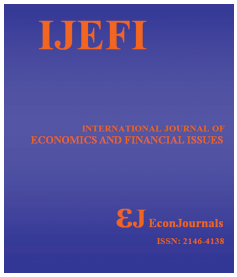

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# Global Macroeconomic Announcements and Foreign Exchange Implied Volatility

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**ABSTRACT**

This paper examines the impact of the US and Chinese macro economic announcements on foreign exchange implied volatilities of SPX, VXFXI, BPVIX, JYVIX, and EUVIX from 2011 to 2016. The study indicates that implied volatility becomes significant and leads to the resolution of uncertainty on the day of the announcement but some part of information make significant revisions in the expectations of future volatility. However, no significant evidence found that uncertainty increases following an actual announcement. The EUVIX found more sensitive to US macroeconomic announcements and JYVIX to Chinese macro economic announcements. Most announcements related to Chinese manufacturing, industrial output and investments are found to have a significant effect on global implied volatilities. This study will help global and local investors to consider relevant announcements impact during portfolio evaluation and also monetary thinkers to devise a mechanism to reduce volatility around announcements.

**Keywords:** Implied Volatility, Macroeconomic Announcements, Foreign Exchange
**JEL Classification:** F31

## 1. INTRODUCTION

This study focuses on foreign exchange implied volatility integration with respect to scheduled macroeconomic announcements. This study especially investigates how foreign exchange implied volatility indices of Chicago Board of Options Exchange (CBOE) integrated with US, China, UK, Euro and Japan's scheduled macroeconomic announcements. The macroeconomic announcements contain important information that influences asset and financial markets (Jones et al., 1998; Bauwens et al., 2005). The release of macroeconomic announcement affect the investor preferences and their portfolio selection. Most studies have established the link between macroeconomic announcements and equity markets, few have captured the impact on option implied volatilities of foreign exchange since investors incorporate these into their trading models and hedging risk.

This study contributes to the literature considering mainly the effect of both US and Chinese macro economic announcements on implied volatilities of SPX, VXFXI, BPVIX, JYVIX, and EUVIX respectively. However, the earlier study of Marshall et al. (2012) only examines the impact of US economic releases on implied volatility for four major foreign exchange rates. The paper of Baum et al. (2015) explores the effect of macroeconomic announcements of China on global financial and commodity futures markets. Besides the US, China has proved itself an increasingly important part of the world economy over the past two decades. It's tremendous economic growth has got more than the double share of the world gross domestic product (GDP), along with an appropriate increase in its world trade since 2000. The financial markets of China have also shown a substantial increase since the turn of this century (Garner et al., 2016). However, the economic and financial developments in China have become influential in the world financial markets. For example, the recent developments in Chinese exchange rate have resulted in substantial global volatility in asset and financial markets (Mathews, 2016). He argues that Australian financial markets react more strongly to Chinese economic releases. To our knowledge, literature has not analyzed the impact of Chinese macro economic announcements on foreign exchange implied volatility. Moreover, this paper also considers

the impact of macrocosmic announcements of UK, Japan, and Euro Area news on of BPVIX, JYVIX, and EUVIX respectively.

The earlier studies of Jones et al. (1998), Bauwens et al. (2005) state that private information affects trading in anticipation of the macroeconomic announcements. However, the present study also analyzes the behavior of VIX not only on the day of the announcement but also before the release of the actual announcement (5 days before). In this regard, empirical studies of Ederington and Lee (1993; 1996), Thorbecke (1997), Bomfim (2003), Kearney and Lombra (2004), Nikkinen and Sahlström (2004a), Chen and Clements (2007), Vähämaa (2009), Füss et al. (2011), Marshall et al. (2012) and Shaikh and Padhi (2013) examine that stock return volatility and implied volatility increases before the release of actual announcement and gets resolved on the day of announcement. While, the study Marshall et al. (2012) found that macro economic announcement tends to drop implied volatility on the day of the announcement, unlikely no significant effect observed on pre and post announcements. On the other hand Jones et al. (1998) examine the pre-announcement effect on the treasury markets and evidence higher volatility on the day of the announcement as "storm effect" and lower volatility before the announcement as "calm before the storm."

Overall, the present study indicates that implied volatility becomes significant for most of the macroeconomic variables on the day of the announcement. Results vary for each macroeconomic announcement. Most announcements of macroeconomic variables lead to the resolution of uncertainty but some part of information make significant revisions in the expectations of future volatility. However, no significant evidence found that uncertainty increases following an actual announcement. The EUVIX found more sensitive to US macroeconomic announcements (Marshall et al., 2012) and JYVIX to Chinese macroeconomic announcements. Most announcements related to Chinese manufacturing, industrial output and investments are found to have a significant effect on global implied volatilities.

The rest of this study is organized in following way; the second section presents data sources, descriptive analysis, and proposed methodology. The third part deals with regression results of the impact of macroeconomic announcements on VIX on the day of the announcement, before the announcement day, US and Chinese news effects. The conclusion is drawn in the final section of this paper.

## 2. DATA AND METHODOLOGY

### 2.1. Data Sources

We investigate the impact of scheduled announcements on implied volatility indices (VIX) of SPX, VXFXI, BPVIX, JYVIX, and EUVIX[1]. The scheduled announcements are reported in Table 1.

