.157 [0]
USDCAD	− 1.324 [0]	0.534 [0]	1.402 [0]	0.612 [0]	− 0.527 [0]	− 0.636 [0]
USDCHF	− 0.132 [0]	− 0.481 [0]	0.283 [0]	0.835 [0]	− 1.611 [0]	− 0.134 [0]
USDHKD	19.371 [0]	15.442 [0]	12.669 [0]	0.334 [0]	1.650 [0]	− 0.333 [0]
USDJPY	− 0.564 [0]	− 0.304 [0]	0.463 [0]	0.219 [0]	− 1.156 [0]	0.565 [0]
USDMXN	0.492 [0]	− 0.523 [0]	− 0.584 [0]	0.417 [3]	− 0.904 [3]	− 0.157 [3]
USDNOK	0.227 [0]	− 0.629 [0]	− 0.052 [0]	0.834 [0]	0.298 [0]	− 0.298 [0]
USDSEK	0.071 [0]	− 1.170 [0]	− 0.031 [0]	0.691 [0]	− 0.043 [0]	0.518 [0]

Numbers in square brackets correspond to lags for Dickey–Fuller structural break test. Maximum lags are set to 10, and lag length is determined using the modified Schwarz Information Criterion

t , b_c and b_t refer to Trend, Intercept Break and Trend Break respectively.

*, **, *** Indicate statistical significance at the 1%, 5% and 10% level respectively. Any statistical significance would indicate the existence of a structural break

transmit volatility to some sample currencies, yet in intraday frequencies they lose this particular role.

This result becomes even more pronounced in short-term shock transmissions. Notably, as opposed to daily results, the majority of the major currencies, including the British Pound and Japanese Yen, become shock receivers, while the majority of the minor currencies become shock transmitters. Considering the fact that the Hong Kong Dollar was pegged to the U.S Dollar in 2005,⁴ the presence of ARCH effect in HKD series indicates high volatility in intraday data, and provides additional evidence for the importance of using intraday analysis. These findings distinctly connote the importance of using high-frequency observations when analyzing the volatility impacts of major currencies.

We have decided to extract and plot the 1-month forward swap spreads as a proxy to gauge the risk premium levels for the sample currencies. Figure 1 displays the graphical representation of 1-month forward swap rates.

⁴ Since 18 May 2005, HKD is allowed to float between HKD 7.75 and HKD 7.85 per USD.

Table 4 Daily VAR-BEKK-GARCH summary

Currency	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	TOTAL
Volatility transmission												
AUDUSD	-	←	↔	↔	-	↔	↓	↔	↔	↔	-	Unilateral 38
EURUSD	→	-	←	-	←	↑	-	←	↑	↔	↑	
GBPUSD	↔	→	-	↔	↔	↔	-	→	↔	↔	↔	
NZDUSD	↔	-	↔	-	-	↓	-	←	↔	-	-	Bilateral 48
USDCAD	-	→	↔	-	↔	↔	↓	→	↔	↔	↔	
USDCHE	↔	←	↔	→	↔	-	↓	↔	↔	↔	↔	
USDHKD	→	-	-	-	→	↑	-	↔	↔	-	-	None 24
USDJPY	↔	→	←	→	←	↔	↔	-	↔	↔	↔	
USDMXN	↔	←	↔	↔	↔	↔	↑	↔	-	↔	↔	
USDNOK	↔	↔	↔	-	↔	↔	-	←	↔	-	-	
USDSEK	-	←	↔	-	↓	↔	-	↓	↑	-	-	
Shock transmission												
AUDUSD	-	←	↔	↔	-	↓	↓	↓	↑	↑	-	Unilateral 40
EURUSD	→	-	↔	-	←	↑	↔	↔	↔	↔	-	
GBPUSD	↔	↔	-	↔	↔	↔	↑	→	↔	↔	↔	
NZDUSD	↔	-	↔	-	←	-	↓	←	↔	↔	-	Bilateral 54
USDCAD	-	→	↔	→	-	↑	↓	↔	↔	↔	↔	
USDCHE	→	←	↔	-	←	-	↔	↔	↔	↔	↔	
USDHKD	→	↔	←	→	→	↔	-	↔	↔	-	↔	None 16
USDJPY	→	→	←	→	↔	↔	↔	-	↔	↔	↔	
USDMXN	←	↔	↔	↔	←	↔	↔	↔	-	↔	↔	
USDNOK	←	↔	↔	↔	↔	↔	-	↔	↔	-	-	
USDSEK	-	-	↔	-	↓	↔	↓	↓	↔	-	-	

↔→ Indicates a bidirectional volatility transmission, → or ← indicates a unilateral volatility transmission, and — indicates no volatility transmission. ← means the related pair on the first column is volatility receiver while → is the indication of volatility transmitter

Table 5 30 Minute VAR-BEKK-GARCH summary

Currency	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	TOTAL
Volatility transmission												
AUDUSD	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	
EURUSD	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	Unilateral 18
GBPUSD	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	
NZDUSD	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	Bilateral 92
USDCAD	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	
USDCHF	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	
USDHKD	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	None 0
USDJPY	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	
USDMXN	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	
USDNOK	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	
USDSEK	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	
Shock transmission												
AUDUSD	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	
EURUSD	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	Unilateral 12
GBPUSD	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	
NZDUSD	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	Bilateral 96
USDCAD	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	
USDCHF	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	None 2
USDHKD	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	
USDJPY	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	
USDMXN	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	
USDNOK	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	
USDSEK	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	

↔↔ Indicates a bidirectional volatility transmission, → or ← indicates a unilateral volatility transmission, and — indicates no volatility transmission. ← means the related pair on the first column is volatility receiver while → is the indication of volatility transmitter

Table 6 15 Minute VAR-BEKK-GARCH summary

Currency	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDSEK	USDNOK	USDMXN	USDJPY	USDMXN	USDSEK	TOTAL			
Volatility transmission																			
AUDUSD	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	Unilateral 8		
EURUSD	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	Bilateral 102	
GBPUSD	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0	
NZDUSD	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0	
USDCAD	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0	
USDCHE	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0	
USDHKD	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0	
USDJPY	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0	
USDMXN	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	None 0	
USDNOK	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	None 0	
USDSEK	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	None 0	
Shock transmission																			
AUDUSD	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	Unilateral 8	
EURUSD	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	Bilateral 102
GBPUSD	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0
NZDUSD	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0
USDCAD	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0
USDCHE	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0
USDHKD	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0
USDJPY	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0
USDMXN	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	↔	↔	↔	None 0
USDNOK	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	↔	None 0
USDSEK	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	-	↔	↔	↔	↔	↔	None 0

↔ Indicates a bidirectional volatility transmission, → or ← indicates a unilateral volatility transmission, and — indicates no volatility transmission. ← means the related pair on the first column is volatility receiver while → is the indication of volatility transmitter

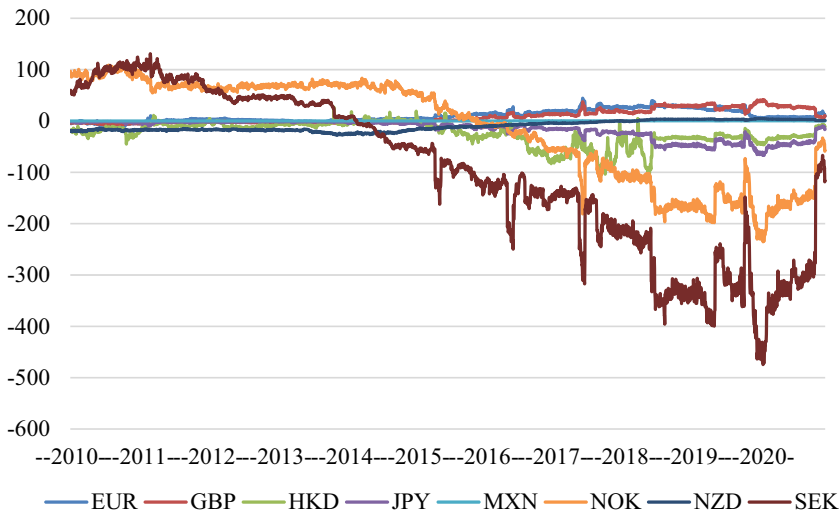


Fig. 1 1 month forward swap rates for selected sample currencies (2009–2020)

An interesting observation from Fig. 1 is the fact that minor currencies, including the Norwegian Krone, Swedish Krone and Hong Kong Dollar, have negative risk premiums in nominal terms, but the volatility of forward swap spreads in these currencies are much higher compared to their major-currency counterparts.

These results connote that minor currencies are open to much wider speculation conducive to higher volatility in those currencies' forward swap spreads, which is in turn transmitted into spot rate volatility, particularly in higher frequency trading.

These results combined with increasing FX trading and turnover in minor and exotic currencies might explain why these currencies transform to an originator role in volatility transmission processes.

A comparison between daily frequency and intra-day frequency results indicates that the unidirectional volatility linkages among sample currencies tend to transform into bidirectional relationships. Even among two sample currencies seemingly unrelated in terms of volatility linkages (i.e., NZDUSD and EURUSD), bidirectional volatility linkages are observed in intra-day observations. Such difference may be caused by aggressive monitoring of the intraday traders and arbitrageurs to benefit from any possible change in market conditions.

These findings carry vital implications for traders and policymakers. From a trader's perspective, one of the most salient finding is the need for day traders to monitor not only the major currency fluctuations but also minor and exotic currency fluctuations for speculation and hedging purposes. This finding is a greater priority for day-traders and arbitrageurs attempting to exploit price fluctuations. From a hedgers' points of view, findings signal that minor and exotic currencies should closely be monitored or added to portfolios for controlling the currency risk.

From a policymaker's perspective, the findings signify that the monetary authorities should monitor the volatility interactions of their home currency against both

major and minor currencies simultaneously. This action could prevent excess volatility, especially due to the unexpected impact of minor and exotic currencies, as revealed in the results of this study.

6 Conclusion

As discussed, the results of this particular research reveal various previously untold stories with regard to volatility linkages in currency markets. It may be possible to generalize these results to provide inferences for global FX markets, as the sample and number of observations is quite extensive in comparison with the pertinent literature.

In terms of answers to the research questions above, these results shed new light on the leading role of major currencies, clearly indicating that soft currencies also play a leading role in shock and volatility transmissions, and that fluctuations in these currencies should carefully be monitored. In contrast to Baklaci et al. (2020), minor currencies' leading role in shock and volatility transmissions remains consistent with respect to various sampling frequencies. Furthermore, Baklaci et al. (2020) build sub-samples based on operating and non-operating hours of three major stock markets (Tokyo, London and New York), which results in different discrete samples. On the other hand, since the currency market operates continuously, the results of the current study is more feasible in terms of identifying pure currency market dynamic settings.

In addition, from both academic and professional points of view, the results underline the importance of using high frequency data to scrutinize volatility interdependencies in currency markets. Particularly since the number of volatility interdependencies is directly proportional to frequency, risk diversification opportunities erode in intraday currency market transactions. Furthermore, such a situation involving tight interdependencies could be exploited by speculators and arbitrageurs through frequent trading and dynamic portfolio management.

The existence of tight volatility and shock transmissions represents a potential challenge for monetary authorities aiming to prevent excess volatility. Furthermore, previously unexplored phenomena involving the significant roles and impacts of minor and exotic currencies in shock and volatility transmissions denote that this issue is of great concern for the monetary authorities in major economies, as they suggest the need to monitor volatility in a greater range of currencies than is the norm at present.

One inherent assumption utilized in this study was that intraday volatility in higher frequencies incorporates news announcements as revealed in recent studies (Chan & Gray, 2018; Hussain et al., 2019). Yet, even beyond the scope of this particular study, the impact of news announcements can be examined in further studies by including news innovation in GARCH specifications, which requires rummaging all available news announcements to impact all sample currency pairs simultaneously, in an intraday setting.

Appendix

See Tables 7, 8 and 9.

