# Do spillover effects exist in Indian markets?

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**Abstract:** Using forecast error variance (FEV) decomposition technique of a generalised VAR model of Diebold and Yilmaz (2012), this study is an inquiry into the return and volatility spillovers across various market segments in India viz., stock, bond, money and currency markets over the period July 2005 to August 2020. The empirical results confirm the spillover effects among the above stated markets; however, the degree of spillovers is very low (at around 5%) when compared with advanced economies. Further, our results reveal that stock and bond markets are the contributors of spillovers to other markets, while currency and money markets are receivers of spillovers from other markets.

**Keywords:** market spillovers; FEV decomposition; VAR.

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## 1 Introduction

Prior to initiation of economic reforms in 1990s, Indian financial markets were characterised by administered interest rates, severe restrictions on current and capital account transactions, statutory pre-emptions, pegged exchange rate, etc. However, reforms brought significant changes in the overall functioning of financial markets and made outcomes more market-driven and market-determined than earlier. Now, markets are characterised by market-discovered interest and exchange rates, sustainable equity and debt markets, current account convertibility and substantial capital account liberalisation, etc. However, to further improve the operations of financial markets and to reduce the vulnerability of different market segments, Government and RBI initiated several steps from time to time. Resultantly, Indian markets have become one of the most favoured destinations for inflows in the world.

Literature on the topic suggests that significant efforts were made to identify cross-market spillovers among various markets both within the country and across different countries. Some studies found strong spillovers between stock and debt markets particularly during the periods of high uncertainty. These studies inferred that during the periods of extreme volatility, investors generally inclined to sell risky stocks and divert their investments into most liquid assets (Baur and Lucey, 2009; Caballero and Krishnamurthy, 2008). Further, Baur and Lucey's (2010) portfolio rebalancing hypothesis envisages buying of particular asset and selling of another asset, leading thereby to a change in the composition of a portfolio. Both of the above-mentioned propositions suggest a negative association between equity and bond markets, particularly in episodes of crises or periods of high uncertainty.

Alternatively, some studies suggest that cross-market spillovers is a channel of information transmission; here, buying or selling of particular asset with the objective to lock a position in another, resulting in a positive association among the two asset classes (Fleming et al., 1998). Nonetheless, except the study by Diebold and Yilmaz (2009), which focused on world-wide markets, most of the studies concentrate on international equity markets while measuring the spillover effects.

In the context of India –

1 measuring spillover-effects in different financial markets

2 knowing about which markets are transmitting the spillovers and which markets are receiving the spillover-effects

3 understanding the behaviour of spillovers during economic up and down turns provide useful insights to policy makers to further improve the policy prescriptions.

Since the spillover effects across markets may generally transform into financial instability coupled with economic contraction (In, 2007), undertaking a separate study in Indian context is very essential to fill the existing research gap. The answer to these questions shall, from the policy and academic perspective, provides a useful guidance for actions by contributing to the understanding of financial spillovers and mechanisms of their propagation, thereby springing up insights for preservation of financial stability. On the other hand, these can be guiding tools for individual investors and money managers in portfolio construction and decision-making by helping understand the linkages between different asset classes, especially during economic ups and downs.

According to our understanding, the current study examined the spillover effects by utilising the latest data consisting of various periods of economic significance viz., demonetisation, taper tantrum, economic deceleration and COVID-19 pandemic for first ever time. The study put forth two objectives:

1 computing spillover effects across four Indian markets viz., equity, bond, money and currency markets

2 analysing the behaviour of spillovers across periods of economic down and up turns.

The paper is organised into five sections. Section 2 contains review of existing literature on the subject. Section 3 discusses the methodology and data used for the study. Discussion of results is documented in Section 4, and Section 5 presents concluding observations.