**Table 1: List of scheduled macroeconomic announcements**

| Variables | Number of observations | Frequency |
|---|---|---|
| USA | | |
| Conference Board of Consumer Confidence | 70 | M |
| Construction spending (MOM) | 71 | M |
| CPI (YOY) | 71 | M |
| Current account balance | 23 | Q |
| Monthly budget statement | 71 | M |
| Capacity utilization | 71 | M |
| Factory orders | 71 | M |
| GDP annualized (QOQ) | 70 | M |
| Housing starts | 71 | M |
| Personal income | 70 | M |
| Industrial production (MOM) | 71 | M |
| Business inventories | 71 | M |
| Leading index | 71 | M |
| ISM manufacturing index | 71 | M |
| ISM non-manufacturing index | 71 | M |
| Total net TIC flows | 71 | M |
| Trade balance | 71 | M |
| Personal consumption | 70 | M |
| Consumer credit | 71 | M |
| Import price index (YOY) | 71 | M |
| China | | |
| CPI (YOY) | 68 | M |
| Exports (YOY) | 68 | M |
| FDI | 67 | M |
| GDP (YOY) | 23 | Q |
| Imports (YOY) | 68 | M |
| Money supply M0 (YOY) | 69 | M |
| Money supply M1 (YOY) | 69 | M |
| PPI (YOY) | 68 | M |
| Foreign reserves | 33 | M & Q |
| Retail sales (YOY) | 58 | M |
| Trade balance | 68 | M |
| Industrial production (YOY) | 58 | M |
| United Kingdom | | |
| Bank of England bank rate | 70 | M |
| Official reserve change | 71 | M |
| Unemployment rate | 70 | M |
| Japan | | |
| Construction orders (YOY) | 70 | M |
| Exports (YOY) | 70 | M |
| Industrial production | 140 | M/2 |
| Monetary base (YOY) | 71 | M |
| Euro Area | | |
| Exports (MOM) | 71 | M |
| Retail sales (YOY) | 71 | M |
| Consumer confidence | 67 | M |
| Non-farm payrolls (QOQ) | 47 | M |
| PPI (YOY) | 68 | M |

GDP: Gross domestic product, FDI: Foreign direct investment

Our sample period starts from January 03, 2011 and ends on September 11, 2016 except VXFXI that starts from March 16, 2011. The frequency of time-stamped macro economic announcements are available on bi-monthly, monthly and quarterly basis but varies from one country to another. The results of current account balance (USA), GDP (YOY) and initial values of foreign reserves (China) are announced on a quarterly basis;

1 The implied volatility index (VIX) is the trade mark of CBOE and its calculations are based on the options written on S and P 500 index (SPX). Implied volatility is defined as the market's expectation for the remaining life of the options (about 30 days), also known as "investor's-fear-gauge-index." However, VIX is calculated for various equity exchanges, exchange traded funds (ETF), currencies, commodities, etc. This study considers implied volatility of three currencies FX Euro volatility index (EUVIX), FX Yen volatility index (JYVIX) and FX British pound volatility index (BPVIX). While S and P 500 index (SPX) and China ETF volatility index (VXFXI) represent proxy of USD and CNY in this study as these are not published by CBOE.

hence we have four announcements every year. The industrial production is announced twice a month in Japan. All other macro economic announcements are announced on monthly basis. The announcements considered in the study are available after the normal market is open. Further, the announcement date and time is not fixed and varies at each announcement. However, the announcements published on weekend postponed to succeeding Monday. Our announcements comprise actual and expected data for each of these releases. The expectations are used to construct the "news" or "surprise" component of each announcement. The news variable is constructed by scaling each series of surprises by that series standard deviation (SD) (Andersen et al., 2007; Love and Payne, 2003; Rime et al., 2007)[2]. So, the standardized news for each series is given by;

$$S_{i,t} = A_{i,t} - E[A_{i,t}] / \hat{\sigma} \quad (1)$$

Where, $Ai$ , is the actual value of data i at time $t$, $[A_{i,t}]$ is the expected value of data $i$, and $\hat{\sigma}$ is the sample SD of $A_{i,t} - E[A_{i,t}]$. The "Bloomberg" publishes actual and expected scheduled announcements regularly from the respective sources. We also consider daily closing prices of VIX, VXFXI, BPVIX, JYVIX and EUVIX available openly from CBOE.

2 This approach has turned to be standard in the empirical literature (Andersen et al., 2007; Love and Payne, 2003).

**Table 2: Descriptive statistics at level**

| Statistics | BPVIX | FXVXI | EUVIX | JYVIX | VIX |
|---|---|---|---|---|---|
| Mean | 8.827212 | 27.57643 | 10.13197 | 10.58738 | 17.23631 |
| Median | 8.3 | 25.885 | 9.695 | 10.43 | 15.54 |
| Maximum | 29.1 | 63.42 | 20.25 | 18.37 | 48 |
| Minimum | 4.33 | 16.93 | 4.43 | 5.03 | 10.32 |
| SD | 2.909008 | 7.042439 | 2.848426 | 2.491597 | 5.681402 |
| Skewness | 2.431182 | 1.633461 | 0.589558 | 0.267402 | 2.115115 |
| Kurtosis | 13.94854 | 6.161773 | 3.095022 | 2.78188 | 8.049447 |
| Jarque–Bera | 8515.111 | 1226.395 | 83.02776 | 19.79311 | 2574.577 |
| P | 0.00 | 0 | 0 | 0 | 0 |
| Observations | 1424 | 1424 | 1424 | 1424 | 1424 |