Table 7 Daily VAR-BEKK-GARCH results

	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$ar(1)_{11}$	0.006 [0.036]	-0.009 [-1.183]	-0.008 [-0.093]	***-0.050 [-1.816]	-0.007 [-0.971]	*-0.067 [-3.341]	-0.035 [-1.285]	**0.059 [2.125]	-0.019 [-0.713]	-0.012 [-0.379]	
$ar(1)_{ii}$	**0.066 [-2.335]	-0.052 [-1.343]	-0.048 [-1.311]	-0.030 [-0.778]	**0.043 [1.797]	**0.852 [1.765]	0.016 [0.342]	*0.098 [4.787]	**0.057 [2.187]	0.032 [1.084]	
Constant	0	0	0	0	0	0	0	*-0.009 [-3.785]	0	0	
$ar(1)_{j1}$	*-0.050 [-2.721]	**0.036 [-1.704]	-0.017 [-0.224]	0.017 [0.598]	0.042 [1.562]	*-0.010 [-3.811]	0.022 [0.947]	*-0.146 [-6.069]	**0.057 [-2.188]	**0.063 [-2.373]	
$ar(1)_{ji}$	0.039 [1.520]	0.041 [1.532]	-0.028 [-0.650]	-0.049 [-1.643]	-0.013 [-0.231]	*-0.069 [-3.266]	0.007 [0.104]	*-0.234 [-7.185]	*-0.091 [-3.307]	*-0.088 [-3.562]	
Constant	**0.009 [-1.744]	0	0	0	**0.009 [-1.927]	0	0	*0.005 [10.534]	0	0	
c_{11}	*-0.007 [-6.929]	*-0.003 [-4.273]	*0.007 [7.629]	*0.003 [6.028]	*-0.009 [-5.374]	*0.009 [14.801]	*0.010 [25.043]	0	*-0.005 [-10.229]	*-0.009 [-5.659]	
c_{i1}	0	0	*0.003 [9.334]	**0.003 [-2.576]	*-0.008 [-139.357]	*0.004 [-3.705]	**0.003 [-1.703]	0.002 [0.637]	*-0.012 [-12.865]	0	
c_{ii}	*0.003 [4.128]	0	*0.006 [-22.351]	**0.005 [-2.029]	0	*0.006 [21.835]	0	*0.013 [5.024]	0	0	
α_{11}	*0.271 [12.477]	*0.257 [12.437]	*0.191 [11.856]	*0.185 [6.027]	*0.265 [15.849]	*0.200 [62.283]	*0.259 [68.063]	*0.137 [6.770]	0.055 [1.387]	*0.256 [10.436]	
α_{1i}	0.020 [1.243]	*0.106 [6.271]	*0.302 [19.024]	-0.016 [-0.469]	0.015 [0.464]	0	0.032 [1.195]	*-0.137 [-3.443]	*-0.268 [-8.617]	**0.052 [-1.829]	
α_{i1}	**0.071 [-2.144]	*-0.287 [-8.342]	*0.066 [10.542]	-0.071 [-1.570]	*0.061 [4.820]	*-1.291 [-9.285]	*0.041 [7.087]	0.030 [0.520]	-0.029 [-0.846]	0.032 [0.957]	
α_{ii}	*0.184 [10.448]	*0.086 [2.951]	*-0.079 [-11.756]	*0.199 [8.956]	*0.191 [25.499]	*0.526 [130.074]	*0.214 [86.248]	*0.932 [15.507]	*0.149 [4.464]	*0.158 [7.416]	
β_{11}	*0.963 [136.275]	*0.926 [119.454]	*0.821 [111.453]	*0.979 [120.737]	*0.960 [157.674]	*0.983 [1795.374]	*0.962 [1331.093]	*0.928 [36.737]	*0.809 [39.634]	*0.964 [116.985]	

Table 7 (continued)

	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDFHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
β_{1i}	-0.007 [-0.881]	*-0.060 [-6.470]	*1.631 [259.838]	***0.011 [1.679]	**_0.016 [-2.369]	***0.004 [1.916]	*_0.027 [-40.839]	*_0.415 [-8.851]	*_0.160 [-10.482]	0.008 [1.018]	
β_{1i}	**0.027 [2.327]	*0.139 [9.775]	*0.172 [22.500]	-0.010 [-0.155]	*_0.036 [-6.202]	*0.290 [6.868]	*0.009 [2.891]	**_0.110 [-2.381]	*_0.221 [-10.739]	-0.016 [-1.526]	
β_{2i}	*0.990 [243.827]	*1.027 [145.248]	*_0.846 [-122.831]	*0.988 [171.886]	*0.962 [244.222]	*0.905 [823.348]	*0.985 [2580.714]	*0.200 [3.611]	*0.767 [34.980]	*0.991 [172.902]	
	EURUSD	GBPUSD	NZDUSD	USDCAD	USDFHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	
$ar(1)_{11}$	0.019 [0.787]	0.039 [1.283]	0.026 [0.871]	0.020 [0.583]	-0.031 [-1.251]	0	0	-0.009 [-0.148]	0.039 [1.201]	**0.059 [1.725]	
$ar(1)_{1i}$	-0.024 [-0.615]	**_0.047 [-2.483]	**0.052 [2.036]	0.024 [0.707]	0.421 [0.853]	-0.012 [-0.255]	*0.067 [4.194]	0.046 [1.620]	0.046 [1.620]	**0.056 [1.970]	
Constant	0	0	0	0	0	0	0	0	**0.009 [-1.949]	0	
$ar(1)_{1i}$	[-0.933]	[-0.535]	[-1.384]	[-0.888]	[-0.634]	[-1.299]	[-0.740]	[-0.948]	[-1.700]	[-0.948]	
$ar(1)_{1i}$	0.009 [0.524]	-0.006 [-0.149]	**0.044 [2.133]	-0.048 [-1.117]	**_0.004 [-2.295]	0.035 [1.556]	*_0.106 [-3.519]	**_0.115 [-2.767]	***_0.067 [-1.700]	*_0.115 [-2.767]	
$ar(1)_{1i}$	0.029 [1.015]	-0.039 [-1.319]	-0.027 [-1.053]	-0.050 [-1.282]	*_0.068 [-2.830]	0.025 [0.733]	*_0.136 [-4.260]	**_0.118 [-3.594]	***_0.058 [-1.704]	*_0.118 [-3.594]	
Constant	0	0	0	0	0	0	*0.005 [5.359]	0	0	0	
c_{11}	*0.006 [-6.983]	0	**0.005 [2.337]	*0.009 [4.450]	*0.002 [17.802]	*0.005 [4.460]	0	**0.006 [1.704]	**0.006 [1.704]	*0.009 [4.450]	
c_{1i}	**0.001 [-1.902]	*0.007 [-18.514]	0	**_0.010 [-2.539]	0	0	*_0.011 [-17.028]	0	0	0	
c_{2i}	*0.007 [6.292]	*_0.009 [-40.767]	*0.003 [-5.110]	0.010 [1.642]	*0.005 [19.797]	*0.008 [5.508]	0	*0.007 [6.395]	*0.007 [6.395]	*_0.002 [-6.209]	

Table 7 (continued)

	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHEF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
α_{11}	*0.221 [16.966]	*0.202 [16.482]	*0.157 [7.930]	*0.169 [6.958]	*0.180 [65.485]	*0.192 [24.866]	*0.158 [5.851]	*0.129 [3.984]	*0.198 [6.963]	
α_{1i}	*0.059 [2.746]	*0.051 [3.085]	0.032 [1.227]	*0.150 [3.927]	*-0.008 [-4.870]	0.036 [1.542]	*0.787 [17.862]	*0.201 [4.637]	**0.085 [1.773]	
α_{1i}	*-0.070 [-3.020]	**0.031 [2.427]	*-0.070 [-3.840]	-0.030 [-0.807]	*-0.475 [-3.775]	**0.042 [2.561]	**0.070 [-2.249]	**0.052 [-2.128]	0.008 [0.101]	
α_{ii}	*0.174 [8.114]	*0.150 [9.424]	*0.230 [12.164]	*0.310 [7.959]	*0.538 [126.117]	*0.241 [10.234]	*1.033 [24.751]	*0.255 [10.774]	*0.242 [6.909]	
β_{11}	*0.984 [269.343]	*-0.417 [-36.433]	*0.987 [250.025]	*1.006 [83.728]	*0.985 [2514.385]	*0.982 [817.193]	*0.995 [99.512]	*0.1006 [121.297]	*-0.986 [-128.732]	
β_{1i}	***-0.008 [-1.786]	*0.946 [53.680]	-0.010 [-1.137]	*-0.131 [-5.335]	0 [1.065]	-0.012 [-1.563]	*-0.347 [-10.030]	*-0.068 [-4.629]	*0.036 [2.742]	
β_{1i}	**0.014 [2.151]	*0.846 [91.203]	*0.018 [2.775]	0.035 [1.558]	**0.085 [1.974]	**0.010 [-2.399]	0.022 [1.076]	**0.023 [2.199]	-0.010 [-0.247]	
β_{ii}	*0.988 [205.569]	*0.414 [30.634]	*0.978 [208.800]	*0.819 [23.518]	*0.898 [761.480]	*0.972 [150.323]	*0.366 [7.455]	*0.946 [94.413]	*-0.962 [-90.363]	
	GBPUSD	NZDUSD	USDCAD	USDCHEF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	
$ar(1)_{11}$	0.026 [0.883]	0.029 [1.254]	-0.005 [-1.396]	0.015 [0.354]	0.015 [0.354]	**0.040 [1.820]	*0.067 [5.982]	0.010 [1.187]	0.015 [0.250]	
$ar(1)_{1i}$	-0.017 [-0.927]	-0.015 [-0.592]	*0.020 [2.907]	0.476 [1.232]	0.476 [1.232]	0.030 [1.220]	0.010 [0.911]	0.006 [0.628]	-0.007 [-0.305]	
Constant	0 [-0.528]	0 [-0.111]	*0.004 [9.222]	0 [0.070]	0 [0.070]	0 [-0.558]	0 [0.304]	0 [-0.420]	0 [-0.236]	
$ar(1)_{i1}$	-0.011 [-1.413]	0.006 [0.191]	***-0.037 [-1.794]	0 [0.395]	0 [0.395]	0.027 [0.846]	0.008 [0.180]	**0.081 [-2.072]	-0.035 [-0.900]	
$ar(1)_{ii}$	-0.016 [-0.598]	*-0.061 [-2.651]	-0.027 [-1.184]	*-0.065 [-2.713]	*-0.065 [-2.713]	0.004 [0.115]	*-0.084 [-3.640]	**0.058 [-2.039]	**0.060 [-2.445]	

Table 7 (continued)

GBPUSD	NZDUSD	USDCAD	USDCHEF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
<i>Constant</i>	0 [0.352]	0 [1.021]	0 [- 1.199]	0 [- 0.414]	**0.007 [1.809]	0 [0.800]	0 [1.194]	0 [1.055]
c_{11}	0 [0.005]	*0.003 [2.685]	*0.002 [27.076]	*0.006 [13.578]	*0.008 [4.829]	*0.005 [33.818]	0 [- 1.582]	0 [- 0.862]
c_{i1}	*0.010 [12.064]	*0.004 [2.875]	*- 0.003 [- 22.539]	*0.009 [- 8.207]	**- 0.003 [- 2.194]	*- 0.005 [- 9.317]	*- 0.004 [- 5.057]	*- 0.009 [- 6.141]
c_{ii}	0 [- 0.443]	0 [- 0.443]	0 [0.007]	*0.008 [- 17.531]	0 [- 0.645]	0 [0.009]	0 [0.002]	0 [- 0.007]
α_{11}	*0.071 [2.913]	*0.177 [9.237]	*0.460 [645.999]	*0.161 [60.297]	*0.202 [17.640]	*0.195 [293.427]	*0.111 [3.615]	*0.124 [8.782]
α_{1i}	*- 0.302 [- 9.666]	*0.067 [3.083]	*- 0.272 [- 68.486]	0 [- 0.140]	*- 0.120 [- 3.870]	*- 0.164 [- 87.210]	*0.228 [6.631]	*0.208 [8.256]
α_{i1}	*0.121 [7.496]	*- 0.098 [- 5.684]	*0.054 [34.334]	*- 0.263 [- 2.584]	0.015 [0.882]	*- 0.015 [- 5.722]	*- 0.079 [- 5.804]	*- 0.083 [- 8.372]
α_{ii}	*0.246 [14.547]	*0.222 [15.788]	*0.106 [23.618]	*0.538 [123.506]	*0.261 [6.759]	*0.080 [13.206]	*0.167 [8.561]	*0.193 [11.278]
β_{11}	*1.014 [169.997]	*- 0.524 [- 13.408]	*0.844 [3456.604]	*0.993 [2523.240]	*0.986 [451.085]	*0.966 [8526.792]	*0.1001 [118.871]	*1.007 [317.721]
β_{1i}	*0.116 [6.111]	*- 0.662 [- 17.061]	*0.315 [532.368]	**0.009 [1.988]	*0.035 [4.921]	*0.112 [435.517]	*- 0.099 [- 7.906]	*- 0.111 [- 12.480]
β_{i1}	*- 0.046 [- 4.854]	*- 1.042 [- 48.578]	*- 0.113 [- 103.236]	0.024 [0.509]	- 0.014 [- 1.079]	*- 0.024 [- 231.926]	*0.022 [3.034]	*0.034 [8.448]
β_{ii}	*0.933 [115.894]	*0.528 [15.711]	*1.033 [1979.106]	*0.899 [737.175]	*0.964 [65.147]	*1.016 [8177.608]	*0.949 [139.088]	*0.942 [220.933]

Table 7 (continued)