## 2 A note on literature survey

Good number of studies examined how spillover effects transmit across markets. Previous studies (Eun and Shim, 1989; Arshanapalli and Doukas, 1993, Cheung and Ng, 1996) mainly focused on spillover-effects between equity markets of US and those of other countries. Studies thereafter extended the scope to stock markets specific to regions such as Scandinavian or European markets and investigated the linkages between spot and futures markets (Tse, 1999; Bartram et al., 2007). Further, efforts were also made to analyse other classes of assets, viz. energy (Rittler, 2012; Xu et al., 2019), credit (Collet and Ielpo, 2018), bond (Reboredo, 2018), commodity (Dahl and Jonsson, 2018) and currency (Francq et al., 2016).

Tiwari et al. (2018), analysed four types of assets viz., equity, bonds, credit default swaps (CDS) and currency over the period Sept-2009 to Sept-2016 for volatility spillovers among these classes. They used a time and frequency domain framework for estimations. The authors applied Diebold and Yilmaz (2012) methodology framework and projected spillover index as 5.08%, suggesting a weak linkage among markets. The authors further present that while the equity and CDS markets transmit volatility, foreign exchange and bond markets receive these transmitted spillovers. By deploying frequency domain analysis, Barunik and Krehlik (2018) suggested that when frequencies are higher, the degree of spillovers rises. They further inferred that the transmission (net) of spillovers (volatility) among markets depends upon the frequency considered for analysis.

Lawrence (2003) by using quarterly data over the period 1975–2001 examined the behaviour and correlations among returns on US equity, bonds and gold. The author

discovered that returns on gold and other financial assets are not correlated; it is reasoned that returns on gold are not correlated with economic indicators, while returns on equity and bonds are, suggesting the potential utility of gold in portfolio diversification. Somewhat qualifying this finding, Baur and Lucey (2010) investigated linkages among US, UK and German equity, bond and gold returns which are time-varying to examine gold as stable and safe haven of investment. The authors concluded that albeit gold is a safeguard against stocks in severe fluctuations in equity market, however, it holds good only during short-term. Sumner et al. (2010) studied the sample period January 1970 to April 2009 using a spillover index methodology and examined whether US stock and bond market movements can be predicted using gold returns and volatilities or vice versa for the. The authors discovered no significant association among gold, stock, bond markets, thereby, questioning if gold prices can predict the prices of stocks and bonds.

A few studies have also focused on international equity markets (see for instance, Engle et al., 2012). These studies employed asymmetric volatility spillover models. They examine interconnections of the volatility across stock markets in eight East Asian countries around the time of the Asian currency crisis. They discover dynamic transmission of volatility trends occurring across a network of interconnectedness. Similarly, Diebold and Yilmaz (2009) formulated and examined metrics to capture spillovers of returns and volatility across 19 global equity markets for a period close to two decades from the early 1990s to 2009. The authors found that evidence in support of dissimilar pattern in return and volatility spillovers. By employing the Diebold and Yilmaz (2009) methodology, Claeys and Vasicek (2012) analysed the association and direction of relationship between sovereign bond markets and found a clear heterogeneity in bidirectional spillovers transmitted and absorbed among the bond markets of the EU member countries. On the similar lines, Christiansen (2007) analysed the volatility spillovers across US and European bond markets and confirmed existence of spillovers among markets.

The repertoire of studies in this field also includes investigation of volatility spillovers among three swap markets (the USA, Japan and the UK). The authors found that the US swap market has significant impact on the Japanese and UK markets, but it is not true the other way. Further, the authors also discovered reciprocal spillovers between the UK and Japanese markets.

Currency markets have also been subject to such analyses, for instance, Antonakakis (2012) examined the co-movements in returns and spillovers of volatility between major exchange rates (having considered currencies viz., the US dollar, the British pound and the euro/Deutsche mark) pre and post introduction of euro, noting the positive link between such trends/spillovers and crises and episodes of US dollar appreciations. With cross-market volatility spillover being bidirectional, the dominant net transmitter of volatility happens to be the euro (Deutsche mark) while the dominant net receiver of volatility happens to be the British pound and cross-market volatility spillovers being bidirectional. Bubak et al. (2011) examined the behaviour of volatility spread among Central European (CE) currencies and the EUR/USD foreign exchange by employing a modified version of the Diebold and Yilmaz (2009) method, and found notable intra-regional spillovers in exchange markets.