SD: Standard deviation

## 2.2. Descriptive Statistics

Tables 2 and 3 reports the descriptive statistics of VIX, VXFXI, BPVIX, JYVIX, and EUVIX at the level and log returns consecutively. Starting with the mean, we find the highest average VIX 27.58% for VXFXI and the lowest average 8.83% for the BPVIX (also presented in Figure 1). The market participants consider that the mean more than 30% signifies market in the red zone. Since the average value of VIX for all the samples is less than the market range that indicates markets were somewhat remained normal. The average log-return of all the indices looks mean-reverting with zero return like any other indices. The maximum market volatility 63.42% and 48% found for VXFXI and VIX respectively. The minimum market volatility 4.3% found for the BPVIX. The high market volatility indicates that market is expected to be more volatile and the low volatility figures imply muted volatility. Now analyzing the SD of log-return series, the highest SD 7.63% and the lowest 4.47% found for VIX and BPVIX respectively. This phenomenon implies that implies volatility is the expectations of the future volatility under the efficient market hypothesis. The efficient markets impound the important market-related good and bad announcements. The measures kurtosis and skewness the indices depart from the normality condition like any other benchmark indices. Figures 1 and 2 indicates that the indices are free from the unit root at the level and log-return series.

Table 4 reports that the returns of VIX and VXFXI are highly correlated at 65.68% and EUVIX is correlated at 57.15% with BPVIX.

## 2.3. Methodology

The impact of individual macroeconomic announcements on implied volatility is evaluated by using event style regression approach. This describes that how $k^{th}$ announcement affects each VIX series. The model motivations are obtained from the studies

**Table 3: Descriptive statistics of log-return series**

| Statistics | DLBPVIX | DLVXFXI | DLEUVIX | DLJYVIX | DLVIX |
|---|---|---|---|---|---|
| Mean | 2.25E-05 | −0.00024 | −0.000193 | −0.00021 | −6E−04 |
| Median | −0.001071 | −0.00458 | −0.00117 | 0 | −0.005 |
| Maximum | 0.286713 | 0.365767 | 0.444953 | 0.301068 | 0.4055 |
| Minimum | −0.438694 | −0.18514 | −0.402683 | −0.2801 | −0.314 |
| SD | 0.044698 | 0.050821 | 0.045897 | 0.049348 | 0.0763 |
| Skewness | −0.44382 | 1.124606 | 0.391485 | 0.283765 | 0.7295 |
| Kurtosis | 14.77086 | 7.913724 | 15.03457 | 6.902469 | 6.3384 |
| Jarque–Bera | 8250.148 | 1729.099 | 8611.486 | 920.7695 | 785.9 |
| P | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 1421 | 1421 | 1421 | 1421 | 1421 |

SD: Standard deviation

**Table 4: Correlation matrix**

| | DLBPVIX | DLVXFXI | DLEUVIX | DLJYVIX | DLVIX |
|---|---|---|---|---|---|
| DLBPVIX | 1 | 0.241633 | 0.57152089 | 0.3678906 | 0.2415 |
| DLVXFXI | 0.241633 | 1 | 0.35323087 | 0.3678906 | 0.65683 |
| DLEUVIX | 0.5715209 | 0.3532309 | 1 | 0.419452 | 0.364 |
| DLJYVIX | 0.3678906 | 0.3630877 | 0.41945203 | 1 | 0.35894 |
| DLSPX | 0.2415009 | 0.6568313 | 0.36400338 | 0.358938 | 1 |

**Figure 1: Volatility Indices at level**

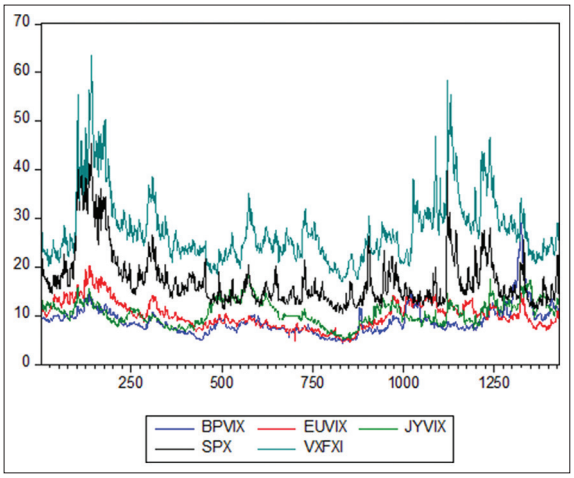
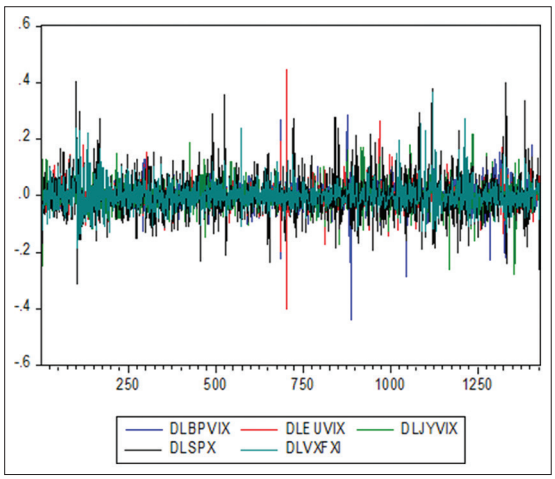



