Economics Bulletin

Volume 36, Issue 4

Greek debt negotiations and VIX currency indices: A HYGARCH approach

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Abstract

This study investigates the impact of the Greek debt negotiations, along with the increasing fears of a "Grexit", on British pound (GBP), Euro (EUR) and Japanese Yen (JPY) currencies. Their respective implied volatility currency indices (i.e., BPVIX, EUVIX and JYVIX) were used on daily changes, in order to estimate Hyperbolic GARCH(1,d,1) model with a "negotiations" dummy in the mean equation. The results indicated the immunity of BPVIX, EUVIX and JYVIX to Greece's debt negotiations with its creditors. Thus, the corresponding central banks have solidly established a firewall of protection against a potential "Grexit".

We are grateful to the anonymous referees of this journal for making several helpful comments and suggestions. Any unintended errors or omissions are our own doing.
Citation: Dimitrios Dimitriou, (2016) "Greek debt negotiations and VIX currency indices: A HYGARCH approach", *Economics Bulletin*, Volume 36, Issue 4, pages 2154-2160
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Submitted: July 08, 2016. **Published:** November 26, 2016.

1. Introduction

The fears of a Greek sovereign insolvency and potential "Grexit" (the possibility that Greece could leave the Euro zone) existed from 2012. However, in January 2015, speculation about a Greek exit from the eurozone was revived.[1] After the Greek elections held on 25th of January 2015, a new round of aggressive negotiations with the Institutions (European Central Bank, European Stability Mechanism, European Commission and International Monetary Fund) began and ended with the final agreement on 13 July 2015. The scope of this study is to empirically investigate the impact of the Greek debt negotiations, along with the increasing fears of a "Grexit" on British pound (GBP), Euro (EUR) and Japanese Yen (JPY) currencies. If the debt negotiations had left the implied volatility of the above currencies unchanged, then firewalls would have been substantially established by central banks in order to protect currencies (mostly EUR) from Greek debt issues.

The Chicago Board Options Exchange (CBOE, hereafter) has developed gauges to measure investors' fear of market crash, namely implied volatility indices (VIX, hereafter). Recently, the CBOE introduced the VIX on currencies. Implied volatilities reflect market expectations regarding future price movements and provide better volatility forecasts than the realized volatility, especially during turmoil periods (Blair et al., 2001) and are widely used as proxies for risk aversion. Early volatility literature provide evidence mainly on volatility spillover effects and market integration using volatility indices across different stock markets (e.g., Nikkinen and Sahlstrom, 2004 and Äijö, 2008).

One recent example is the study of Kenourgios (2014), which investigates volatility contagion across US and European stock markets during the Global Financial Crisis (GFC) and the Eurozone Sovereign Debt Crisis (ESDC). He observed a different pattern of infection across the phases, implying that the initial signal of the two crises has been differently recognized by implied volatility markets.

In order to empirically investigate the impact of Greek negotiations and a potential "Grexit", our study applies a Hyperbolic GARCH(1,d,1) - HYGARCH(1,d,1), thereafter - (Davidson, 2004), adding a "negotiations" dummy in the mean equation. To the best of our knowledge, it is the first study that presents evidence on behavior of currencies during the phase of the Greek debt negotiations with its creditors that lead to increased fears of a potential "Grexit". Furthermore, in order to provide a sensitivity analysis of our central results, we take into account more turbulent periods related with different phase of Greek crisis. Thus, we create four more dummy variables and incorporate them to the HYGARCH(1,d,1)model.

The results of both methodologies imply that, during the negotiations, none of the VIX indices showed increasing pattern, indicating that the fear of a potential "Grexit" did not affect the implied volatilities of major currencies (GBP, EUR and JPY). Moreover, during different phases of Greek crisis, such as the first bailout package at 2010 or the debt reduction at 2012 none of the implied volatility currency indices showed increasing pattern. Our findings imply that a potential threat of a "Grexit" did not affect the EUR currency volatility in any way, as well as GBP and JPY. The currency market seems to be protected against contagion by a potential "Grexit". The small size of Greek economy, as well as the prudent policy of European central banks, protected the EUR currency and Eurozone from the effects of Greek crisis.