In the Indian context, Dey and Sampath (2020) employed Diebold and Yilmaz (2012) modelling technique and estimated the linkages between multiple segments – gold, realty, banking, IT and forex for the period July 2010 to March 2017. They use the sectoral NIFTY indices, gold spot and exchange rate to estimate the spillovers. The authors

inferred that spillovers contribute a FEV of a little more than 25%. According to authors, real estate and banking are the highly dominant segments in terms of spillovers.

## 3 Econometric methodology and data

We estimate the spillover index among four markets viz., stock, bond, money and currency markets by applying the framework indicated by Diebold and Yilmaz (2012). Both return and return volatilities are considered while computing spillover index.

The calculation of Index using VAR framework is outlined below.

A VAR system is considered, containing $P$ lagged terms in respect of $N$ indicators. The reduced form of VAR can be written as follows

$$X_t = \alpha + \sum_{p=1}^{P} A_p X_{t-p} + v_t$$

where $A_p$ is an $NXN$ regression coefficient matrix, $\alpha$ is a constant vector, $v_t$ is innovation vector. It is assumed that the components related to $v_t$ are not serially correlated. However, correlation exists among various components. $\sum$ is the matrix of covariance pertain to $v_t$. In moving average notation, the VAR model can be written as under:

$$X_t = \alpha + \sum_{i=1}^{\infty} \varphi_i u_{t-i}$$

where

$u_t = Pv_t$

$P^{-1}$ = Cholesky factorisation of $\sum_v$

$\varphi_i = M_i P^{-1}$

where

$$M_i = \sum_{j=1}^{\min(i,p)} A_j M_{i-j}$$

$M_0 = I$.

It is easily demonstrable that the $h$ periods ahead of covariance matrix using the following equation

$$\sum_{fe,h} = \sum_{fe,h-1} + M_{h-l} \sum_{v} M'_{h-l}$$

The FEV decomposition is the proportion (in percentage terms) of volatility (i.e., variance) to indicator $I$ which arises on account of shocks to indicator $J$. The decompositions of volatility stemming from the remaining indicators will be given by the off-diagonal elements present in matrix $\varphi_i$. The decomposition of FEV for an indicator $I$, at prediction length $H$, due to indicator $J$ is computed using the following equation

$$\sum_{h=0}^{H-1} \sum_{J=1}^{N} \varphi^2_{h,I,J}$$

The index of spillover for is computed using the below mentioned equation:

$$SPILL^{H} = 100 \frac{\sum_{h=0}^{H-1} \varphi_{h,I,J}^{2}}{\sum_{h=0}^{H-1} \sum_{J=1}^{N} \varphi_{h,I,J}^{2}}$$

In the above equation

$$\text{Denominator} = \sum Trace\ of\ \ FECM$$

where FECM = forecast error covariance matrix.

## *3.1 Dynamic conditional correlation*

For calculating correlations, literature shows various equations, however most researchers use the equation proposed by Engle (2002). In this equation, the correlations will change over time dynamically.