**Figure 2: Log-return series of volatility indices**




of Nikkinen and Sahlström (2004a; 2001; 2004b), Dominguez and Panthaki (2005) and Shaikh and Padhi (2013) that explains the behavior of VIX during set of scheduled announcements;

$$\Delta vix_{it} = \ln\left(\frac{VIX_{it}}{VIX_{it-1}}\right) \quad (2)$$

Model 1:

$$\Delta vix_{it} = \delta_0 + \sum_k \delta_{1,t}^k N_t^k + \sum_m \sum_g \delta_{2t}^m \Delta vix_{t-g}^m + \varepsilon_{it} \quad (3)$$

Model 2:

$$\Delta vix_{it} = \delta_0 + \sum_k \sum_{t=0}^{-5} \delta_{1,t}^k N_{t-5}^k + \sum_m \sum_g \delta_{2t}^m \Delta vix_{t-g}^m + \varepsilon_{it} \quad (4)$$

$$\sigma_t^2 = \omega_o + \omega^{ARCH(1)} \varepsilon_{t-1}^2 + \omega^{GARCH(1)} \sigma_{t-1}^2 \quad (5)$$

$$\varepsilon_{it} \sim N(0, \sigma_t^2)$$

Here, the $\delta_0$ evaluate the behavior of VIX of currency $i$ during non-announcement period and $\delta_{1,t}^k$ explore the effect of $k^{th}$ announcement at time $t$. Further, residuals of the model are assumed to be normally distributed $\varepsilon_{it} \sim N(0, \sigma_t^2)$. The Model (1) and (2) tested for the presence of auto-correlation and heteroscedasticity. To resolve the problem of auto-correlation an AR (1) term is added and the presence of the heteroscedasticity is addressed applying generalized auto-regressive conditional heteroskedasticity (1,1). The hypothesis of the model is constructed on earlier studies (i) Model 1 suggest, the slopes of news announcements should be negative on the day of actual announcement because the uncertainty about the news gets resolved on the day of announcement and VIX becomes normal. An efficient market hypothesis describes that market is efficient and responds to the important announcement results. (ii) In addition Model 2 describes that the slopes of variables should be positive before the release of actual announcement, the possible reason is that the investors are unaware of information the content of macroeconomic news during non-announcement days, hence the future of the market is uncertain. The VIX is considered as investor's-fear-gauge-index, when market is uncertain investors acquire more hedge funds to protect their future portfolio. Buying more index hedge funds increases the implied volatility and VIX index, during the non-announcement periods. Ederington and Lee (1993; 1996) analyzed that VIX increases significantly before the announcement hence the slopes of pre-announcement fundamentals should be positive.

## 3. EMPIRICAL RESULTS AND DISCUSSION

Tables 5 and 6 present the results of announcement day and pre-announcement day effects on the implied volatility of SPX, VXFXI, BPVIX, JYVIX, and EUVIX. The VIX represents the market expectations of an investor in near future. We observe the behavior of expected volatility during the set of macro economics announcements. It is well-documented fact that investors consider macroeconomic announcements in their portfolio selection. The Bloomberg provides a handsome package of information regarding macro economic releases along with their expectations. This study considers numerous fundamental releases along with their announcement day and time. Generally, the market participants are aware of these indicators and advance release calendar dates but they are uncertain about the information content and nature of the news. The literature document that they are more uncertain during pre-announcement days, hence over-react for forthcoming news. Therefore, during pre-announcement days implied volatility increases and reaches at maximum level till the day of actual release. Once, the macro economic announcement released the uncertainty gets resolved and VIX gets normal. We follow the models tested empirically by Ederington and Lee (1993; 1996), Nikkinen and Sahlström (2001; 2004a; 2004b), Chen and Clements (2007) and Shaikh and Padhi (2013).

### 3.1. Announcement Day Impact of Scheduled Macroeconomic Indicators

The first panel of Table 5 displays the slopes of the US indicators construction spending (MOM), CPI (YOY), housing starts, personal income business inventories, ISM manufacturing index, ISM non-manufacturing index, trade balance, personal consumption and consumer credit are negative but only CPI and ISM manufacturing index are found statistically significant,