2. Dataset and descriptive statistics

The data comprises daily closing prices of three major implied volatility indices for currencies, namely by the following tickers: BPVIX (GBP's VIX), EUVIX (EUR's VIX) and JYVIX (JPY's VIX).[2] CBOE offers these volatility indices that measure the market's expectation of 30-day currency-related volatility by applying the VIX methodology to options on currency-related instruments. The sample covers a period from 2 January 2007 to 20 May 2016 in order to secure a sufficient number of observations (2370 obs.) required by a GARCH family model.

The descriptive statistics are displayed in Table 1. All series exhibit statistical significant high values of excess kurtosis and positive skewness, while none are normally distributed, based on the Jarque-

[1] The deputy leader of the CDU/CSU faction in the German Bundestag, Dr. Michael Fuchs, was quoted on 31 December 2014: "The time when we had to rescue Greece is over. There is no more blackmail potential. Greece is not systemically relevant for the euro".

[2] The dataset extracted from CBOE. The CBOE calculated the volatility indices using the prices of CME (Chicago Mercantile Exchange, hereafter) for USD/EUR, ESD/GBP and USD/JPY futures options. The underlying options are the most liquid foreign exchange options traded at the CME, and in 2014, accounted for a combined 80% of over 15 million total currency options traded at CME.

Bera statistic. To accommodate the presence of “non-normality” and asymmetry, we use the skewed student’s t distribution. Lambert and Laurent (2000) applied and extended the skewed-Student density proposed by Fernández and Steel (1998) to the GARCH framework. Also, augmented Dickey-Fuller (ADF) tests for the presence of unit roots can convincingly be rejected for all time series. Finally, in order to detect long-memory process in the time series we implemented the Gaussian semiparametric (GSP) long-memory test of Robinson (1995). The results rejected the null hypothesis of no long-memory for a significance level of 1%. Overall, we conjecture that ARCH effects, “non-normality”, asymmetry and long-range memory characteristics should be taken into account in econometric modelling of currencies’ implied volatilities. Thus, the HYGARCH seems to be an appropriate specification in order to capture the above econometric characteristics.

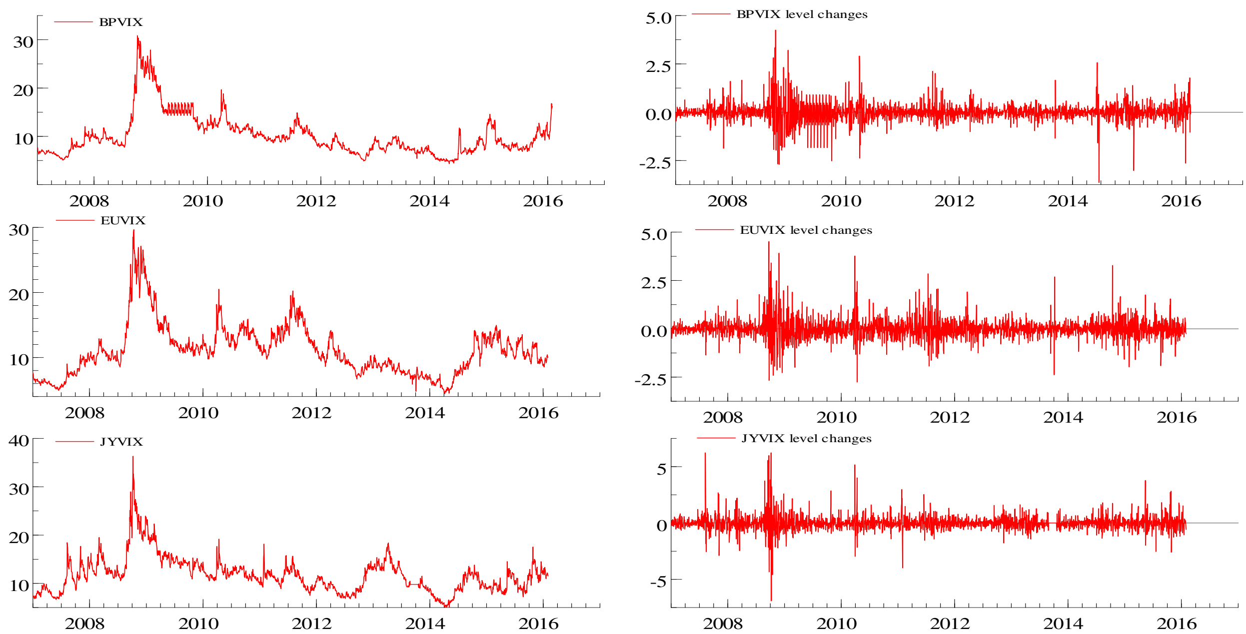
Table 1. Descriptive statistics of implied volatility indices (level changes).