The following equation gives variance covariance matrix

$$H_t = D_t R_t D_t$$

where

$D_t$ = diagonal matrix with conditional square root of variances

$$D_t = \left( h_{1t}^{\frac{1}{2}}, \ldots, h_{nt}^{\frac{1}{2}} \right)$$

$R_t$ = Matrix of conditional correlation

Constant conditional correlation can be achieved by forcing $R_t$ into not changing over time. $R_t$ is represented as:

$$R_t = dia\left\{Q_t^*\right\}^{-1} Q_t dia\left\{Q_t^*\right\}^{-1}$$

where

*dia*(.) = Matrix of diagonal elements

$Q^*$ = matrix containing square roots of individual elements

## *3.2 The data*

For measuring the spillover effects among four markets namely stock, bond, money, and currency markets, we have used weekly data over the period July 7, 2005, to August 2, 2020. The sample period chosen covers various episodes of economic significance such as demonetisation, taper tantrum, economic deceleration and COVID-19 pandemic. We have used Nifty50 index to represent return from stock market, call-money rate to capture the return from money market, 10-year bond yield to track returns in the bond market and Rupee/USD exchange rate for measuring the rate of return from currency market. By following previous research, the periodicity of the data is chosen as weekly. Selecting weekly data will evade some of the trading day effects (Skintzi and Refenes, 2006).

## 4 Empirical results and interpretation

Descriptive statistics of return and return-volatility across four markets namely stock, money, bond and currency markets are furnished in Table 1. On perusal of statistics, it was found that returns from equity and money market are relatively more volatile than other markets. The bond market yield is appearing to be least volatile, suggesting that bond market has been functioning smoothly without many fluctuations. The metrics represents shape of the distribution suggests that both returns and volatility in return may not follow normal distribution.

**Table 1** Descriptive statistics

| *Returns* | *Stock market* | *Money market* | *Bond market* | *Currency market* |
|---|---|---|---|---|
| Mean | 0.243 | 6,530 | 7,632 | 0.074 |
| St. deviation | 3,002 | 2,488 | 0.726 | 1,053 |
| Skewness | –0.280 | 9,058 | –0.412 | 0.581 |
| Kurtosis | 4,435 | 172,807 | –0.095 | 6,301 |
| Min | –15,980 | 0.180 | 5,350 | –5,200 |
| Max | 18,400 | 54,320 | 9,470 | 7,720 |
| No. of observations | 788 | 788 | 788 | 788 |
| *Volatility* | | | | |
| Mean | 2,583 | 0.696 | 0.151 | 0.915 |
| St. deviation | 1,411 | 1,749 | 0.112 | 0.498 |
| Skewness | 1,495 | 6,673 | 2,666 | 2,054 |
| Kurtosis | 2,020 | 48,352 | 10,657 | 5,654 |
| Min | 0.720 | 0.020 | 0.020 | 0.210 |
| Max | 8,460 | 14,710 | 0.900 | 3,290 |
| *No. of observations* | 788 | 788 | 788 | 788 |

**Table 2** Dynamic correlations between markets

| *Returns* | *Stock market* | *Bond market* | *Currency market* | *Money* |
|---|---|---|---|---|
| Stock market | 1.000 | | | |
| Bond market | 0.383*** | 1.000 | | |
| Currency market | 0.978*** | 0.584*** | 1.000 | |
| Money market | 0.465*** | 0.554*** | 0.644*** | 1.000 |

Note: ***Significant at 1%.

### *4.1 Dynamic correlations*

To identify the interdependence and spillovers among markets, the dynamic correlations are used (Baur and Lucey, 2009; Skintzi and Refenes, 2006). The results of dynamic correlations estimated using DCC model are presented below. The results confirm that the correlation among various markets is positive and statistically significant. It appears that there exists relatively high positive correlation between stock and currency markets.

Similarly, 'stock and money market', and 'stock and bond market' are also positively associated but the degree of association is relatively low.

## *4.2 Spillover tables*

The spillover effects across four markets estimated using VAR (2) model with a forecast horizon of ten weeks and results are reported in Tables 3 and 4 separately for returns and return-volatility series respectively[1] (VAR model estimates are presented in Annex). By using Akaike information criteria we have selected the optimal lag length for VAR model.