NZDUSD	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$\alpha(1)_{11}$	-0.029 [-0.934]	-0.027 [-0.892]	** -0.056 [-2.522]	-0.004 [-0.931]	0.016 [0.560]	-0.033 [-0.987]	-0.021 [-0.559]
$\alpha(1)_{ii}$	-0.031 [-0.627]	0.006 [0.170]	0.478 [0.906]	-0.007 [-0.070]	**0.056 [2.497]	0.017 [0.573]	0.011 [0.148]
Constant	0	0	0	0	0	0	0
$\alpha(1)_{11}$	[-0.078]	[0.254]	[-0.027]	[-0.278]	[0.160]	[-0.451]	[-0.160]
$\alpha(1)_{ii}$	-0.022 [-0.978]	0.026 [0.889]	* -0.008 [-3.328]	0.032 [1.527]	*0.043 [2.622]	-0.017 [-0.533]	-0.048 [-1.638]
Constant	* -0.073 [-2.675]	-0.029 [-1.022]	* -0.077 [-2.856]	-0.012 [-0.129]	** -0.057 [-2.290]	-0.040 [-1.447]	* -0.076 [-2.902]
Constant	0	**0.009 [-1.987]	0	**0.007 [1.747]	*0.010 [6.292]	0	0
c_{11}	[1.045]	[-1.987]	[-0.622]	[1.747]	[6.292]	[1.145]	[1.040]
c_{i1}	* -0.004 [-4.526]	*0.003 [3.344]	*0.007 [5.887]	0	0	* -0.002 [-4.472]	*0.009 [4.070]
c_{i1}	*0.006 [4.090]	0.007 [1.379]	0	* -0.008 [-7.081]	* -0.008 [-30.167]	0	0
c_{ii}	0	*0.010 [3.532]	*0.002 [4.172]	0	* -0.009 [-3.322]	[-1.026]	[-0.878]
α_{11}	[-0.773]	[-3.532]	[-4.172]	[-0.082]	[-3.322]	[0.009]	[-2.077]
α_{ii}	*0.158 [4.398]	*0.232 [11.130]	*0.189 [12.307]	*0.200 [13.301]	*0.102 [3.445]	*0.126 [5.176]	*0.218 [6.458]
α_{1i}	-0.026 [-0.733]	0.043 [1.549]	0	-0.024 [-1.149]	*0.615 [17.431]	* -0.228 [-11.721]	-0.054 [-1.221]
α_{i1}	* -0.119 [-2.638]	0.038 [1.351]	** -1.437 [-2.529]	*0.139 [5.448]	* -0.127 [-3.153]	* -0.087 [-3.272]	-0.013 [-0.239]
α_{ii}	*0.201 [7.646]	*0.200 [9.535]	*0.524 [23.529]	*0.322 [13.379]	*1.090 [31.326]	* -0.095 [-3.764]	*0.169 [5.124]

Table 7 (continued)

	USDUSD	USDCAD	USDCHE	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
β_{11}	*-0.985 [-106.639]	*0.967 [146.181]	***-0.017 [-1.948]	*0.988 [296.877]	*0.981 [312.704]	*1.031 [124.937]	*0.988 [200.744]	*0.981 [107.735]	
β_{1i}	-0.015 [-1.400]	***-0.028 [-1.948]	**0.338 [1.946]	0 [0.889]	0.006 [0.619]	*-0.262 [-23.336]	-0.006 [-0.756]	0.015 [0.728]	
β_{11}	-0.010 [-0.957]	**0.338 [1.946]	**0.338 [1.946]	**0.338 [1.946]	*-0.038 [-4.244]	*0.089 [4.397]	0.011 [1.249]	0 [0.039]	
β_{ii}	*-0.988 [-152.913]	*0.962 [117.044]	*0.904 [138.128]	*0.904 [138.128]	*0.943 [98.416]	*0.490 [23.867]	*0.987 [210.520]	*0.992 [113.859]	
	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK		
$ar(1)_{11}$	-0.023 [-0.826]	*-0.085 [-4.038]	0 [0.530]	**0.058 [-2.367]	*0.046 [2.052]	***-0.044 [-1.688]	***-0.049 [-1.717]		
$ar(1)_{1i}$	-0.025 [-1.474]	0.067 [0.149]	0 [0.149]	-0.006 [-0.220]	*-0.052 [-3.709]	-0.004 [-1.247]	-0.026 [-1.219]		
Constant	0 [0.724]	0 [1.094]	0 [0.530]	0 [0.530]	*0.008 [4.985]	0 [1.026]	0 [1.425]		
$ar(1)_{i1}$	-0.055 [-1.405]	*0.005 [3.158]	0.010 [0.513]	0.010 [0.513]	*0.150 [4.732]	**0.075 [2.351]	0.033 [0.778]		
$ar(1)_{ii}$	0.032 [0.834]	*-0.070 [-3.098]	*-0.070 [-3.098]	-0.012 [-0.175]	*-0.127 [-4.077]	**0.055 [-2.174]	**0.058 [-2.306]		
Constant	0 [0.200]	0 [-0.279]	0 [1.558]	0 [1.558]	*0.003 [10.486]	0 [1.571]	0 [1.357]		
c_{11}	*0.003 [10.086]	*0.002 [13.886]	*0.004 [8.398]	*0.004 [8.398]	*0.006 [3.853]	*0.007 [-4.388]	*0.001 [-5.879]		
c_{ii}	*0.005 [174.992]	0 [0.548]	0 [0.455]	0 [0.455]	*0.009 [28.209]	**0.002 [1.884]	0 [-0.186]		

Table 7 (continued)

	USDCAD	USDFHKD	USDJPY	USDMXN	USDSEK	USDCAD	USDFHKD	USDJPY	USDMXN	USDSEK	USDCAD	USDFHKD	USDJPY	USDMXN	USDSEK
c_i	*0.007 [125.944]	*0.007 [22.669]	*0.007 [6.327]	0 [-0.010]	0 [0.010]	0 [0.010]	*0.007 [22.669]	*0.007 [6.327]	0 [-0.010]	0 [0.010]	0 [0.010]	0 [0.010]	0 [0.010]	0 [0.010]	0 [0.010]
α_{11}	*0.192 [46.133]	*0.183 [60.236]	*0.235 [21.087]	*0.251 [18.761]	*0.248 [14.197]	*0.235 [21.087]	*0.183 [60.236]	*0.235 [21.087]	*0.251 [18.761]	*0.248 [14.197]	*0.248 [14.197]	*0.235 [21.087]	*0.235 [21.087]	*0.251 [18.761]	*0.248 [14.197]
α_{1i}	*-0.261 [-30.288]	0 [0.656]	*-0.058 [-5.463]	*0.366 [6.348]	*0.137 [5.414]	*-0.261 [-30.288]	0 [0.656]	*-0.058 [-5.463]	*0.366 [6.348]	*0.137 [5.414]	*0.137 [5.414]	*-0.058 [-5.463]	*-0.058 [-5.463]	*0.366 [6.348]	*0.137 [5.414]
α_{1i}	-0.018 [-1.629]	*0.607 [5.136]	*-0.042 [-3.393]	0.020 [0.572]	*-0.048 [-2.814]	-0.018 [-1.629]	*0.607 [5.136]	*-0.042 [-3.393]	0.020 [0.572]	*-0.048 [-2.814]	*-0.048 [-2.814]	*-0.042 [-3.393]	*-0.042 [-3.393]	0.020 [0.572]	*-0.048 [-2.814]
α_{2i}	*0.279 [11.432]	*0.525 [124.985]	*0.221 [39.367]	*0.858 [16.985]	*0.115 [7.409]	*0.279 [11.432]	*0.525 [124.985]	*0.221 [39.367]	*0.858 [16.985]	*0.115 [7.409]	*0.115 [7.409]	*0.279 [11.432]	*0.279 [11.432]	*0.858 [16.985]	*0.115 [7.409]
β_{11}	*0.989 [1055.393]	*0.988 [2053.331]	*0.979 [365.601]	*1.012 [75.664]	*0.978 [300.379]	*0.989 [1055.393]	*0.988 [2053.331]	*0.979 [365.601]	*1.012 [75.664]	*0.978 [300.379]	*0.978 [300.379]	*0.989 [1055.393]	*0.989 [1055.393]	*1.012 [75.664]	*0.978 [300.379]
β_{1i}	*0.092 [14.344]	0 [-1.270]	*0.018 [6.032]	*0.403 [6.081]	*-0.029 [-5.750]	*0.092 [14.344]	0 [-1.270]	*0.018 [6.032]	*0.403 [6.081]	*-0.029 [-5.750]	*-0.029 [-5.750]	*0.092 [14.344]	*0.092 [14.344]	*0.403 [6.081]	*-0.029 [-5.750]
β_{1i}	*-0.023 [-4.611]	*-0.109 [-3.009]	0.008 [1.610]	**-0.074 [-2.134]	**0.013 [3.009]	*-0.023 [-4.611]	*-0.109 [-3.009]	0.008 [1.610]	**-0.074 [-2.134]	**0.013 [3.009]	**0.013 [3.009]	*-0.023 [-4.611]	*-0.023 [-4.611]	**-0.074 [-2.134]	**0.013 [3.009]
β_{2i}	*0.887 [724.345]	*0.908 [798.312]	*0.981 [973.519]	*0.138 [2.611]	*0.999 [453.194]	*0.887 [724.345]	*0.908 [798.312]	*0.981 [973.519]	*0.138 [2.611]	*0.999 [453.194]	*0.999 [453.194]	*0.887 [724.345]	*0.887 [724.345]	*0.138 [2.611]	*0.999 [453.194]
USDCHEF	USDHKD	USDJPY	USDMXN	USDSEK	USDSEK	USDCHEF	USDHKD	USDJPY	USDMXN	USDSEK	USDCHEF	USDHKD	USDJPY	USDMXN	USDSEK
$ar(1)_{11}$	***-0.051 [-1.908]	*-0.128 [-5.247]	-0.016 [-0.511]	*-0.039 [-2.530]	$ar(1)_{11}$	***-0.051 [-1.908]	*-0.128 [-5.247]	-0.016 [-0.511]	*-0.039 [-2.530]	*-0.062 [-2.542]	*-0.071 [-2.840]	*-0.062 [-2.542]	*-0.071 [-2.840]	*-0.062 [-2.542]	*-0.071 [-2.840]
$ar(1)_{1i}$	-1.072 [-1.615]	*0.092 [3.761]	-0.010 [-0.192]	0.017 [0.389]	$ar(1)_{1i}$	-1.072 [-1.615]	*0.092 [3.761]	-0.010 [-0.192]	*0.005 [3.180]	*0.002 [2.779]	*0.005 [3.180]	*0.002 [2.779]	*0.005 [3.180]	*0.002 [2.779]	*0.005 [3.180]
Constant	*0.008 [-2.768]	*-0.004 [-5.315]	0 [0.278]	0 [0.389]	Constant	*0.008 [-2.768]	*-0.004 [-5.315]	0 [0.278]	0 [0.389]	0 [0.430]	0 [0.457]	0 [0.430]	0 [0.457]	0 [0.430]	0 [0.457]
$ar(1)_{1i}$	0 [1.593]	*0.069 [2.940]	*-0.053 [-3.616]	*-0.058 [-5.981]	$ar(1)_{1i}$	0 [1.593]	*0.069 [2.940]	*-0.053 [-3.616]	-0.050 [-0.115]	-0.551 [-0.977]	-0.568 [-0.919]	-0.551 [-0.977]	-0.568 [-0.919]	-0.551 [-0.977]	-0.568 [-0.919]

Table 7 (continued)

	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$ar(1)_{it}$	* - 0.075 [- 2.871]		***0.038 [1.941]	* - 0.162 [- 6.039]	** - 0.055 [- 2.214]	0.028 [1.477]	$ar(1)_{it}$	* - 0.107 [- 6.383]	** - 0.058 [- 2.381]	* - 0.089 [- 3.467]	* - 0.107 [- 6.383]
Constant	0 [- 1.430]		*0.008 [3.046]	*0.009 [4.372]	**0.007 [1.734]	*0.006 [- 12.904]	Constant	0 [1.610]	0 [1.056]	0 [1.111]	0 [1.610]
c_{11}	*0.005 [10.579]		*0.005 [10.680]	* - 0.007 [- 9.376]	*0.010 [8.947]	*0.005 [51.976]	c_{11}	*0.006 [20.814]	*0.009 [7.130]	*0.004 [7.797]	*0.006 [20.814]
c_{1i}	0 [0.306]		*0.004 [10.157]	*0.003 [3.035]	0 [- 1.247]	*0.003 [25.751]	c_{1i}	*0.006 [8.702]	0 [- 0.170]	0 [- 0.449]	*0.006 [8.702]
c_{2i}	*0.002 [2.638]		0 [0.003]	0 [- 0.014]	0 [0.006]	0 [0.009]	c_{2i}	*0.009 [38.481]	*0.004 [5.846]	*0.003 [- 4.320]	*0.009 [38.481]
α_{11}	*0.150 [8.433]		*0.128 [37.287]	*0.685 [13.690]	*0.698 [15.335]	*0.058 [10.389]	α_{11}	*0.522 [124.445]	*0.527 [23.862]	*0.530 [41.511]	*0.522 [124.445]
α_{1i}	*0.009 [3.044]		* - 0.026 [- 13.088]	** - 0.160 [- 2.097]	*0.125 [4.586]	* - 0.160 [- 57.818]	α_{1i}	*0.602 [15.453]	0.899 [1.543]	**1.173 [2.098]	*0.602 [15.453]
α_{21}	**1.164 [2.098]		*0.187 [36.839]	* - 0.737 [- 19.843]	* - 0.651 [- 22.398]	*0.272 [40.107]	α_{21}	*0.001 [4.056]	0 [1.187]	0 [1.241]	*0.001 [4.056]
α_{2i}	*0.525 [24.493]		*0.320 [447.183]	*0.297 [4.767]	0.032 [0.974]	*0.488 [71.547]	α_{2i}	*0.049 [37.494]	*0.165 [14.807]	*0.162 [14.894]	*0.049 [37.494]
β_{11}	*0.975 [176.124]		*1.017 [3901.515]	- 0.066 [- 0.487]	*0.673 [20.650]	*1.053 [1804.510]	β_{11}	*0.908 [777.207]	*0.907 [141.1.007]	*0.906 [225.114]	*0.908 [777.207]
β_{1i}	0 [- 0.153]		*0.070 [78.807]	*0.757 [7.102]	* - 0.073 [- 5.541]	*0.189 [50.514]	β_{1i}	- 0.007 [- 0.381]	- 0.164 [- 0.860]	- 0.220 [- 1.272]	- 0.007 [- 0.381]
β_{21}	** - 0.404 [- 2.496]		* - 0.162 [- 394.927]	*0.644 [18.479]	*0.195 [11.790]	* - 0.259 [- 681.927]	β_{21}	*0.003 [- 4.084]	0 [- 0.542]	0 [- 0.598]	*0.003 [- 4.084]
β_{2i}	*0.905 [146.731]		*0.928 [5527.513]	*0.512 [3.512]	*1.029 [171.900]	*0.814 [4043.056]	β_{2i}	*0.999 [26424.503]	*0.989 [471.734]	*0.993 [531.274]	*0.999 [26424.503]