	BPVIX	**EUVIX**	**JYVIX**
Mean	0.0035	0.0010	0.0017
Max.	4.2582	4.5205	6.2312
Min.	-3.6423	-2.7621	-6.9107
St. deviation	0.4899	0.5354	0.6937
Skewness	0.3928***	0.9771***	1.1032***
t-stat.	7.840	19.455	21.946
Ex. kurtosis	11.314***	9.3813***	19.596***
t-stat.	112.52	93.385	195.14
Jarque-Bera	2.369,1***	1.343,3***	3.862,9***
p-value	[0.0000]	[0.0000]	[0.0000]
ARCH (5)	55.358***	56.944***	106.39***
ADF test	-34.172	-37.460	-36.351
GSP test			
d-estimates ($m=T^{0.5}$)	-0.0390***	-0.0956***	-0.1256***
p-value	[0.0071]	[0.0000]	[0.0000]

All figures are expressed on a daily basis. The absence of an ARCH effect is rejected uniformly up to 5 lags. For the ADF test, the choice of lag length is based on Schwarz Information Criterion. The critical values for the ADF test at 1% and 5% significant levels are −3.44 and −2.86, respectively. (m) denotes the bandwidth for the GSP long memory test of Robinson (1995).
*** denote statistical significance at 1% level.

Figure 1 shows that implied volatilities at levels vary considerably over time, while they seem to behave similarly across the currencies. Upward spikes are observed during the Greek debt negotiations, especially for EUVIX. Finally, the volatility indices on level changes trembled around 2008 and 2009, as well as during the Greek debt negotiations, especially for BPVIX and EUVIX. However, their impact needs further empirical investigation, across different phases of Greek crisis.

Figure 1. Volatility indices and their level changes behaviors over time.



3. The HYGARCH(1,d,1) process

The HYGARCH(1,d,1) model is used for each implied volatility currency index of first order level difference (changes between day t-1 and day t). The mean equation, which includes the "negotiations" dummy, is specified as follows:

$$r_t = c_0 + K_{neg.} * Dum_{negotiations} + \varepsilon_t, \ \varepsilon_t \mid \Omega_{t-1} \sim skewed\ t.d.\ (1, \sqrt{h_t}, v, \xi), \tag{1}$$

where r_t is the vector of implied volatility currency indices (on level changes) and ε_t is the vector of innovations conditional on the information set at time *t-1*. The information available at period *t-1* is denoted by Ω_{t-1}. We assume that the random term ε_t is distributed under the skewed student's t distribution with v degrees of freedom (while ξ is the asymmetry parameter). Finally, we determine the "negotiations" dummy based to the timeline of the Greek debt negotiations with its creditors. The negotiations started almost immediately after the Greek elections of 25th of January 2015 and ended when the final agreement was reached at 13th of July 2015. Thus, the dummy of Eq. (1) spans from 25 January to 13 July 2015 (i.e., $Dum_{negotiations}$).[3] As the model implies, the statistical significance of the estimated dummy coefficient ($K_{neg.}$) indicates structural changes in mean of each currency VIX index (on daily changes), due to the Greek debt negotiations. The null hypothesis (**H$_0$**) and alternative hypothesis (**H$_1$**) are given by:

H$_0$: $K_{neg.}$=0 or statistically not significant [The corresponded VIX index was not affected by the Greek debt negotiations (i.e., immunity effect)].

H$_1$: $K_{neg.} \neq 0$ and statistically significant [The corresponded VIX index was affected by the Greek debt negotiations, either by increasing its values when the sign of $K_{neg.}$ is positive (i.e., contagion effect) or by decreasing when the sign of $K_{neg.}$ is negative (i.e., hedging effect)].