Every $i, j$ observation in the spillover table represents an estimate of impact to market $i^{th}$ FEV produced by shocks to $j^{th}$ market. The elements in the diagonal in the spillover table indicates fraction of FEV of market $i$ as a result of their own jolts. Adding all the off diagonal elements in the row gives effects of spillover taken by $i^{th}$ market from the remaining markets (column total). Similarly, adding all the off diagonal elements in the column provides spillovers from $i^{th}$ market to rest of the markets (row total). The spillovers (net) is arrived at by taking the difference between row and column totals. The aggregate level index (in % terms) is the ratio between sum of all off-diagonal elements and total of all observations in Table 3.

**Table 3** Return spillovers

| *To* | *From* | | | | *Contributions from others* |
|---|---|---|---|---|---|
| | *Stock market* | *Bond market* | *Currency market* | *Money market* | |
| Stock market | 99.45 | 0.42 | 0.06 | 0.07 | 0.55 |
| Bond market | 0.93 | 98.65 | 0.27 | 0.14 | 1.34 |
| Currency market | 8.02 | 0.72 | 90.49 | 0.77 | 9.51 |
| Money market | 1.01 | 4.48 | 0.03 | 94.48 | 5.52 |
| Directional spillover to other markets | 9.96 | 5.62 | 0.36 | 0.98 | Total Spillover index = 4.23% |
| Net spillovers | 9.41 | 4.28 | –9.48 | –4.54 | |

Gross spillover measures also provide useful information, for instance, 9.51% of FEV transmits from rest of the markets to currency market, on the other hand, 5.52% of the money market FEV could be credited to the remaining markets (column: 'directional spillovers from other markets', Table 3). Relatively low share (less than 1.5%) of the stocks and bonds FEV spills from other markets. In other words, among all the markets, stock market is largest provider of spillovers to the rest of the markets and bond market is 2nd biggest contributor. Spillovers from currency and money markets are relatively low.

The results suggest that total spillover index related return and volatility in return series remained at 4.23% and 5.48% respectively, indicating very low linkages among four markets in India. Estimates of '*Net spillovers*' indicates that equity and bond markets are net-transmitters of shocks in Indian markets. In respect of return spillovers, shocks

propagated through the equity and bond market are received by the currency and money markets. Our results (low spillovers) diverge from those found by Dey and Sampath (2020). This may be attributed to the different variables used across the two studies for sector representation. The sectoral stock indices may show higher interconnectedness as they are part of the overall stock market as compared to the interconnectedness between stock index, money market, bond market and exchange rate.

As far as return volatility is concerned Table 4, results confirm that 8.43% and 11.61% of FEV for the bond market and currency market respectively can be elucidated by spillovers from remaining markets. In respect of stock and money market, spillover effects from other markets contribute to less than 1.5% of FEV. Stock market contributes the most to other markets' forecast-error variances, but the spillovers exhibited by the currency market is relatively lower to the other markets.

**Table 4** Volatility in return spillovers

| *To* | *From* | | | | *Contributions from others* |
|---|---|---|---|---|---|
| | *Stock market* | *Bond market* | *Currency market* | *Money market* | |
| Stock market | 99.56 | 0.31 | 0.02 | 0.11 | 0.44 |
| Bond market | 6.54 | 91.57 | 1.85 | 0.04 | 8.43 |
| Currency market | 1.36 | 9.29 | 88.39 | 0.96 | 11.61 |
| Money market | 0.80 | 0.47 | 0.18 | 98.55 | 1.45 |
| Directional spillover to other markets | 8.7 | 10.07 | 2.05 | 1.11 | Total spillover index = 5.48% |
| Net spillovers | 8.26 | 1.64 | –9.56 | –0.34 | |