Table 7 (continued)

USDIPY	USDMXN	USDNOK	USDSEK	USDMXN	USDNOK	USDSEK	USDNOK	USDSEK	USDNOK	USDSEK
$ar(1)_{11}$	* - 0.084 [- 11.154]	- 0.008 [- 0.106]	0.006 [0.149]	$ar(1)_{11}$	* - 0.089 [- 2.856]	* - 0.130 [- 4.856]	$ar(1)_{11}$			- 0.010 [- 0.111]
$ar(1)_{1i}$	- 0.015 [- 1.179]	- 0.017 [- 1.016]	- 0.023 [- 1.320]	$ar(1)_{1i}$	- 0.004 [- 0.401]	0.036 [1.264]	$ar(1)_{1i}$			- 0.018 [- 0.491]
Constant	0	***0.001 [1.921]	0	Constant	*0.007 [11.008]	*0.008 [3.985]	Constant			0 [1.465]
$ar(1)_{i1}$	*0.205 [38.617]	0.023 [0.662]	0.007 [0.051]	$ar(1)_{i1}$	0.009 [0.197]	- 0.022 [- 0.848]	$ar(1)_{i1}$			0.025 [0.578]
$ar(1)_{ii}$	* - 0.088 [- 4.066]	- 0.027 [- 0.1.002]	*** - 0.047 [- 1.827]	$ar(1)_{ii}$	- 0.029 [- 0.936]	*** - 0.053 [- 2.420]	$ar(1)_{ii}$			- 0.061 [- 1.554]
Constant	*0.003 [25.042]	***0.007 [1.677]	0	Constant	0	0	Constant			0 [0.886]
c_{11}	*0.009 [57.354]	*0.002 [35.126]	*0.005 [18.232]	c_{11}	*0.008 [29.097]	*0.012 [23.1.006]	c_{11}			*0.003 [5.650]
c_{i1}	*0.011 [121.469]	***0.008 [- 1.937]	0	c_{i1}	*0.009 [- 5.209]	* - 0.009 [- 3.721]	c_{i1}			**0.006 [2.171]
c_{ii}	0	*0.001 [7.060]	***0.006 [1.839]	c_{ii}	0	0	c_{ii}			*0.009 [5.341]
α_{11}	*0.149 [39.461]	*0.260 [87.133]	*0.239 [41.103]	α_{11}	*1.082 [28.433]	*0.882 [27.039]	α_{11}			*0.174 [6.104]
α_{i1}	* - 0.620 [- 102.049]	* - 0.129 [- 21.720]	* - 0.123 [- 6.577]	α_{i1}	*0.141 [9.822]	*0.091 [2.998]	α_{i1}			- 0.021 [- 0.611]
α_{i1}	*0.062 [13.228]	***0.012 [2.200]	*** - 0.016 [- 1.719]	α_{i1}	* - 0.748 [- 21.308]	* - 0.723 [- 21.531]	α_{i1}			0.023 [0.490]
α_{ii}	*0.783 [184.073]	*0.186 [55.702]	*0.202 [13.896]	α_{ii}	*0.086 [7.402]	*0.128 [5.101]	α_{ii}			*0.202 [6.030]

Table 7 (continued)

	USDIPY	USDMXN	USDNOK	USDSEK	USDMXN	USDNOK	USDSEK	USDNOK	USDSEK
β_{11}	*0.930 [1206.815]	*0.964 [1727.035]	*0.968 [1123.758]	β_{11}	*0.310 [12.359]	*- 0.309 [- 8.011]	β_{11}	*0.987 [154.292]	
β_{1i}	*- 0.223 [- 47.126]	*0.035 [43.197]	0.024 [1.119]	β_{1i}	*- 0.053 [- 15.688]	0.017 [0.348]	β_{1i}	0.014 [0.566]	
β_{11}	*- 0.109 [- 70.905]	0 [- 0.057]	**0.005 [2.041]	β_{11}	*0.313 [17.315]	*- 0.349 [- 16.384]	β_{11}	- 0.008 [- 0.159]	
β_{ii}	*0.334 [46.554]	*0.981 [2200.354]	*0.978 [244.869]	β_{ii}	*1.006 [544.261]	*- 0.990 [- 90.189]	β_{ii}	*0.980 [114.239]	

Table 8: 30 minute VAR-BEKK-GARCH results

	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDFHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$\alpha(1)_{11}$	*-0.033 [-8.991]	*-0.041 [-11.654]	*-0.056 [-13.039]	*-0.040 [-14.253]	*-0.030 [-10.152]	*-0.035 [-13.486]	*-0.039 [-13.730]	*-0.030 [-8.941]	*-0.045 [-12.499]	*-0.044 [-13.274]	
$\alpha(1)_{i1}$	-0.010 [-0.481]	0.012 [1.615]	*0.023 [5.961]	-0.011 [-1.532]	0.007 [1.200]	0.030 [0.451]	*-0.016 [-5.090]	*0.033 [14.329]	0 [-0.048]	-0.006 [-1.393]	
<i>Constant</i>	**0.003 [2.380]	0 [1.044]	**0.003 [2.501]	0 [-0.399]	**0.001 [2.036]	0 [0.467]	**0.008 [2.181]	*0.001 [-8.446]	0 [1.563]	0 [1.041]	
$\alpha(1)_{j1}$	*0.013 [3.328]	*0.021 [8.639]	*0.079 [18.330]	*-0.040 [-17.741]	*-0.035 [-13.316]	*-0.004 [-9.984]	***-0.012 [-1.854]	*-0.128 [-40.278]	*-0.043 [-13.954]	*-0.042 [-14.538]	
$\alpha(1)_{ji}$	*-0.035 [-8.660]	*-0.063 [-18.288]	*-0.111 [-26.292]	*-0.092 [-25.742]	*-0.067 [-18.732]	*-0.122 [-39.909]	*-0.047 [-12.939]	*-0.237 [-60.295]	*-0.094 [-28.483]	*-0.078 [-23.762]	
<i>Constant</i>	0 [1.324]	0 [1.064]	*0.009 [9.216]	*0.002 [3.775]	*0.006 [-3.581]	*0.001 [-5.219]	0 [1.587]	*0.008 [-33.337]	**0.001 [-1.794]	0 [-1.007]	
c_{11}	*0.001 [23.158]	*0.005 [13.883]	0 [0.439]	*0.006 [-30.368]	*0.008 [36.230]	*0.001 [23.823]	*0.002 [45.103]	*0.002 [-20.562]	*0.009 [-13.124]	*0.006 [15.124]	
c_{i1}	*0.006 [38.258]	*0.005 [88.694]	*0.009 [-24.756]	*0.003 [86.681]	*0.007 [-45.618]	***0.005 [-1.679]	*0.002 [-39.138]	*0.001 [2.823]	*0.003 [80.469]	*0.004 [-92.100]	
c_{i1}	*0.008 [19.547]	0 [0.194]	*0.002 [72.965]	0 [0.019]	*0.009 [15.553]	*0.007 [-38.277]	*0.002 [17.916]	0 [0.003]	0 [0.022]	0 [0.022]	
α_{11}	*0.113 [53.063]	*0.074 [50.752]	*0.066 [23.362]	*0.063 [37.643]	*0.136 [64.356]	*0.083 [63.615]	*0.154 [73.833]	*0.019 [7.430]	*0.102 [54.312]	*0.100 [64.612]	
α_{1i}	*-0.028 [-8.756]	*-0.056 [-25.969]	*-0.261 [-47.057]	*0.075 [31.852]	0 [0.035]	*0.008 [-6.434]	-0.011 [-1.384]	*0.318 [137.929]	*0.019 [4.787]	*0.032 [9.626]	
α_{1j}	*0.188 [62.429]	*0.173 [57.648]	*0.053 [13.448]	*-0.197 [-65.061]	*-0.142 [-46.870]	*-0.288 [-6.438]	*-0.039 [-15.082]	*-0.151 [-65.476]	*-0.118 [-51.889]	*-0.130 [-54.974]	
α_{ji}	*0.461 [130.883]	*0.511 [173.916]	*0.455 [92.461]	*0.498 [152.380]	*0.497 [154.155]	*0.254 [70.342]	*0.335 [90.409]	*0.644 [209.218]	*0.475 [141.946]	*0.484 [141.939]	
β_{11}	*1.001 [3770.921]	*1.011 [6004.937]	*1.012 [1180.409]	*1.009 [5340.906]	*0.996 [2320.581]	*0.998 [9650.100]	*0.993 [2736.643]	*1.006 [7433.881]	*1.009 [4313.261]	*1.005 [4953.338]	

Table 8: (continued)

	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDFCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
β_{1i}	*0.022 [28.796]	*0.113 [47.181]	*-0.031 [-56.761]	0 [-0.363]	*0.006 [5.357]	*0.014 [11.465]	*-0.027 [-52.112]	*-0.023 [-27.063]	*-0.030 [-29.348]		
β_{1i}	*-0.057 [-51.462]	*-0.024 [-13.468]	*0.055 [63.812]	*0.040 [42.167]	*0.048 [4.746]	*0.016 [17.735]	*0.033 [57.396]	*0.036 [46.124]	*0.044 [49.993]		
β_{2i}	*0.902 [689.382]	*0.865 [307.916]	*0.890 [803.865]	*0.894 [776.196]	*0.972 [1220.381]	*0.944 [772.457]	*0.906 [1371.584]	*0.891 [646.258]	*0.877 [612.275]		
EURUSD	GBPUSD	NZDUSD	USDCAD	USDFCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK		
$ar(1)_{11}$	*-0.033 [-7.682]	*-0.036 [-8.1004]	*-0.017 [-4.447]	*-0.038 [-9.760]	*-0.033 [-8.696]	*-0.029 [-8.950]	*-0.058 [-16.164]	*-0.014 [-3.400]	*-0.022 [-3.951]		
$ar(1)_{1i}$	**0.011 [2.511]	*0.015 [2.962]	*-0.016 [-3.331]	**0.015 [-2.291]	**0.075 [1.911]	**0.008 [-1.927]	*-0.033 [-14.944]	*0.015 [3.205]	*0.011 [3.446]		
Constant	0	0	0	**0.003 [1.720]	0	**0.003 [2.029]	*0.007 [-9.600]	0	0		
$ar(1)_{1i}$	*0.036 [12.810]	*0.023 [5.442]	*-0.027 [-7.140]	*-0.073 [-16.552]	*-0.005 [-9.027]	-0.006 [-0.342]	*-0.153 [-38.920]	*-0.092 [-17.199]	*-0.080 [-16.374]		
$ar(1)_{2i}$	*-0.078 [-18.661]	*-0.061 [-18.911]	*-0.062 [-16.837]	*-0.103 [-24.479]	*-0.131 [-44.010]	*-0.038 [-13.196]	*-0.161 [-36.657]	*-0.119 [-28.755]	*-0.112 [-27.176]		
Constant	0	*0.009 [3.319]	0	0	*0.003 [1.036]	**0.002 [2.008]	*0.008 [-25.108]	*0.004 [-3.801]	**0.004 [-2.383]		
c_{11}	*0.003 [82.727]	*0.001 [89.046]	*0.006 [124.916]	*0.006 [79.323]	*0.001 [82.996]	*0.005 [87.308]	*0.009 [101.606]	*0.005 [86.622]	*0.006 [83.916]		
c_{21}	*0.006 [40.753]	*0.002 [20.145]	*0.002 [-23.544]	*0.002 [-52.300]	*0.006 [11.543]	*0.009 [-32.184]	*0.007 [-62.399]	*0.008 [-26.969]	*0.008 [-28.437]		
c_{2i}	*0.009 [90.210]	*0.009 [36.638]	0	*0.004 [74.466]	*0.007 [32.099]	*0.003 [51.429]	0	*0.004 [95.639]	*0.006 [106.954]		

Table 8: (continued)