[3] It is important to mention that this period includes continuous negotiations and many political/financial events. Among them is the extension by the Eurogroup of the bailout programme for four months (20 February 2015), the Greece's failure to repay IMF at 1 July 2015, as well as, the referendum held in 5th of July 2015.

Table 2. Estimation results of the HYGARCH(1,d,1) model.

Panel A:Estimates of HYGARCH(1,d,1)			
	BPVIX	**EUVIX**	**JYVIX**
c_0 (mean)	-0.0003	0.0049	-0.0012
t-stat.	-0.054	0.686	-0.138
$K_{neg.}$ (mean)	-0.0041	0.0196	-0.0089
t-stat.	-0.106	0.352	-0.227
c_1 (variance)	0.0012	-0.0016	0.0066
t-stat.	0.556	-0.367	0.540
d	0.7409***	0.5116***	0.4905***
t-stat.	3.192	3.197	6.915
Arch-φ(λ)	0.1151***	0.2265***	0.2431**
t-stat.	3.224	4.909	2.081
Garch-β(λ)	0.8758***	0.7679***	0.7213***
t-stat.	4.308	7.249	3.834
log (a)	0.0364***	0.0519**	0.0718***
t-stat.	4.081	2.068	3.831
(v)	3.7973***	4.0574***	3.6918***
t-stat.	11.902	10.80	11.972
Asymmetry (ξ)	0.1076***	0.1260***	0.1622***
t-stat.	3.909	4.437	6.026
Panel B: Diagnostic tests			
Q(10)	25.5274	15.933	18.851
p-value	[0.523]	[0.403]	[0.682]
$Q^2(10)$	1.9527	2.8210	1.2410
p-value	[0.789]	[0.632]	[0.826]

The lag length is determined by the AIC and SIC criteria. *(v)* is student's distribution's degrees of freedom, while ξ is the asymmetry parameter (in logarithmic form). Q and Q^2 are the Ljung-Box Q-statistics up to the 10^{th}, order in the standardized and the squared standardized residuals, respectively.
***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

The general form of HYGARCH(p,d,q) specification is given as follows:

$$h_t = \omega[1-\beta(L)]^{-1} + \left\{1-[1-\beta(L)]^{-1}\phi(L)\{1+\log(a)[(1-L)^d]\}\right\}\varepsilon_t^2, \quad (2)$$

where $h_{i,t}$ is the conditional variance for the series, ω is a constant term $\omega \in (0,\infty)$, d is the long memory parameter with $0 \le d \le 1$, while *log(a)* is the hyperbolic term.[4] The *φ(L)* and *β(L)*are polynomials in lag operator, denoted by *L*. Also, *φ(L)* captures the ARCH effect, while *β(L)* measures the persistence of the

[4] The financial differencing operator, $(1-L)^d$ is the most conveniently expressed in terms of the hypergeometric function:

$$(1-L)^d = F(-d,1;1;L) = \sum_{j=0}^{\infty} \frac{\Gamma(j-d)}{\Gamma(-d)\Gamma(j+1)} L^j = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j ,$$

where $F(a,b;c;z) = \sum_{j=0}^{\infty} \frac{(a)_j (b)_j}{(c)_j} \frac{z^j}{j!}$

is the Gaussian hypergeometric series, $(b)_j$ is the shifted factorial defined as $(b)_j = \Pi_{i=0}^{j-1}(b+i)$, with $(b)_0 = 1$ and $\Gamma(\bullet)$ is the gamma function.

volatility. In order to ensure positive and stable conditional variances, the coefficients must satisfy the constraints $\varphi(L) > 0$ and $\varphi(L) + \beta(L) < 1$.

Estimation results of the HYGARCH(1,d,1) model for each volatility index on level changes are presented in Table 2 (Panel A). The volatility for each currency VIX index displays a highly persistent fashion, since the sum of the estimated ARCH and GARCH parameters in each variance equation is close to unity. Since, all *log(a)* terms are statistically significant and different to zero, indicating that HYGARCH model is preferable than other GARCH models that contain long memory parameters (i.e., FIGARCH). In addition, all degrees of freedom (v) and asymmetry (ξ) terms are statistically significant, supporting the selection of skewed student's t distribution for our analysis. Finally, the Ljung-Box Q statistics in the standardized and the squared standardized residuals indicate the absence of linear and non-linear serial correlation (see Table 2, Panel B).