**Table 5: Announcement day impact**

| Variables | Coefficient | P value | $R^2$ |
|---|---|---|---|
| USA | | | |
| Conference Board of Consumer Confidence | 0.0555** | 0.0495 | 0.0563 |
| Construction spending (MOM) | −0.0288 | 0.3374 | 0.0915 |
| CPI (YOY) | −0.0099* | 0.0969 | 0.0131 |
| Current account balance | 0.0959 | 0.1379 | 0.3468 |
| Monthly budget statement | 0.0408 | 0.1658 | 0.1247 |
| Capacity utilization | 0.0247 | 0.3809 | 0.1429 |
| Factory orders | 0.01148 | 0.6877 | 0.1081 |
| GDP annualized (QOQ) | 0.0367 | 0.1582 | 0.1247 |
| Housing starts | −0.0351 | 0.1996 | 0.1573 |
| Personal income | −0.0156 | 0.5901 | 0.1141 |
| Industrial production (MOM) | 0.0583** | 0.0393 | 0.2315 |
| Business inventories | −0.0403 | 0.1666 | 0.0836 |
| Leading index | 0.0061 | 0.8318 | 0.0968 |
| ISM manufacturing index | −0.0501* | 0.0846 | 0.1141 |
| ISM non-manufacturing index | −0.0156 | 0.5683 | 0.0831 |
| Total net TIC flows | 0.00002 | 0.121 | 0.1742 |
| Trade balance | −0.0021 | 0.9339 | 0.0955 |
| Personal consumption | −0.0101 | 0.6991 | 0.0994 |
| Consumer credit | −0.0079 | 0.7719 | 0.1306 |
| Import price index (YOY) | 0.0571** | 0.0371 | 0.1995 |
| China | | | |
| CPI (YOY) | −0.0008 | 0.9697 | 0.1094 |
| Exports (YOY) | −0.0121 | 0.6115 | 0.1043 |
| FDI | 0.4917** | 0.0434 | 0.1587 |
| GDP (YOY) | −0.0876* | 0.0975 | 0.1312 |
| Imports (YOY) | 0.0139 | 0.5578 | 0.1055 |
| Money supply M0 (YOY) | 0.5735 | 0.1318 | 0.1014 |
| Money supply M1 (YOY) | −0.0421** | 0.049 | 0.1249 |
| PPI (YOY) | −0.0172 | 0.4341 | 0.1641 |
| Foreign reserves | −0.1201*** | 0.0018 | 0.3519 |
| Retail sales (YOY) | −0.0545** | 0.0324 | 0.0819 |
| Trade balance | −0.0171 | 0.4651 | 0.1082 |
| Industrial production (YOY) | −0.0442 | 0.1065 | 0.1711 |
| United Kingdom | | | |
| Bank of England bank rate | −0.0854*** | 0.0001 | 0.1901 |
| Official reserve change | −0.0451** | 0.0366 | 0.1805 |
| Unemployment rate | 0.0009 | 0.9694 | 0.0954 |
| Japan | | | |
| Construction orders (YOY) | −0.2244** | 0.0152 | 0.1097 |
| Exports (YOY) | 0.0298* | 0.0949 | 0.0411 |
| Industrial production | −0.2305 | 0.259 | 0.0425 |
| Monetary base (YOY) | 0.6707*** | 0.00 | 0.6707 |
| Euro area | | | |
| Exports (MOM) | 0.0337** | 0.0371 | 0.0623 |
| Retail sales (YOY) | −0.0139 | 0.4537 | 0.1092 |
| Consumer confidence | −0.0202 | 0.3079 | 0.1281 |
| Non-farm payrolls (QOQ) | 0.0001** | 0.0337 | 0.0984 |
| PPI (YOY) | −0.9507 | 0.7661 | 0.1232 |

The figures containing ***.**and *show P values at 1%, 5% and 10% level of significance respectively. GDP: Gross domestic product, FDI: Foreign direct investment

**Table 6: Pre-announcement day impact**

| Variables | Coefficient | P value | $R^2$ |
|---|---|---|---|
| USA | | | |
| Monthly budget statement | 0.0462* | 0.0829 | 0.1482 |
| Capacity utilization | 0.0084 | 0.7421 | 0.0943 |
| Construction spending | −0.018 | 0.6002 | 0.2012 |
| Personal consumption | 0.0172 | 0.5293 | 0.1015 |
| CPI (YOY) | 0.0587** | 0.0428 | 0.1818 |
| Consumer credit | −0.0595** | 0.0348 | 0.1339 |
| Factory orders | 0.0175 | 0.5311 | 0.1085 |
| GDP annualized (QOQ) | 0.0686** | 0.0101 | 0.1841 |
| Housing starts | −0.0037 | 0.8864 | 0.1264 |
| Import Price Index (YOY) | 0.0361 | 0.1905 | 0.1401 |
| Industrial production | 0.02041 | 0.4417 | 0.1009 |
| Business inventories | −0.0486 | 0.1052 | 0.1963 |
| Leading index | 0.0236 | 0.3994 | 0.0809 |
| ISM manufacturing index | 0.0014 | 0.9617 | 0.1975 |
| ISM non-manufacturing index | −0.0156 | 0.5971 | 0.1616 |
| Total net TIC flows | 0.00012 | 0.4807 | 0.0923 |
| Trade balance | 0.0001 | 0.9961 | 0.1476 |
| China | | | |
| Money supply M0 | 0.4696 | 0.2762 | 0.0953 |
| FDI | 0.7761*** | 0.0028 | 0.1987 |
| Industrial production | −0.0071 | 0.7904 | 0.2401 |
| Money supply M1 (YOY) | −0.0389* | 0.0976 | 0.1279 |
| Foreign reserves | −0.1018** | 0.0213 | 0.2115 |
| Retail sales (YOY) | −0.0201 | 0.4617 | 0.2469 |
| United Kingdom | | | |
| Unemployment rate | 0.0384 | 0.1654 | 0.1192 |
| Official reserves change | −0.0567*** | 0.0095 | 0.096 |
| Bank of England bank rate | −0.0581** | 0.0169 | 0.0821 |
| Japan | | | |
| Industrial production | −0.4679* | 0.0775 | 0.1326 |
| Euro area | | | |
| Exports (MOM) | 0.029 | 0.1341 | 0.1215 |
| Non-farm payrolls (QOQ) | 0.003 | 0.4746 | 0.1124 |