	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
α_{11}	*0.369 [79.104]	*0.458 [133.207]	*-0.393 [-78.054]	*0.340 [80.525]	*0.466 [138.255]	*0.429 [135.761]	*0.596 [139.245]	*0.411 [81.290]	*0.409 [87.542]	
α_{1i}	*-0.088 [-20.967]	*0.176 [45.174]	*0.407 [93.096]	*0.086 [14.833]	*0.008 [6.596]	*-0.058 [-22.132]	*-0.099 [-18.555]	*0.077 [9.681]	*0.070 [9.983]	
α_{r1}	*0.044 [5.465]	*-0.014 [-2.822]	*0.068 [7.847]	*-0.081 [-20.342]	*0.122 [2.579]	*-0.020 [-6.899]	*0.104 [21.788]	*0.043 [8.592]	*0.036 [9.283]	
α_{ri}	*0.508 [102.309]	*0.163 [58.405]	*0.364 [70.395]	*0.479 [89.427]	*0.171 [86.641]	*0.303 [72.677]	*0.474 [94.327]	*0.469 [91.842]	*0.458 [92.975]	
β_{11}	*0.941 [506.845]	*0.905 [693.050]	*0.646 [143.905]	*0.955 [589.753]	*0.901 [684.560]	*0.921 [786.203]	*0.820 [429.531]	*0.912 [360.998]	*0.903 [427.783]	
β_{1i}	*0.037 [19.130]	*-0.054 [-41.250]	*0.397 [83.333]	*-0.045 [-16.502]	*0.005 [-12.226]	*0.020 [23.753]	*0.175 [68.693]	*-0.041 [-10.090]	*-0.039 [-11.682]	
β_{r1}	*-0.028 [-8.258]	*0.008 [8.610]	*-0.424 [-73.155]	*0.042 [23.602]	*-0.075 [-6.322]	*0.013 [10.061]	*-0.063 [-45.814]	*-0.026 [-9.200]	*-0.029 [-14.250]	
β_{ri}	*0.882 [394.664]	*0.991 [1603.410]	*1.049 [598.150]	*0.867 [359.272]	*0.993 [3210.578]	*0.954 [768.382]	*0.966 [957.387]	*0.898 [370.928]	*0.896 [412.185]	
	GBPUSD	NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	
$ar(1)_{11}$	*-0.069 [-21.880]	*-0.054 [-17.701]	*-0.062 [-17.152]	*-0.054 [-14.1.002]	*-0.050 [-16.104]	*-0.118 [-35.402]	*-0.063 [-16.372]	*-0.058 [-18.003]		
$ar(1)_{1i}$	*0.015 [8.267]	*-0.030 [-9.973]	*-0.018 [-6.475]	*0.100 [3.186]	*-0.010 [-2.423]	*-0.045 [-24.257]	*-0.022 [-7.493]	*-0.023 [-8.637]		
Constant	0	0	0	0	0	*0.004	0	0		
$ar(1)_{r1}$	[0.386]	[0.595]	*-0.822 [-0.822]	*-0.498 [-0.498]	[0.385]	*-0.168 [-14.282]	*-0.275 [-0.275]	*-0.609 [-0.609]		
$ar(1)_{ri}$	*0.026 [5.450]	*-0.033 [-10.211]	*-0.046 [-11.162]	*-0.004 [-7.457]	*-0.015 [-2.472]	*-0.168 [-38.715]	*-0.059 [-12.342]	*-0.062 [-14.093]		
	*-0.062 [-22.037]	*-0.068 [-19.318]	*-0.088 [-25.495]	*-0.127 [-45.310]	*-0.046 [-13.202]	*-0.213 [-56.828]	*-0.086 [-23.472]	*-0.088 [-25.049]		

Table 8: (continued)

GBPUSD	NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
<i>Constant</i>	**0.004 [2.029]	0 [1.392]	*0.009 [- 4.445]	*0.003 [- 4.290]	***0.004 [1.759]	*0.009 [- 27.669]	**0.004 [- 2.105]	0 [- 1.326]
c_{11}	*0.009 [84.930]	*0.007 [99.052]	*0.009 [87.407]	*0.004 [91.133]	*0.009 [98.226]	*0.006 [119.351]	*0.004 [95.048]	*0.002 [89.592]
c_{i1}	*0.008 [10.632]	*0.009 [3.582]	*0.004 [- 34.607]	*0.004 [13.454]	*0.001 [- 26.796]	*0.009 [- 62.947]	*0.006 [- 16.892]	*0.001 [- 16.027]
c_{ii}	*0.001 [26.195]	*0.001 [42.598]	*0.006 [79.855]	*0.003 [33.302]	*0.009 [42.864]	0 [0.005]	*0.002 [84.259]	*0.004 [97.607]
α_{11}	*0.507 [163.792]	*0.438 [128.910]	*0.387 [118.210]	*0.486 [142.974]	*0.468 [156.844]	*0.620 [140.254]	*0.424 [112.734]	*0.416 [111.248]
α_{1i}	*0.169 [37.651]	*0.193 [50.611]	*0.168 [30.259]	*0.006 [12.812]	*- 0.074 [- 22.010]	*0.025 [3.858]	*0.080 [10.462]	*0.110 [14.750]
α_{i1}	*- 0.032 [- 16.316]	*0.011 [2.960]	*- 0.020 [- 6.106]	*0.249 [6.549]	0.003 [0.699]	*0.084 [17.386]	*0.018 [6.390]	0.012 [0.970]
α_{ii}	*0.110 [51.150]	*0.432 [150.900]	*0.508 [146.753]	*0.176 [105.401]	*0.268 [53.500]	*0.562 [108.438]	*0.437 [114.411]	*0.453 [117.848]
β_{11}	*0.884 [693.870]	*0.924 [760.358]	*0.938 [786.407]	*0.888 [646.231]	*0.898 [786.444]	*0.784 [321.441]	*0.916 [622.581]	*0.920 [637.903]
β_{1i}	*- 0.052 [- 31.981]	*- 0.100 [- 43.037]	*- 0.065 [- 23.934]	*0.008 [- 18.236]	*0.036 [24.564]	*0.199 [52.268]	*- 0.047 [- 12.465]	*- 0.064 [- 17.135]
β_{i1}	*0.021 [22.933]	*0.013 [6.852]	*0.020 [14.052]	*- 0.089 [- 9.579]	*0.009 [4.147]	*- 0.072 [- 47.012]	*- 0.008 [- 3.506]	0.007 [1.578]
β_{ii}	*0.1.002 [2646.561]	*0.892 [758.806]	*0.882 [603.680]	*0.990 [4413.009]	*0.962 [704.212]	*0.943 [839.759]	*0.910 [559.668]	*0.896 [524.686]

Table 8: (continued)

NZDUSD	USDCAD	USDCHEF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$ar(1)_{11}$	* - 0.066 [- 21.036]	* - 0.054 [- 16.057]	* - 0.052 [- 15.893]	* - 0.061 [- 19.587]	* - 0.056 [- 16.560]	* - 0.058 [- 18.476]	* - 0.062 [- 21.880]
$ar(1)_{ii}$	* - 0.046 [- 9.208]	* - 0.013 [- 3.461]	*** - 0.106 [- 1.676]	* - 0.031 [- 7.919]	* 0.040 [16.532]	* - 0.018 [- 3.250]	* - 0.022 [- 6.827]
Constant	0 [1.214]	* 0.002 [2.865]	*** 0.008 [2.278]	* 0.006 [2.798]	* 0.005 [- 10.248]	*** 0.005 [2.150]	0 [1.617]
$ar(1)_{11}$	* - 0.024 [- 10.806]	* - 0.031 [- 11.507]	* - 0.002 [- 7.796]	*** - 0.012 [- 1.741]	* - 0.133 [- 48.419]	* - 0.037 [- 13.454]	* - 0.034 [- 11.602]
$ar(1)_{ii}$	* - 0.074 [- 19.470]	* - 0.072 [- 18.912]	* - 0.127 [- 39.658]	* - 0.044 [- 14.127]	* - 0.351 [- 92.632]	* - 0.088 [- 25.547]	* - 0.074 [- 23.336]
Constant	0 [0.381]	* 0.006 [- 5.202]	* 0.001 [- 4.665]	*** 0.003 [2.100]	* 0.001 [- 41.998]	*** 0.006 [- 1.870]	0 [- 0.945]
c_{11}	* 0.005 [10.384]	* 0.005 [- 43.417]	* 0.007 [28.976]	* 0.005 [66.751]	* 0.004 [29.903]	*** 0.002 [- 1.789]	* 0.009 [5.328]
c_{1i}	* 0.009 [59.884]	* 0.009 [48.718]	* 0.006 [6.209]	* 0.001 [- 51.805]	0	* 0.009 [96.528]	* 0.007 [- 36.888]
c_{ii}	0 [0.009]	* 0.008 [11.272]	* 0.007 [29.930]	* 0.007 [34.216]	0	* 0.001 [19.925]	* 0.003 [43.120]
α_{11}	* 0.090 [39.327]	* 0.167 [66.359]	* 0.290 [43.871]	* 0.248 [75.905]	* 0.084 [32.704]	* 0.135 [58.909]	* 0.119 [59.104]
α_{1i}	* 0.091 [38.965]	* - 0.028 [- 10.654]	* 0.008 [3.027]	* - 0.049 [- 22.215]	* 0.275 [121.305]	* 0.012 [3.138]	* 0.034 [9.598]
α_{1i}	* - 0.149 [- 34.682]	* - 0.138 [- 40.042]	* 0.019 [4.531]	* - 0.086 [- 26.057]	* - 0.157 [- 51.176]	* - 0.121 [- 44.733]	* - 0.143 [- 49.971]
α_{ii}	* 0.506 [158.586]	* 0.495 [145.620]	* 0.185 [79.948]	* 0.336 [69.599]	* 0.714 [230.736]	* 0.484 [141.701]	* 0.494 [153.240]

Table 8: (continued)

NZDUSD	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
β_{11}	*1.004 [2667.563]	*0.994 [1848.513]	*0.960 [393.531]	*0.968 [1084.473]	*0.998 [3005.895]	*0.1006 [3433.150]	*0.1007 [3929.011]
β_{1i}	*-0.029 [-54.502]	*0.008 [6.763]	*0.009 [-4.165]	*0.020 [33.862]	*-0.027 [-39.857]	*-0.031 [-24.973]	*-0.025 [-21.972]
β_{21}	*0.043 [27.879]	*0.044 [38.900]	***-0.041 [-1.846]	*0.033 [33.154]	*0.032 [40.046]	*0.037 [37.473]	*0.043 [43.142]
β_{2i}	*0.888 [742.367]	*0.894 [727.373]	*0.993 [2591.477]	*0.940 [614.900]	*0.886 [1230.290]	*0.883 [633.043]	*0.875 [623.137]
USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	
$ar(1)_{11}$	*-0.053 [-17.605]	*-0.047 [-16.948]	*-0.054 [-17.738]	-0.011 [-1.429]	*-0.061 [-16.588]	*-0.061 [-17.757]	
$ar(1)_{ii}$	0.010 [1.451]	0.024 [0.530]	*0.013 [2.902]	*0.014 [8.072]	*0.017 [5.282]	*0.021 [6.819]	
Constant	0 [0.420]	*0.001 [4.320]	*0.003 [3.313]	*0.004 [3.021]	0 [0.908]	***0.006 [2.577]	
$ar(1)_{j1}$	*0.059 [15.716]	*0.004 [7.160]	***0.013 [1.925]	*0.079 [18.431]	*0.061 [14.575]	*0.052 [11.142]	
$ar(1)_{ji}$	*-0.075 [-21.677]	*-0.133 [-51.565]	*-0.049 [-15.772]	*-0.059 [-16.842]	*-0.094 [-27.656]	*-0.076 [-24.162]	
Constant	**0.008 [-2.118]	*0.004 [-4.614]	*0.008 [2.656]	*0.008 [-3.184]	0 [-1.284]	0 [-0.630]	
c_{11}	*0.008 [79.257]	*0.002 [85.316]	*0.005 [90.281]	*0.002 [64.595]	*0.007 [55.310]	*0.009 [67.015]	
c_{21}	*0.001 [32.379]	*0.008 [-10.002]	*0.004 [22.659]	*0.009 [-7.979]	*0.004 [30.199]	*0.007 [24.392]	

Table 8: (continued)

	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
c_{ii}	*0.007 [74.659]	*0.002 [32.855]	0	*0.001 [46.277]	0	*0.004 [68.313]	*0.008 [82.056]
α_{11}	*0.385 [129.618]	*0.460 [168.622]	*0.333 [151.113]	*0.438 [161.698]	*0.333 [151.113]	*0.390 [106.436]	*0.406 [119.608]
α_{1i}	*-0.089 [-18.188]	*0.007 [-5.350]	0	0	*-0.138 [-47.337]	-0.010 [-0.734]	0.017 [1.506]
α_{i1}	*0.056 [17.723]	***0.082 [1.906]	*-0.018 [-4.794]	*-0.018 [-4.794]	*-0.025 [-13.148]	*0.079 [27.614]	*0.059 [16.031]
α_{ii}	*0.510 [156.052]	*0.169 [97.072]	*0.299 [67.247]	*0.299 [67.247]	*0.235 [129.120]	*0.461 [129.604]	*0.439 [114.692]
β_{11}	*0.937 [989.897]	*0.906 [856.869]	*0.916 [1015.305]	*0.916 [1015.305]	*0.972 [1611.047]	*0.948 [689.965]	*0.937 [684.428]
β_{1i}	*0.042 [22.012]	*0.005 [10.639]	*-0.009 [-6.645]	*-0.009 [-6.645]	*0.125 [162.687]	*0.057 [18.539]	*0.032 [11.1.007]
β_{i1}	*-0.044 [-26.987]	*0.033 [2.677]	-0.003 [-1.287]	-0.003 [-1.287]	*-0.039 [-118.674]	*-0.063 [-33.782]	*-0.045 [-18.221]
β_{ii}	*0.891 [733.024]	*0.988 [3870.737]	*0.954 [707.265]	*0.954 [707.265]	*0.953 [2378.892]	*0.878 [516.621]	*0.892 [478.616]