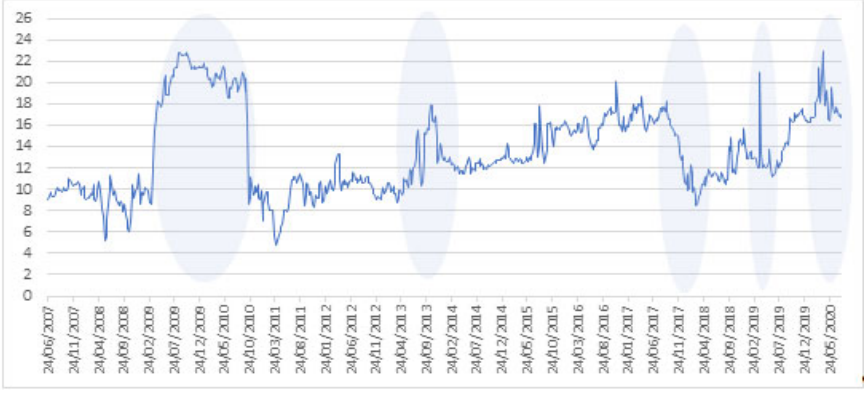
## *4.3 Rolling sample spillovers*

The above table provides overall spillover effects in respect of entire sample. Ideally, these spillover measures may not reflect true picture of future distresses, hence, Diebold and Yilmaz (2009, 2012), proposed rolling window sample approach for building time-varying spillovers. Accordingly, VAR (2) model in respect of return and return-volatilities is constructed and estimated by considering 104 observations pertaining to two years rolling window. The trend/pattern in time-varying return spillover index is exhibited in Figure 3. The trend in spillover index shows that it fluctuated between 6% to 24% during the chosen sample period.

Several cycles of spillovers were noticed from Figure 1 firstly starting in mid 2009 and continuing till mid 2010, the spillover index during this period is around 20% with a peak value close to 23%. The index value increased sharply on account of outbreak of global financial crisis. The index exceeded 22% in the initial months of 2009 indicating the evolving financial turmoil. The spillover index subsequently declined to less than 5% in early 2011. The period from 2011 till 2013 (June–August) is characterised as a relatively 'low' spillover cycle with fluctuations between 10% and 15% indicating significant growth in the financial/economic environment during that period.

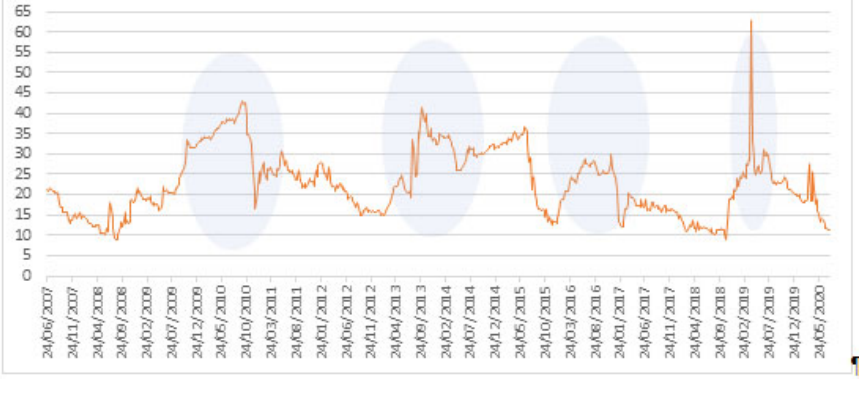
Further, it was observed that the spillover index increased sharply since 3rd quarter of 2013 till 1st quarter of 2014. Increase in this period can be attributed to the taper tantrum i.e., an increase in US Treasury yields which resulted in rupee depreciation by over 15% between May 22 and August 30, 2013 forcing the RBI to suddenly raise interest rates to stem the outflows. After this period, the spillover continued to rise moderately till the second quarter of 2017, may be influenced by market volatility because of demonetization and uncertainties related to GST roll-outs.

**Figure 1** Total return spillover index (see online version for colours)




We, then, notice considerable decline in spillover-effects during June 2017 to April 2018. Completion of GST roll-out, reduction in repo rates as well as India's upgraded sovereign bond rating by Moody's to Baa2 from Baa3 with a stable outlook in November 2017 as well as an overall good year for emerging markets and a better economic forecast lead to a period of low volatility and spillover.