The figures containing ***.** and *show P values at 1%, 5% and 10% level of significance respectively. This study analyzes the impact of each macro economic announcement individually as time and date of each announcement varies over time. However, the panel of macroeconomic variables changes in Table 6 (Rime et al., 2007). GDP: Gross domestic product, FDI: Foreign direct investment

hence pointing to a resolution of uncertainty on announcement day as per our null hypothesis. The negative slope of ISM manufacturing index indicates that a decrease in manufacturing activity increases uncertainty in the US economy. The negative sign of CPI implies that the rates were falling during the sample period and investors overreact to CPI announcements (Shaikh and Padhi, 2013). Hence, manufacturing index can be considered as an indicator that is capable of forecasting future uncertainty in the US economy. Results may suggest that the sign of macro economic announcement play important role in forecasting future implied volatility. On the other hand, the slopes of Conference Board of Consumer Confidence, current account balance, monthly budget statement, capacity utilization, factory orders, GDP annualized (QOQ), industrial production (MOM), leading index, total net TIC flows and import price index (YOY) are found positive but only Conference Board of Consumer Confidence, industrial production (MOM), and import price index (YOY) indicate significant results. The positive slope of Import price index (YOY) implies that the increase in imports leads to an increase in uncertainty in the market. However, the positive industrial production may indicate the reduction of production during the sample period and investors over-reacted to each announcement. However, the results of industrial production is consistent but insignificant in previous studies (Marshall et al., 2012). Our outcome of no significant effect for trade balance, leading index, current account balance and housing starts supports some earlier studies (Ederington and Lee, 1996; Marshall et al., 2012).

Second panel of Table 5 shows the slopes of CPI (YOY), exports (YOY), GDP (YOY), money supply M1 (YOY), PPI (YOY), foreign reserves, retail sales (YOY), trade balance and industrial production (YOY) are found negative but only GDP (YOY),

money supply M1 (YOY), foreign reserves and retail sales (YOY) are statistically significant. These results are compatible with the earlier studies of Nikkinen and Sahlström (2004a; 2004b), Chen and Clements (2007), Marshall et al. (2012) and Shaikh and Padhi (2013) and pointing to a resolution of volatility on the day of the announcement. Conversely, the slopes of foreign direct investment (FDI), imports (YOY) and money supply M0 (YOY) are positive but only FDI is statistically significant. FDI is a highly weighted announcement in portfolio selection. Further, the FDI remained volatile and mostly showed decreasing trend during the sample period hence positively associated with VIX. The high volatility can also be linked with the large trend in foreign reserves. Conclusively, we find FDI and foreign reserves are considered important determinants of uncertainty in the Chinese markets.

The announcements of Bank of England bank rate and official reserve significantly affect BPVIX and carry negative slopes, hence indicate the resolution of volatility on the day of the announcement. The results of official reserve change are applicable to forecast future uncertainty in the UK economy and state that a rise in reserves will turn VIX to decrease. The negative sign of bank rate suggests a drop-down of BPVIX. The investors over-reacted toward the market expectations for the fall of bank rate in July 2016. This announcement might have boosted the consumer confidence for cheap credits in the UK. We may analyze that the good announcements reduce volatility on the day of the announcement. However, these results are in compliance with our null hypothesis and previous literature. On the other side, the outcome of Unemployment Rate is positive but insignificant.

Fourth panel of Table 5 presents, construction orders (YOY) and industrial production carry negative slopes but only construction orders (YOY) show significant results. It's negative slope is favorably applicable to the economy of Japan and highly weighted indicator in portfolio valuation, hence pointing to the resolution of uncertainty in the market. On the other side, exports (YOY) and monetary base (YOY) both are statistically positive. The monetary base is highly significant and highly weighted component. The positive sign implies that the growth in the monetary base will turn the VIX to rise. The exports showed high volatility during the sample period. This might be linked to the change in export structure in international market e.g., emergence of Chinese exports.

The last panel of Table 5 reports that exports (MOM) and non-farm payrolls (QOQ) indicate significantly positive slopes. The co-movement of VIX and exports can also be linked with volatile series of exports. On the opposite side, the results of retail sales (YOY), consumer confidence and PPI (YOY) show negative but insignificant slopes for the Euro VIX. A comprehensive view of all the insignificant macro economic indicators implies that most investors are least concerned about these variables in their portfolio valuation.