	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$ar(1)_{11}$	*-0.052 [-13.729]	*-0.059 [-18.896]	*-0.032 [-9.180]	*-0.060 [-14.905]	*-0.157 [-50.767]	*-0.128 [-44.305]	*-0.132 [-50.864]
$ar(1)_{1i}$	***-0.091 [-1.957]	*0.026 [9.708]	0	*0.025 [8.976]	*0.007 [4.290]	*0.009 [5.848]	*0.008 [6.888]
Constant	*0.005 [-4.217]	*0.009 [-6.583]	*0.003 [9.497]	0	*0.003 [-4.847]	*0.001 [-4.924]	*0.001 [-4.354]
$ar(1)_{i1}$	*0.001 [3.865]	-0.007 [-1.521]	*0.011 [3.089]	*0.041 [10.116]	*-0.208 [-2.752]	***0.092 [1.818]	0.054 [1.036]

Table 8: (continued)

	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$ar(1)_{it}$	*-0.133 [-46.691]		*-0.045 [-12.664]	*-0.034 [-9.335]	*-0.098 [-29.466]	*-0.083 [-24.322]	$ar(1)_{it}$	*-0.026 [-7.190]	*-0.071 [-25.773]	*-0.066 [-19.460]	*-0.066 [-7.190]
Constant	*0.009 [-4.759]		0 [1.504]	0 [0.660]	*0.008 [-3.949]	**0.004 [-1.832]	Constant	**0.009 [1.935]	**0.002 [-2.154]	0 [-0.731]	**0.009 [1.935]
c_{11}	*0.001 [80.410]	*0.005 [148.247]	*0.005 [37.274]	*0.006 [54.915]	*0.004 [57.160]	*0.004 [61.960]	c_{11}	*0.001 [47.894]	*0.003 [16.980]	*0.004 [-37.017]	*0.001 [47.894]
c_{1i}	*0.009 [13.349]	*0.005 [37.274]	*0.005 [37.274]	*0.006 [52.913]	*0.006 [29.608]	*0.005 [30.394]	c_{1i}	*0.005 [26.677]	*0.002 [-18.692]	*0.004 [-7.733]	*0.005 [26.677]
c_{2i}	*0.007 [-32.147]	*0.001 [34.200]	*0.001 [34.200]	0 [-0.002]	*0.002 [-84.954]	*0.007 [91.581]	c_{2i}	0 [0.004]	*0.001 [41.532]	*0.006 [52.329]	0 [0.004]
α_{11}	*0.533 [146.407]	*0.500 [149.964]	*0.087 [49.307]	*0.515 [190.193]	*0.532 [151.193]	*0.535 [141.144]	α_{11}	*0.372 [176.772]	*0.167 [30.345]	*0.175 [90.384]	*0.372 [176.772]
α_{1i}	*0.007 [9.153]	*0.007 [49.307]	*0.007 [49.307]	*0.336 [74.090]	*0.036 [6.603]	*0.031 [6.770]	α_{1i}	*-2.920 [-46.995]	*-0.302 [-6.480]	**0.122 [1.942]	*-2.920 [-46.995]
α_{21}	0.070 [1.363]	*0.041 [10.829]	*0.041 [10.829]	*-0.224 [-61.666]	*-0.176 [-55.543]	*-0.170 [-49.330]	α_{21}	*0.009 [50.977]	*0.002 [-18.195]	*0.009 [5.644]	*0.009 [50.977]
α_{2i}	*0.174 [89.919]	*0.273 [66.320]	*0.273 [66.320]	*-0.282 [-70.060]	*0.376 [103.966]	*0.356 [103.321]	α_{2i}	*0.241 [119.865]	*0.478 [146.460]	*0.478 [145.833]	*0.241 [119.865]
β_{11}	*0.879 [587.535]	*0.900 [774.714]	*0.900 [774.714]	*0.830 [833.105]	*0.866 [573.449]	*0.870 [520.907]	β_{11}	*0.949 [1669.896]	*0.994 [1127.849]	*0.993 [3551.528]	*0.949 [1669.896]
β_{1i}	*0.005 [-14.066]	*-0.035 [-48.600]	*-0.035 [-48.600]	*-0.409 [-257.203]	*-0.034 [-16.927]	*-0.023 [-12.461]	β_{1i}	*2.681 [143.064]	*0.110 [8.319]	*0.064 [3.958]	*2.681 [143.064]
β_{21}	*0.045 [3.266]	*-0.025 [-14.184]	*-0.025 [-14.184]	*0.178 [242.107]	*0.077 [46.806]	*0.065 [39.561]	β_{21}	*-0.007 [-140.458]	*0.008 [1.4376]	*0.001 [-6.877]	*-0.007 [-140.458]
β_{2i}	*0.993 [3531.562]	*0.961 [847.167]	*0.961 [847.167]	*0.980 [857.454]	*0.943 [723.098]	*0.938 [747.183]	β_{2i}	*0.975 [2219.094]	*0.892 [616.567]	*0.888 [644.621]	*0.975 [2219.094]

Table 8: (continued)

USDIPY	USDMXN	USDNOK	USDSEK	USDMXN	USDNOK	USDSEK	USDNOK	USDSEK	USDNOK	USDSEK
$ar(1)_{11}$	*-0.070 [-18.948]	*-0.040 [-11.993]	*-0.041 [-13.504]	$ar(1)_{11}$	*-0.098 [-22.311]	*-0.199 [-49.425]	*-0.098 [-22.311]	*-0.199 [-49.425]	$ar(1)_{11}$	*-0.128 [-32.073]
$ar(1)_{ii}$	*0.019 [11.930]	***-0.004 [-1.872]	0 [-0.259]	$ar(1)_{ii}$	*0.049 [16.694]	*0.124 [48.377]	*0.049 [16.694]	*0.124 [48.377]	$ar(1)_{ii}$	*0.071 [19.344]
<i>Constant</i>	*0.007 [18.096]	**0.008 [2.325]	**0.007 [2.207]	<i>Constant</i>	*0.009 [-14.532]	*0.008 [-33.832]	*0.009 [-14.532]	*0.008 [-33.832]	<i>Constant</i>	***0.007 [-1.842]
$ar(1)_{11}$	*0.073 [18.423]	0.007 [1.597]	***0.013 [1.718]	$ar(1)_{11}$	*0.027 [15.313]	*0.082 [33.076]	*0.027 [15.313]	*0.082 [33.076]	$ar(1)_{11}$	*0.041 [11.386]
$ar(1)_{ii}$	*-0.094 [-26.478]	*-0.072 [-23.050]	*-0.060 [-19.339]	$ar(1)_{ii}$	*-0.085 [-26.027]	*-0.128 [-42.796]	*-0.085 [-26.027]	*-0.128 [-42.796]	$ar(1)_{ii}$	*-0.083 [-20.822]
<i>Constant</i>	*0.002 [-24.067]	**0.009 [-2.086]	0 [-0.849]	<i>Constant</i>	0 [-1.651]	*0.004 [16.722]	0 [-1.651]	*0.004 [16.722]	<i>Constant</i>	0 [0.473]
c_{11}	*0.006 [87.819]	*0.007 [31.123]	*0.004 [54.614]	c_{11}	*0.001 [87.492]	*0.006 [-54.016]	*0.001 [87.492]	*0.006 [-54.016]	c_{11}	*0.001 [88.710]
c_{i1}	*0.002 [52.278]	*0.007 [25.394]	*0.009 [32.919]	c_{i1}	*0.004 [-88.571]	*0.007 [-117.128]	*0.004 [-88.571]	*0.007 [-117.128]	c_{i1}	*0.006 [32.1.003]
c_{ii}	0 [0.006]	*0.002 [55.153]	*0.001 [56.280]	c_{ii}	0 [0.004]	0 [0.001]	0 [0.004]	0 [0.001]	c_{ii}	*0.002 [94.065]
α_{11}	*0.521 [159.809]	*0.238 [36.830]	*0.254 [59.251]	α_{11}	*0.285 [65.313]	*0.473 [88.931]	*0.285 [65.313]	*0.473 [88.931]	α_{11}	*0.459 [97.086]
α_{i1}	*0.127 [31.045]	**0.016 [11.1004]	0.013 [1.513]	α_{i1}	**0.026 [-7.038]	*-0.202 [-32.780]	*-0.026 [-7.038]	*-0.202 [-32.780]	α_{i1}	*0.021 [3.600]
α_{r1}	*-0.131 [-58.234]	*0.055 [31.636]	*0.051 [27.488]	α_{r1}	*0.100 [30.457]	*0.092 [27.106]	*0.100 [30.457]	*0.092 [27.106]	α_{r1}	*-0.048 [-8.351]
α_{ii}	*0.357 [105.716]	*0.459 [157.664]	*0.471 [143.890]	α_{ii}	*0.482 [147.257]	*0.613 [196.808]	*0.482 [147.257]	*0.613 [196.808]	α_{ii}	*0.391 [79.402]

Table 8: (continued)

	USDIPY	USDMXN	USDNOK	USDSEK	USDMXN	USDNOK	USDSEK	USDNOK	USDSEK	USDSEK	USDSEK	USDSEK	USDSEK	USDSEK	USDSEK
β_{11}		*0.866 [564.962]	*0.972 [593.429]	*0.973 [850.538]	β_{11}	*0.891 [386.781]	*0.958 [1002.576]	β_{11}	*0.889 [353.477]						
β_{1i}		*-0.214 [-117.096]	*-0.011 [-6.078]	*-0.012 [-8.085]	β_{1i}	*-0.067 [-13.504]	*0.094 [58.206]	β_{1i}	*-0.013 [-2.320]						
β_{11}		*0.066 [87.204]	*-0.022 [-35.714]	*-0.025 [-32.292]	β_{11}	*-0.646 [-96.961]	*-0.146 [-73.002]	β_{11}	*0.038 [10.654]						
β_{ii}		*0.943 [1380.744]	*0.897 [787.381]	*0.893 [728.259]	β_{ii}	*-0.875 [-438.983]	*0.808 [527.980]	β_{ii}	*0.925 [383.206]						