**Figure 2** Total volatility spillover index (see online version for colours)




The spillover index increased sharply in mid-2019 possibly on account of speculation related to the Indian general elections. Stock market index (SENSEX) increased considerably by 3.75% (in other words, SESEX increased by 1,422 points) after declaration of exit polls in May 2020. The spillover index continued to witness upward

trend which may be influenced by the announcement of reduction of corporate tax in September. The index witnesses another sharp increase in during the early 2020s due to COVID-19 pandemic, thereafter, the spillover index followed declining trend.

The pattern of return-volatility spillover index also witnessed similar pattern Figure 2.

It is observed that during post financial crisis, spillovers measured using volatility in returns increased significantly, this has disturbed declining trend which began in the last quarter of 2010 and ended in the 1st quarter of 2011.

Volatility index reached its peak during the mid-2019 on account of the elections in India. The impact of elections and demonetization on return and volatility spillovers among financial assets was also found by Dey and Sampath (2020).

## 5 Conclusions

Examining the spillover effects across financial markets is considered as one of the fascinating topics of research in recent past. Accordingly, good number of studies investigated the spillover effects across various markets, and their impact on financial stability, portfolio diversification, hedging strategies, market efficiency, risk management, etc.

In this study, an attempt is made to analyse the return and volatility spillovers across stock, bond, money and currency markets in India over the period July 2005 to August 2020. For estimating the spillovers, we have used the most widely adopted framework of Diebold and Yilmaz (2012). Our results suggest significantly low level of spillover-effects among various markets. The results corroborate that equity and bond markets are net emitters of spillovers to other markets, while money and currency markets are the net receivers of spillovers from other markets.

Since the spillover measures based on entire sample may not reflect the true picture, an attempt also made in this study to compute time-varying rolling window spillovers. The rolling window spillover index almost tracked the periods of economic significance. It exhibited significant spikes during the periods of global financial crisis, taper tantrums, COVID pandemic and relatively low fluctuations during the periods of high growth in economy and GST reforms. Further, to identify the interdependence and spillovers among the markets, the dynamic correlations are also computed using DCC model. The results of the model also witness that there exists positive and significant correlation among various markets, in particular a relatively high positive and significant correlation between stock and currency markets, and a relatively low degree of association in respect of 'stock and money market' and 'stock and bond market'.

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## Notes

1 Forecasting horizon of 10 weeks is generally selected in similar studies (Diebold and Yilmaz, 2012).

## Annex

*VAR estimates – return*

| *Variable* | *Dependent variable = return from stock market* | | *Dependent variable = return from bond market* | |
|---|---|---|---|---|
| | *Coef.* | *t-value* | *Coef.* | *t-value* |
| *Stock-return*$_{t-1}$ | 0.063 | 1,695 | –0.005 | –3,432 |
| *Stock-return*$_{t-2}$ | 0.128 | 3,283*** | 0.001 | 0.848 |
| *Bond-return*$_{t-1}$ | –1,501 | –1,746 | 0.99 | 27,658 |
| *Bond-return*$_{t-2}$ | 1,436 | 1,660 | –0.00004 | –0.001 |
| *Currency-return*$_{t-1}$ | –0.033 | –0.299 | 0.002 | 0.431 |
| *Currency-return*$_{t-2}$ | –0.057 | –0.538 | –0.009 | –2,083 |
| *Money-return*$_{t-1}$ | –0.019 | –0.387 | –0.0006 | –0.262 |
| *Money-return*$_{t-2}$ | –0.020 | 0.107 | –0.001 | –0.506 |
| Residual standard error | 2.97 | | 0.123 | |
| Multiple r-squared | 0.033 | | 0.971 | |
| F-statistic | 3,374 | | 3,287 | |
| p-value | 0.0008 | | 0.0000 | |