### 3.2. Pre-announcement Impact of Scheduled Macroeconomic Indicators

Table 6 reports the estimation outcome of Model 2 around the scheduled macro economics announcements. The literature documents that VIX rises following the actual announcement. As mentioned earlier, the positive slope indicates that the investors are more concerned about forthcoming announcements hence buy more and more options to secure their portfolio which ultimately cause the VIX to rise. However, the options are traded at a higher premium than original prices. Model 2 estimate the behavior each VIX series before an announcement. Our null hypothesis indicates the significant rise in VIX following a news announcement. The first panel of Table 6 reports the slopes of monthly budget statement, CPI (YOY) and GDP annualized QOQ are significantly positive before the release of announcements that support our null hypothesis and previous literature. This reveals that investors feel more uncertain about the information content of monetary policy of US. The uncertainty exists before the announcements and gets resolved on the day on the actual announcement, hence CPI (YOY) is the only announcement found compatible with our hypothesis in US panel. Moreover, the investors are seemed to consider consumer credit before the actual announcement but no significant revision is found on the day of the announcement.

FDI remained highly weighted and significant indicator in forecasting VIX for the Chinese economy. The positive slope of FDI reveals that investors feel more uncertain about the information content of announcement and also on the day of the announcement as discussed earlier. This means the information confined in the announcement leads to significant revisions in expectations of future volatilities. Our results offer some support that the announcements of scheduled macroeconomic variables revise some part of the information on the day of their release (Marshall et al., 2012). However, money supply M1 (YOY) and foreign reserves generate same outcomes as discussed in Table 5. The slopes are again negative and significant. The official reserves change and Bank of England bank rate also generate same results with significant negative slopes of BPVIX and industrial production for JYVIX. However, macroeconomic indicators of Euro do not capture significant impact before the release of news announcements.

Conclusively, this study finds that results vary for each macroeconomic announcement. Most announcements of macroeconomic variables lead to the resolution of uncertainty on the day of the announcement but some part of information make significant revisions in the future volatility expectations. However, no significant evidence find that uncertainty increases the release of the actual announcement and drops on the day of announcement except CPI in US market (Marshall et al., 2012).

### 3.3. Impact of US Announcements on VXFXI, BPVIX, JYVIX, and EUVIX

Table 7 shows that 11 out of the 22 macro economic announcements have a significant impact on the VIX of at least one series. The level of VXFXI is significantly affected by the macroeconomic announcements of current account balance, import price index, leading index, and ISM manufacturing index. The announcements of housing starts and capacity utilization significantly affect the BPVIX. Only one announcement of industrial production significantly affects the JYVIX. The announcements of construction spending, housing starts, unemployment rate, monthly budget statement and GDP annualized (QOQ) have a significant impact on EUVIX options.

The announcements of current account balance, import price index on VXFXI and construction spending, unemployment rate, monthly budget statement, and GDP Annualized (QOQ) result in a positive effect on EUVIX. A possible justification could be that these releases result in unexpected announcements and resulted in upward revisions in expected future volatility on the day of the announcement by market participants. The positive slopes current account balance, construction spending and GDP annualized QOQ are consistent with the results of Marshall et al. (2012) but GDP found insignificant in their case. The positive slope of unemployment rate found consistent with the earlier study of Shaikh and Padhi (2013) but contradict with Marshall et al. (2012). This contradiction can be associated with their combined outcome of both unemployment and non-farm payrolls.

The significant negative slopes of housing starts, leading index, ISM manufacturing index, capacity utilization and industrial production support our null hypothesis. When the release of macroeconomic announcement indicates the significant negative impact on VIX, that effect tends to normalize the level of VIX on the day of the announcement. These results indicate that implied volatility gets resolved on the day of announcement around the news announcements. This result offers some support from earlier studies that the release of information content enclosed in scheduled macroeconomic announcements reduces the expectations of future volatility (Ederington and Lee, 1996; DeGennaro and Shrieves, 1997; Kim and Kim, 2004). The results of housing starts contradict the earlier study of Marshall et al. (2012), it might be linked with different sample period because their sample period includes mortgage crises of 2007.

### 3.4. Impact of Chinese Announcements on VIX, BPVIX, JYVIX, and EUVIX

Table 8 presents that 7 out of 16 macro economic announcements have a significant effect on the implied volatility of at least one VIX on the day of the announcement. The implied volatility of

**Table 7: Impact of US announcements on VXFXI, BPVIX, JYVIX and EUVIX**

| US announcements | VXFXI | BPVIX | JYVIX | EUVIX |
|---|---|---|---|---|
| Construction spending | −0.0116 | −0.0262 | - | 0.0368* |
| Consumer credit | −0.004 | 0.0013 | - | 0.0031 |
| Current account balance | 0.0867* | 0.0904 | 0.0569 | - |
| Durable goods orders | −0.4191 | - | - | - |
| Factory orders | −0.0165 | −0.0352 | - | −0.0267 |
| Housing starts | −0.0275 | −0.0525** | - | −0.0328* |
| Import price index | 0.0522** | - | - | 0.0271 |
| Personal income | −0.0067 | - | - | −0.0044 |
| Industrial production | 0.0251 | - | −0.0433** | - |
| Leading index | −0.0577*** | −0.0091 | - | - |
| ISM manufacturing index | −0.0424* | 0.0188 | - | −0.0069 |
| ISM non-manufacturing index | 0.0022 | −0.0122 | - | 0.0091 |
| Trade balance | −0.027 | 0.0261 | - | −0.0174 |
| Unemployment rate | 0.0274 | 0.0237 | - | 0.0411* |
| Capacity utilization | - | −0.0551** | - | −0.0156 |
| Business inventories | - | −0.0301 | - | - |
| Retail sales advance | - | 0.0091 | - | - |
| Monthly budget statement | - | - | - | 0.0388** |
| Consumer confidence | - | - | - | −0.0149 |
| Personal consumption | - | - | - | −0.0101 |
| GDP annualized (QOQ) | - | - | - | 0.0388** |