Table 9 15 Minute VAR-BEKK-GARCH Results

	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$ar(1)_{11}$	*-0.056 [-14.281]	*-0.056 [-13.090]	*-0.045 [-13.090]	*-0.059 [-14.119]	*-0.066 [-15.479]	*-0.049 [-14.934]	*-0.039 [-14.455]	*-0.051 [-18.324]	*-0.056 [-18.458]	*-0.056 [-15.173]	*-0.057 [-15.362]
$ar(1)_{ii}$	*0.028 [4.882]	0.014 [1.446]	*0.038 [8.788]	*0.038 [8.788]	*-0.035 [-8.099]	*-0.011 [-3.608]	**0.075 [1.688]	-0.008 [-1.316]	*-0.032 [-9.255]	*-0.020 [-4.771]	*-0.016 [-5.706]
<i>Constant</i>	*5.269 [5.269]	*0.008 [4.848]	*0.008 [4.848]	*5.059 [5.059]	*0.001 [5.253]	*0.005 [4.937]	*0.009 [5.669]	*0.004 [4.397]	*0.004 [9.208]	*0.004 [5.614]	*0.003 [5.390]
$ar(1)_{j1}$	*0.014 [5.050]	*0.024 [9.095]	*0.024 [9.095]	*0.078 [18.139]	*-0.035 [-12.267]	*-0.017 [-4.815]	*-0.006 [-13.385]	*-0.010 [-3.963]	*-0.063 [-26.997]	*-0.046 [-13.591]	*-0.043 [-13.020]
$ar(1)_{ji}$	*-0.047 [-12.046]	*-0.065 [-19.296]	*-0.065 [-19.296]	*-0.099 [-23.933]	*-0.073 [-19.803]	*-0.063 [-17.324]	*-0.149 [-47.611]	*-0.052 [-13.922]	*-0.075 [-22.512]	*-0.063 [-19.542]	*-0.059 [-15.839]
<i>Constant</i>	0 [0.646]	**0.006 [1.711]	**0.006 [1.711]	*0.002 [3.314]	*0.007 [-3.559]	0 [-0.791]	*0.009 [-5.231]	*0.005 [10.055]	*0.003 [-5.236]	**0.002 [-1.999]	**0.007 [-2.457]
c_{11}	*0.006 [49.552]	*0.008 [47.379]	*0.008 [47.379]	*0.004 [72.315]	*0.003 [45.383]	*0.008 [61.016]	*0.008 [65.257]	*0.009 [56.635]	*0.001 [56.567]	*0.001 [54.400]	*0.005 [47.292]
c_{i1}	*0.007 [32.314]	*0.004 [18.743]	*0.004 [18.743]	*0.009 [54.310]	*0.007 [-18.592]	*0.008 [-27.818]	*0.009 [-3.886]	*0.004 [-13.017]	*0.004 [-29.800]	*0.004 [-38.708]	*0.002 [-34.491]
c_{ii}	*0.001 [56.367]	*0.003 [-53.284]	*0.003 [-53.284]	*0.002 [-25.814]	*0.002 [51.805]	*0.002 [-54.024]	*0.003 [39.952]	*0.004 [86.516]	*0.006 [45.147]	*0.003 [-45.665]	*0.001 [46.599]
α_{11}	*0.222 [48.690]	*0.216 [55.992]	*0.216 [55.992]	*0.317 [66.580]	*0.206 [55.273]	*0.235 [78.393]	*0.301 [88.884]	*0.239 [83.254]	*0.252 [66.027]	*0.235 [55.934]	*0.230 [51.022]
α_{1i}	*-0.009 [-2.431]	*-0.017 [-4.290]	*-0.017 [-4.290]	*0.146 [24.581]	*0.047 [11.561]	*0.049 [14.1001]	*-0.010 [-5.060]	*0.035 [14.814]	*-0.052 [-17.109]	*-0.063 [-14.995]	*-0.050 [-9.379]
α_{i1}	*0.086 [19.258]	*0.082 [16.221]	*0.082 [16.221]	0.013 [1.627]	*-0.088 [-20.479]	*-0.038 [-12.181]	*0.185 [5.522]	*0.029 [5.879]	*-0.044 [-13.994]	*-0.050 [-15.404]	*-0.067 [-20.718]
α_{ii}	*0.335 [89.338]	*0.357 [105.667]	*0.357 [105.667]	*0.184 [34.016]	*0.384 [110.527]	*0.383 [143.080]	*0.237 [96.238]	*0.455 [126.397]	*0.307 [105.243]	*0.298 [86.238]	*0.312 [87.372]
β_{11}	*0.980 [794.668]	*0.978 [911.908]	*0.978 [911.908]	*0.958 [684.361]	*0.981 [869.178]	*0.971 [1261.426]	*0.956 [837.892]	*0.972 [1216.794]	*0.975 [935.163]	*0.975 [853.108]	*0.977 [740.461]

Table 9 (continued)

	AUDUSD	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHEF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
β_{ii}	*0.008 [4.951]	*0.009 [2.066]	*-0.043 [-22.844]	*-0.013 [-8.166]	*-0.015 [-10.371]	*0.005 [6.464]	*-0.007 [-7.532]	*0.017 [15.056]	*0.013 [8.517]	*0.010 [5.529]	
β_{i1}	*-0.028 [-17.361]	*-0.024 [-11.143]	*-0.013 [-7.418]	*0.019 [14.355]	*0.014 [13.1003]	*-0.076 [-9.054]	0 [0.108]	*0.019 [12.448]	*0.018 [16.430]	*0.027 [18.868]	
β_{ii}	*0.941 [795.690]	*0.944 [917.756]	*0.982 [712.692]	*0.941 [872.019]	*0.938 [1070.920]	*0.981 [1920.282]	*0.903 [663.995]	*0.951 [1097.867]	*0.950 [838.121]	*0.947 [834.735]	
	EURUSD	GBPUSD	NZDUSD	USDCAD	USDCHEF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	
$ar(1)_{i1}$	*-0.035 [-8.475]	*-0.038 [-13.822]	*-0.044 [-13.524]	*-0.056 [-25.158]	*-0.029 [-10.623]	*-0.042 [-11.827]	*-0.033 [-10.226]	*-0.036 [-6.532]	*-0.036 [-5.896]		
$ar(1)_{ii}$	0.013 [1.413]	*0.014 [6.854]	*-0.026 [-11.284]	*-0.025 [-9.536]	-0.007 [-0.056]	*-0.013 [-3.430]	-0.008 [-0.826]	-0.009 [-0.236]	0.006 [0.394]		
Constant	0 [0.792]	0 [0.656]	0 [-0.083]	0 [0.113]	0 [0.722]	0 [0.043]	0 [1.371]	0 [0.827]	0 [0.742]		
$ar(1)_{j1}$	*0.034 [10.055]	*0.049 [20.404]	*-0.036 [-16.736]	*-0.063 [-25.100]	*-0.004 [-14.511]	*-0.014 [-3.126]	*-0.068 [-23.729]	*-0.058 [-9.335]	*-0.051 [-7.613]		
$ar(1)_{ji}$	*-0.071 [-19.963]	*-0.068 [-24.050]	*-0.062 [-26.677]	*-0.102 [-38.298]	*-0.151 [-46.989]	*-0.049 [-13.800]	*-0.077 [-22.630]	*-0.077 [-15.930]	*-0.062 [-12.409]		
Constant	0 [0.928]	*0.004 [3.444]	*0.008 [-2.636]	0 [-1.054]	*0.002 [-4.945]	*0.001 [10.614]	*0.009 [-4.354]	*0.006 [-2.775]	*0.004 [-2.047]		
c_{11}	*0.002 [61.846]	*0.008 [67.239]	*0.001 [64.687]	*0.008 [106.083]	*0.007 [65.273]	*0.005 [67.755]	*0.008 [66.981]	*0.005 [66.129]	*0.005 [62.158]		
c_{i1}	*0.005 [31.132]	*0.008 [27.907]	*0.006 [-19.921]	*0.008 [-106.891]	*0.002 [-4.711]	*0.002 [-14.477]	*0.003 [-15.147]	*0.003 [-36.079]	*0.002 [-32.561]		
c_{ii}	*0.003 [-53.816]	*0.003 [38.386]	*0.004 [51.341]	0 [0.018]	*0.007 [41.924]	*0.008 [83.614]	*0.007 [69.026]	*0.004 [-70.688]	*0.003 [59.064]		

Table 9 (continued)

	EURUSD	GBPUSD	NZDUSD	USDCAD	USDFHF	USDHKD	USDIPY	USDMXN	USDNOK	USDSEK
α_{11}	*0.279 [49.249]	*0.337 [102.135]	*0.298 [86.145]	*0.266 [128.492]	*0.320 [117.842]	*0.283 [118.823]	*0.306 [105.998]	*0.302 [67.171]	*0.284 [53.039]	
α_{1i}	*-0.031 [-6.783]	*0.125 [32.178]	0.005 [0.752]	*0.029 [17.272]	*-0.006 [-3.475]	*0.058 [22.263]	*-0.061 [-17.177]	*-0.033 [-4.429]	0.009 [1.137]	
α_{r1}	*0.048 [4.966]	-0.010 [-0.213]	*-0.024 [-4.355]	*-0.055 [-22.162]	-0.014 [-0.327]	*-0.035 [-10.674]	*-0.015 [-4.353]	0 [-0.093]	*-0.017 [-3.556]	
α_{ii}	*0.359 [67.262]	*0.171 [50.842]	*0.339 [93.728]	*0.369 [160.025]	*0.240 [100.417]	*0.457 [131.721]	*0.309 [113.620]	*0.313 [61.007]	*0.333 [59.217]	
β_{11}	*0.964 [521.630]	*0.947 [937.101]	*0.960 [923.977]	*0.964 [2291.436]	*0.947 [1079.788]	*0.961 [1391.498]	*0.956 [1047.968]	*0.958 [569.925]	*0.957 [420.339]	
β_{1i}	*0.008 [3.415]	*-0.033 [-27.701]	***0.008 [1.856]	*0.010 [25.898]	*0.004 [3.795]	*-0.017 [-15.749]	*0.013 [9.376]	-0.004 [-1.048]	*-0.014 [-3.843]	
β_{r1}	*-0.022 [-4.020]	0.006 [0.967]	0.006 [1.320]	*0.018 [26.733]	-0.014 [-1.395]	*0.023 [12.965]	*0.011 [6.072]	0.008 [1.308]	***0.007 [1.717]	
β_{ii}	*0.949 [502.512]	*0.991 [1198.252]	*0.948 [850.353]	*0.946 [1408.787]	*0.983 [2064.179]	*0.907 [676.169]	*0.952 [1234.089]	*0.947 [484.419]	*0.941 [400.870]	
	GBPUSD	NZDUSD	USDCAD	USDFHF	USDHKD	USDIPY	USDMXN	USDNOK	USDSEK	
$ar(1)_{11}$	*-0.059 [-16.500]	*-0.063 [-21.727]	*-0.057 [-15.933]	*-0.044 [-15.447]	*-0.047 [-16.256]	*-0.055 [-17.089]	*-0.064 [-18.323]	*-0.064 [-18.323]	*-0.064 [-17.304]	
$ar(1)_{1i}$	*0.016 [5.151]	*-0.026 [-12.594]	*-0.013 [-4.818]	-0.046 [-1.451]	*-0.010 [-2.608]	*-0.011 [-3.937]	*-0.023 [-9.738]	*-0.024 [-8.657]	*-0.024 [-8.657]	
Constant	0 [1.449]	0 [0.739]	0 [0.734]	0 [1.397]	0 [1.469]	***0.008 [2.038]	0 [1.198]	0 [1.093]	0 [1.093]	
$ar(1)_{i1}$	*0.027 [6.155]	*-0.017 [-6.527]	*-0.023 [-5.682]	*-0.010 [-10.640]	*-0.014 [-5.335]	*-0.055 [-18.122]	*-0.055 [-18.122]	*-0.042 [-8.114]	*-0.038 [-7.717]	
$ar(1)_{ii}$	*-0.054 [-15.583]	*-0.048 [-19.173]	*-0.059 [-17.494]	*-0.147 [-45.128]	*-0.047 [-13.318]	*-0.058 [-18.242]	*-0.053 [-16.222]	*-0.053 [-16.222]	*-0.046 [-12.321]	

Table 9 (continued)

	GBPUSD	NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
<i>Constant</i>	*0.003 [3.373]	*0.001 [- 2.673]	0	*0.009 [- 4.429]	*0.001 [10.019]	*0.006 [- 4.721]	0	**0.008 [- 2.234]	
c_{11}	*0.003 [53.973]	*0.009 [54.395]	*0.007 [59.795]	*0.008 [55.277]	*0.009 [56.106]	*0.003 [- 53.652]	*0.003 [52.295]	*0.002 [52.939]	
c_{i1}	*0.004 [14.749]	*0.001 [- 31.302]	*0.007 [- 40.141]	**0.009 [- 1.885]	0	*0.009 [8.721]	*0.001 [- 24.089]	*0.007 [- 22.322]	
c_{ii}	*0.004 [34.947]	*0.003 [- 47.980]	*0.002 [- 49.745]	*0.008 [42.310]	*0.004 [78.819]	*0.003 [76.649]	*0.009 [54.330]	*0.002 [63.172]	
α_{11}	*0.368 [129.751]	*0.349 [103.485]	*0.292 [114.097]	*0.341 [137.217]	*0.306 [139.668]	*0.321 [125.086]	*0.338 [86.475]	*0.324 [91.159]	
α_{1i}	*0.121 [24.648]	*- 0.070 [- 14.432]	*0.108 [20.361]	*0.004 [- 2.651]	*0.067 [20.251]	*- 0.040 [- 8.823]	**- 0.030 [- 2.158]	0.014 [0.554]	
α_{i1}	*- 0.026 [- 9.820]	*0.017 [3.090]	*- 0.022 [- 8.810]	- 0.019 [- 0.599]	*- 0.021 [- 6.098]	*- 0.011 [- 4.784]	0.006 [1.647]	0.011 [1.061]	
α_{ii}	*0.168 [52.962]	*0.298 [82.490]	*0.391 [129.190]	*0.237 [100.846]	*0.455 [131.679]	*0.311 [119.425]	*0.292 [69.965]	*0.312 [83.243]	
β_{11}	*0.944 [1104.740]	*0.947 [879.492]	*0.963 [1436.969]	*0.955 [1325.058]	*0.966 [1744.671]	*0.953 [1272.567]	*0.959 [723.923]	*0.960 [856.076]	
β_{1i}	*- 0.029 [- 18.680]	*0.032 [18.545]	*- 0.033 [- 16.258]	*0.009 [2.944]	*- 0.028 [- 19.776]	*0.010 [4.210]	- 0.010 [- 0.748]	*- 0.021 [- 4.967]	
β_{i1}	*0.009 [6.527]	*- 0.013 [- 7.603]	*0.019 [14.728]	- 0.009 [- 1.286]	*0.008 [7.800]	*0.006 [7.975]	*0.012 [4.562]	*0.009 [4.931]	
β_{ii}	*0.994 [1362.673]	*0.967 [930.620]	*0.929 [880.967]	*0.978 [2093.105]	*0.901 [641.628]	*0.952 [1203.625]	*0.949 [642.171]	*0.951 [708.415]	

Table 9 (continued)