*VAR estimates – return (continued)*

| *Variable* | *Dependent variable = return from currency market* | | *Dependent variable = return from money market* | |
|---|---|---|---|---|
| | *Coef.* | *t-value* | *Coef.* | *t-value* |
| *Stock-return*$_{t-1}$ | –0.100 | –7,815 | -0.0006 | –0.025 |
| *Stock-return*$_{t-2}$ | 0.002 | 0.202 | –0.053 | –2,012 |
| *Bond-return*$_{t-1}$ | 0.701 | 2,400 | 0.225 | 0.386 |
| *Bond-return*$_{t-2}$ | –0.649 | –2,207 | 0.507 | 0.867 |
| *Currency-return*$_{t-1}$ | –0.072 | –1,909 | 0.032 | 0.424 |
| *Currency-return*$_{t-2}$ | 0.063 | –2,207 | –0.007 | –0.100 |
| *Money-return*$_{t-1}$ | –0.038 | –2,187 | 0.283 | 8,172 |
| *Money-return*$_{t-2}$ | 0.031 | 1,794 | 0.239 | 6,882 |
| Residual standard error | 1.01 | | 2,008 | |
| Multiple R-squared | 0.090 | | 0.356 | |
| F-statistic | 9,699 | | 53.86 | |
| p-value | 0.0000 | | 0.0000 | |

*VAR estimates – return volatility*

| *Variable* | *Stock market return equation* | | *Bond market return equation* | |
|---|---|---|---|---|
| | *Coefficient* | *t-value* | *Coefficient* | *t-value* |
| *Stock-return*$_{t-1}$ | 1,052 | 29,191 | 0.006 | 2,511 |
| *Stock-return*$_{t-2}$ | –0.085 | –2,347 | –0.003 | –1,514 |
| *Bond-return*$_{t-1}$ | 0.452 | 0.992 | 1,528 | 52,910 |
| *Bond-return*$_{t-2}$ | –0.400 | –0.875 | –0.593 | –20,457 |
| *Currency-return*$_{t-1}$ | –0.045 | –0.503 | 0.009 | 1,715 |
| *Currency-return*$_{t-2}$ | 0.041 | 0.460 | –0.006 | –1,081 |
| *Money-return*$_{t-1}$ | 0.004 | 0.178 | –0.000002 | –0.002 |
| *Money-return*$_{t-2}$ | 0.0005 | 0.029 | –0.0003 | –0.245 |
| Residual standard error | 0.332 | | 0.021 | |
| Multiple R-Squared | 0.945 | | 0.965 | |
| F-statistic | 1,677 | | 2,695 | |
| p-value | 0.0000 | | 0.0000 | |

*VAR estimates – return volatility (continued)*

| *Variable* | *Currency market return equation* | | *Money market return equation* | |
|---|---|---|---|---|
| | *Coefficient* | *t-value* | *Coefficient* | *t-value* |
| *Stock-return*$_{t-1}$ | 0.035 | 2,527 | 0.150 | 2,307 |
| *Stock-return*$_{t-2}$ | –0.036 | –2,544 | –0.147 | –2,250 |
| *Bond-return*$_{t-1}$ | 0.057 | 0.322 | –0.011 | –0.014 |
| *Bond-return*$_{t-2}$ | 0.175 | 0.979 | 0.208 | 0.251 |
| *Currency-return*$_{t-1}$ | 0.999 | 27,977 | 0.301 | 1,821 |
| *Currency-return*$_{t-2}$ | –0.066 | –1,874 | –0.353 | –2,165 |
| *Money-return*$_{t-1}$ | 0.011 | 1,509 | 0.962 | 26,974 |
| *Money-return*$_{t-2}$ | –0.008 | –1,059 | –0.026 | –0.732 |
| Residual standard error | 0.129 | | 0.601 | |
| Multiple R-squared | 0.932 | | 0.883 | |
| F-statistic | 1,341 | | 734.3 | |
| p-value | 0.0000 | | 0.0000 | |