The figures containing ***.** and *show P values at 1%, 5% and 10% level of significance respectively. GDP: Gross domestic product

**Table 8: Impact of Chinese announcements on VIX, BPVIX, JYVIX, and EUVIX**

| Chinese announcements | VIX | BPVIX | JYVIX | EUVIX |
|---|---|---|---|---|
| CPI (YOY) | −0.04306 | 0.0001 | - | - |
| Exports (YOY) | 0.0023 | 0.0311 | - | −0.0099 |
| FDI | 0.6101* | - | - | - |
| Imports (YOY) | 0.0217 | −0.0231 | - | −0.0021 |
| Industrial production | −0.0114 | −0.0607* | 0.067** | - |
| Leading index | 0.0236 | - | - | - |
| New year loans | 0.0175 | 0.0345 | 0.0173 | - |
| Money supply M0 | 0.5455 | - | 0.1057 | - |
| Money supply M1 | −0.0082 | - | 0.0044 | - |
| Money supply M2 | −0.0086 | - | −0.0022 | - |
| Manufacturing PMI | −0.054* | −0.028 | - | −0.0412* |
| Non-manufacturing PMI | −0.0668** | −0.0029 | - | 0.0076 |
| PPI (YOY) | −0.0347 | 0.0341 | −0.0391* | - |
| Foreign reserves | −0.0998** | −0.0956** | 0.0616 | −0.1081*** |
| Retail sales (YOY) | −0.0239 | −0.0601* | 0.1028*** | −0.0407* |
| Trade balance | 0.0023 | 0.0419 | | −0.0055 |

The figures containing ***.** and *show P values at 1%, 5% and 10% level of significance respectively. FDI: Foreign direct investment

SPX is significantly affected by FDI, manufacturing PMI, non-manufacturing PMI and foreign reserves. The announcements of industrial production, foreign reserves and retail sales (YOY) significantly impact the BPVIX. The announcements of industrial production, PPI (YOY), and retail sales (YOY) significantly affect JYVIX. Lastly, the manufacturing PMI, foreign reserves and retail sales (YOY) significantly affect the level of EUVIX.

The Chinese announcements of FDI, industrial production and retail sales (YOY) have significantly positive impact VIX and JYVIX respectively. The sample period evidence the high volatility in FDI can be associated with increased volatility of VXFXI and VIX series because both series are highly correlated. Another possible justification could be that these releases result in unexpected announcements and resulted in upward revisions in expected future volatility on the day of the announcement by market participants (Marshall et al., 2012). However, the US market participants give more wieghtage to FDI during valuation of their portfolios. The increase in FDI turns to rise implied volatility of SPX in the US markets. Similarly, the increase in industrial production and retail sales (YOY) of China would rise implied volatility of JYVIX. This seems that US and Japanese asset and financial markets are strong competitors of Chinese markets.

Moreover, foreign reserves and retail sales (YOY) are found most influential announcements in affecting VIX. The release of industrial production and manufacturing PMI impact two VIX series significantly. The announcement of non-manufacturing PMI significantly affects only VIX. The announcements of industrial production, manufacturing PMI, non-manufacturing PMI, PPI (YOY), foreign reserves and retail sales (YOY) contain negative and significant slopes. Overall, when the macro economic announcement has significant negative effect on VIX, that effect tends to decrease the level of VIX on the day of the announcement and this is consistent with our null hypothesis and previous literature (Ederington and Lee, 1996; DeGennaro and Shrieves, 1997; Kim and Kim, 2004; Marshall et al., 2012). The insignificance of CPI is consistent with an earlier study (Mathews, 2016). Most announcements related to Chinese manufacturing, industrial output and investments are found to have a significant effect and these results are in compliance with the findings earlier studies (Baum et al., 2015).

## 4. CONCLUSIONS

Understanding about the nature of implied volatility (VIX) pattern is important for trading and risk management. The present paper aims to examine the impact of US and Chinese macro economic announcements on foreign exchange implied volatilities of SPX, VXFXI, BPVIX, JYVIX and EUVIX from 2011 to 2016. Also, this study considers the impact of UK, Euro and Japanese macro economic announcements on foreign exchange implied volatilities of BPVIX, EUVIX, and JYVIX. The study indicates that implied volatility becomes significant for most of the macroeconomic variables on the day of the announcement. Results vary for each macroeconomic announcement. Most announcements of macroeconomic variables lead to the resolution of uncertainty but some part of information make significant revisions in the expectations of future volatility. However, no significant evidence found that uncertainty increases following an actual announcement.

The EUVIX found more sensitive to US macroeconomic announcements and JYVIX to Chinese macro economic announcements. Most announcements related to Chinese manufacturing, industrial output and investments are found to have a significant effect on global implied volatilities. This study will help global and local investors to consider relevant announcements impact during portfolio evaluation and also monetary thinkers to devise a mechanism to reduce volatility around announcements. The future research can accommodate the impact of good and bad announcements on the similar data structure.

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