NZDUSD	USDCAD	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$\alpha(1)_{11}$	*-0.074 [-20.769]	*-0.051 [-17.592]	*-0.042 [-12.928]	*-0.052 [-17.543]	*-0.062 [-21.228]	*-0.064 [-22.597]	*-0.067 [-19.460]
$\alpha(1)_{1i}$	*-0.058 [-14.071]	*-0.028 [-6.687]	0.031 [0.580]	*-0.012 [-2.888]	*-0.029 [-9.100]	*-0.031 [-10.995]	*-0.034 [-11.153]
Constant	*0.004 [3.375]	*0.008 [3.164]	*0.003 [2.826]	*0.008 [3.817]	*0.008 [3.794]	*0.007 [3.466]	*0.004 [3.389]
$\alpha(1)_{i1}$	*-0.024 [-9.226]	*-0.017 [-5.777]	*-0.004 [-9.570]	0 [0.130]	*-0.045 [-26.869]	*-0.038 [-14.913]	*-0.041 [-11.087]
$\alpha(1)_{ii}$	*-0.058 [-16.170]	*-0.062 [-18.085]	*-0.152 [-45.369]	*-0.044 [-14.064]	*-0.063 [-19.435]	*-0.062 [-20.130]	*-0.049 [-14.515]
Constant	*0.004 [-3.415]	0 [-1.164]	*0.001 [-4.338]	*0.006 [10.218]	*0.008 [-4.494]	**0.007 [-1.768]	**0.005 [-2.216]
c_{11}	*0.003 [36.627]	*0.009 [47.116]	*0.006 [42.436]	*0.006 [43.674]	*0.004 [34.876]	*0.002 [42.289]	*0.008 [34.145]
c_{i1}	*0.005 [-22.856]	*0.007 [-28.890]	**0.008 [-2.077]	*0.008 [-5.424]	*0.007 [-30.268]	*0.007 [-39.209]	*0.007 [-35.495]
c_{ii}	*0.003 [31.058]	*0.001 [33.407]	*0.009 [43.720]	*0.005 [79.197]	*0.005 [37.615]	*0.007 [-33.853]	*0.006 [35.435]
α_{11}	*0.153 [50.358]	*0.198 [79.974]	*0.255 [64.685]	*0.205 [80.875]	*0.168 [52.344]	*0.176 [55.337]	*0.166 [48.656]
α_{1i}	*0.043 [15.426]	*0.040 [10.355]	0 [0.971]	*0.052 [27.245]	*-0.026 [-9.686]	*-0.036 [-7.502]	-0.008 [0.027]
α_{i1}	*-0.136 [-31.749]	*-0.051 [-18.816]	*0.217 [5.829]	*0.018 [3.928]	*-0.087 [-34.527]	*-0.099 [-32.263]	*-0.110 [-34.536]
α_{ii}	*0.383 [119.825]	*0.379 [125.909]	*0.244 [97.738]	*0.464 [130.500]	*0.327 [129.347]	*0.324 [94.780]	*0.339 [99.885]

Table 9 (continued)

	USDUSD	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
β_{11}	*0.987 [1435.124]	*0.987 [1702.387]	*0.966 [796.262]	*0.979 [1556.770]	*0.987 [1612.817]	*0.987 [1315.482]	*0.985 [1205.124]	
β_{1i}	*-0.014 [-6.628]	*-0.007 [-5.532]	0 [1.145]	*-0.011 [-12.756]	*0.005 [6.389]	*0.012 [5.062]	*-0.004 [2.118]	
β_{21}	*0.039 [26.341]	*0.022 [20.091]	*-0.083 [-8.972]	-0.003 [-0.609]	*0.028 [32.713]	*0.033 [29.606]	*0.031 [28.409]	
β_{2i}	*0.940 [973.923]	*0.937 [999.024]	*0.980 [1795.061]	*0.903 [642.873]	*0.947 [1288.178]	*0.950 [837.564]	*0.941 [828.232]	
	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	
$ar(1)_{11}$	*-0.052 [-15.275]	*-0.037 [-10.431]	*-0.047 [-15.042]	*-0.060 [-16.964]	*-0.054 [-16.304]	*-0.057 [-16.152]		
$ar(1)_{ii}$	*0.015 [4.094]	*0.067 [1.985]	*-0.016 [-3.023]	*0.020 [7.233]	*0.021 [8.792]	*0.021 [7.784]		
Constant	*0.004 [-3.889]	*0.009 [-2.187]	*0.005 [-2.712]	*0.002 [-3.209]	*0.007 [-2.957]	*0.005 [-3.563]		
$ar(1)_{j1}$	*0.019 [5.906]	*0.010 [8.091]	-0.006 [-0.736]	*0.073 [26.643]	*0.054 [13.589]	*0.051 [13.123]		
$ar(1)_{ji}$	*-0.062 [-17.841]	*-0.143 [-45.514]	*-0.044 [-13.193]	*-0.068 [-24.333]	*-0.058 [-19.446]	*-0.051 [-15.130]		
Constant	0 [-0.043]	*0.007 [-3.782]	*0.007 [11.762]	*0.006 [-4.501]	0 [-1.600]	**0.007 [-2.010]		
c_{11}	*0.001 [55.239]	*0.005 [56.836]	*0.008 [58.400]	*0.004 [58.752]	*0.006 [57.452]	*0.002 [-55.527]		
c_{21}	*0.007 [31.393]	*0.009 [8.085]	*0.007 [4.106]	*0.006 [23.645]	*0.008 [24.708]	*0.004 [-22.005]		

Table 9 (continued)

	USDCAD	USDCHE	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	
c_{it}	*0.003 [54.919]	*0.004 [37.747]	*0.004 [37.747]	*0.004 [77.078]	*0.007 [68.291]	*0.005 [57.111]	*0.004 [53.178]	
α_{1t}	*0.309 [120.911]	*-0.345 [-122.893]	*-0.345 [-122.893]	*0.304 [126.340]	*0.317 [106.642]	*0.337 [108.583]	*0.327 [102.153]	
α_{2t}	*-0.031 [-5.341]	*-0.005 [-5.341]	*-0.005 [-5.341]	*-0.036 [-12.107]	*0.071 [23.020]	*0.078 [14.764]	*0.059 [11.248]	
α_{3t}	0.008 [1.471]	*0.126 [4.635]	*0.126 [4.635]	*-0.014 [-3.474]	*0.031 [13.207]	*0.012 [3.989]	*0.034 [10.910]	
α_{4t}	*0.374 [124.190]	*0.226 [92.999]	*0.226 [92.999]	*0.445 [122.403]	*0.300 [121.341]	*0.280 [85.603]	*0.289 [93.061]	
β_{1t}	*0.964 [1392.583]	*0.951 [1099.619]	*0.951 [1099.619]	*0.961 [1495.497]	*0.963 [1147.028]	*0.951 [1020.749]	*0.959 [989.422]	
β_{2t}	*0.010 [3.538]	*0.004 [-3.676]	*0.004 [-3.676]	*0.014 [8.393]	*-0.022 [-17.1001]	*-0.020 [-10.512]	*-0.012 [-6.919]	
β_{3t}	*-0.007 [-6.793]	0.004 [0.338]	0.004 [0.338]	0 [-0.432]	*-0.011 [-14.249]	*-0.010 [-6.744]	*-0.018 [-10.467]	
β_{4t}	*0.937 [1000.189]	*0.980 [1998.612]	*0.980 [1998.612]	*0.908 [637.899]	*0.956 [1370.823]	*0.962 [907.702]	*0.952 [959.577]	
	USDCHE	USDHKD	USDJPY	USDNOK	USDSEK	USDMXN	USDNOK	USDSEK
$ar(1)_{1t}$	*-0.046 [-15.157]	*-0.062 [-22.964]	*-0.053 [-17.206]	*-0.059 [-17.634]	*-0.061 [-16.945]	*-0.150 [-52.325]	*-0.146 [-43.671]	*-0.150 [-45.593]
$ar(1)_{2t}$	-0.026 [-0.709]	*0.014 [4.121]	*0.023 [7.200]	*0.020 [6.692]	*0.015 [4.494]	0 [0.336]	*0.004 [11.1.006]	*0.008 [13.462]
Constant	0	0	***0.009 [1.719]	0	0	*0.007 [-4.280]	*0.002 [-6.073]	*0.008 [-5.220]
$ar(1)_{3t}$	*0.006 [8.475]	*0.031 [12.484]	*0.009 [3.052]	*0.025 [4.538]	*0.025 [5.307]	*0.032 [1.138]	*0.075 [1.995]	-0.007 [-0.142]

Table 9 (continued)

	USDCHF	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK	USDHKD	USDJPY	USDMXN	USDNOK	USDSEK
$ar(1)_{it}$	*-0.144 [-48.962]	*-0.052 [-13.197]	*-0.054 [-18.479]	*-0.056 [-15.552]	*-0.047 [-13.505]	$ar(1)_{it}$		*-0.034 [-9.452]	*-0.046 [-14.327]	*-0.049 [-15.325]	*-0.038 [-10.753]
Constant	*0.007 [-4.366]	*0.009 [11.081]	*0.001 [-5.628]	**0.007 [-2.445]	**0.008 [-1.916]	Constant		*0.001 [10.606]	*0.004 [-5.474]	**0.004 [-1.874]	**0.003 [-1.822]
c_{11}	*0.007 [68.375]	*0.005 [-24.151]	*0.003 [71.1.002]	*0.003 [70.404]	*0.006 [69.193]	c_{11}		*0.008 [41.332]	*0.005 [42.088]	*0.002 [44.299]	*0.006 [42.939]
c_{i1}	*0.008 [-2.892]	*0.009 [84.340]	*0.002 [10.963]	*0.003 [51.352]	*0.005 [50.868]	c_{i1}		0 [0.803]	0 [0.825]	0 [-0.858]	**0.003 [1.981]
c_{it}	*0.001 [35.162]	*0.007 [84.340]	*0.001 [83.621]	*0.006 [47.713]	*0.008 [45.600]	c_{it}		*0.007 [76.374]	*0.006 [76.374]	*0.007 [62.953]	*0.009 [65.180]
α_{11}	*0.379 [129.146]	*0.334 [126.405]	*0.354 [135.140]	*0.366 [112.552]	*0.363 [112.918]	α_{11}		*0.223 [95.966]	*0.236 [92.711]	*0.237 [96.061]	*0.236 [99.344]
α_{it}	*-0.009 [-5.251]	**0.013 [2.192]	**0.009 [1.670]	*0.043 [12.692]	*0.037 [9.299]	α_{it}		*0.346 [14.068]	0 [-0.024]	*-0.150 [-3.632]	-0.016 [-0.309]
α_{i1}	-0.036 [-1.116]	*0.084 [23.767]	0 [0.112]	*-0.014 [-3.174]	-0.008 [-0.461]	α_{i1}		0 [-0.098]	**0.009 [1.781]	**0.007 [-2.048]	0 [1.506]
α_{ii}	*0.223 [94.724]	*0.446 [124.500]	*0.316 [145.661]	*0.286 [89.566]	*0.295 [98.293]	α_{ii}		*0.472 [123.936]	*0.332 [121.060]	*0.325 [114.173]	*0.321 [126.785]
β_{11}	*0.933 [927.036]	*0.946 [1154.203]	*0.946 [1037.464]	*0.938 [959.757]	*0.943 [941.221]	β_{11}		*0.978 [2120.436]	*0.982 [1854.569]	*0.979 [2037.768]	*0.981 [2080.532]
β_{it}	*0.007 [6.172]	0.003 [1.117]	0.010 [0.614]	*-0.020 [-15.683]	*-0.018 [-12.561]	β_{it}		*-0.068 [-7.585]	0.012 [1.259]	*0.060 [5.722]	**0.025 [2.076]
β_{i1}	0.017 [1.630]	*-0.036 [-25.306]	**0.006 [-2.283]	*-0.008 [-4.078]	*-0.013 [-5.409]	β_{i1}		0 [0.475]	0 [-1.333]	**0.001 [1.837]	0 [-1.475]
β_{ii}	*0.984 [2130.509]	*0.903 [668.241]	*0.956 [1542.832]	*0.962 [940.986]	*0.957 [1069.458]	β_{ii}		*0.899 [604.818]	*0.947 [1141.145]	*0.950 [955.063]	*0.947 [1095.675]

Table 9 (continued)

	USDIPY	USDMXN	USDNOK	USDSEK	USDMXN	USDNOK	USDSEK	USDNOK	USDSEK
β_{11}	*0.876 [490.351]	*0.900 [607.718]	*0.907 [639.892]	*0.959 [1165.754]	β_{11}	*0.959 [1226.368]	*0.959 [1165.754]	β_{11}	*0.964 [522.480]
β_{1i}	*0.020 [10.180]	*-0.011 [-3.886]	*-0.016 [-10.702]	*-0.016 [-9.457]	β_{1i}	*-0.020 [-12.771]	*-0.016 [-9.457]	β_{1i}	*-0.023 [-8.917]
β_{11}	*-0.008 [-6.270]	0 [-0.032]	*0.013 [15.134]	*-0.018 [-8.963]	β_{11}	*-0.012 [-10.154]	*-0.018 [-8.963]	β_{11}	*-0.023 [-10.898]
β_{ii}	*0.961 [1518.644]	*0.966 [1240.625]	*0.961 [1349.798]	*0.957 [956.928]	β_{ii}	*0.957 [988.279]	*0.957 [956.928]	β_{ii}	*0.957 [569.684]

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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