4. Different phases of Greek Crisis - Robustness tests

In order to ensure the robustness of our central results, we provide a sensitivity analysis by taking into account more turbulent periods related with Greek crisis. Thus, we create four more dummy variables which are equal to unity for each phase of Greek crisis and zero otherwise. Using various dummy variables allows identifying which of the phases exhibit a statistical significant effect for the examined volatility indices. We specify the length of each phase of the Greek crisis according to official timelines and previous literature.[5] The dummy variables are specified as follows:

Phase 1 of Greek crisis (Dum_1): The initial turmoil. It starts at 20 October 2009, when Greece's budget deficit is expected to reach 12.5% of GDP. This deficit exceeds a threshold of 3% of GDP which has set in Stability and Growth Pact for all Eurozone member states. Meanwhile, the Greece credit rating was downgraded from the Big Three credit agencies (i.e., Fitch, S&P's and Moody's). It ends at 2 May 2010, when the IMF, the Greek government and other Eurozone leaders agree to the first bailout package for 110 billion euros over 3 years.

Phase 2 of Greek crisis (Dum_2): Sharp financial and macroeconomic deterioration. It starts at 6 May 2010, when the Greek government passed the third austerity package. It ends at 10 November 2011, when a coalition government is consisted. Meanwhile, another 2 austerity packages passed the Greek parliament and the Big Three credit agencies downgraded Greece's bonds to "junk" level.

Phase 3 of Greek crisis (Dum_3): Debt reduction. It starts at 7 November 2011 and ends at 9 March 2012, when the Greece announced that 82.5% of the 177.3 billion euros in sovereign bonds issued under domestic law had accepted the exchange offer and consent solicitation.[6]

Phase 4 of Greek crisis (Dum_4): Stabilization signs of the economy. It starts at 10 March 2012 and ends at 24 January 2015. During this phase, Greece showed signs of stabilization, such as an upgrade by Moody's (30 November 2013) and Fitch (23 May 2014). Also, Greece posts a primary budget surplus of 1.5% of GDP for the 2013 financial year.

Phase 5 of Greek crisis ($Dum_{negotiations}$): Greek debt negotiations. It corresponds to the negotiations started almost immediately after the Greek elections of 25th of January 2015 and ended when the final agreement was reached at 13th of July 2015. This dummy variable remains same as it is in Eq. (1).

By adding the above dummy variables to Eq. (1), we can examine structural changes in mean of each currency VIX index, during different phases of the Greek crisis. More explicitly, the Eq. (1) takes the following form:

$$r_t = c_0 + K_1 * Dum_1 + K_2 * Dum_2 + K_3 * Dum_3 + K_4 * Dum_4 + \\ + K_5 * Dum_{negotiations} + \varepsilon_t, \varepsilon_t \mid \Omega_{t-1} \sim skewed\ t.d.\ (1, \sqrt{h_t}, v, \xi), \quad (3)$$

The null hypothesis ($\mathbf{H_0}$) and alternative hypothesis ($\mathbf{H_1}$) are given by:

$\mathbf{H_0}$: K_n=0 or statistically not significant [The corresponded VIX index was not affected by the events occurred, during the period dummy K_n referred, n = 1 to 5 (i.e., immunity effect)].

$\mathbf{H_1}$: $K_n \neq 0$ and statistically significant [The corresponded VIX index was affected by events occurred, during the period dummy K_n referred, n = 1 to 5. Its values increase when the sign of K_n

[5] The Reuters timeline can be found at: http://www.reuters.com/article/2010/08/25/eurozone-crisis-events-idUSLDE67O0YD20100825. A similar timeline for the ESDC is also used by Arghyrou and Kontonikas (2012), Kalbaska and Gatkowski (2012) and Kenourgios et al. (2016).

[6] These numbers referring to participation, exclude holdings by the ECB and national central banks.

is positive (i.e., contagion effect) and decrease when the sign of K_n is negative (i.e., hedging effect)].

Estimation results of the HYGARCH(1,d,1) model for each volatility index are presented in Table 3 (Panel A). Similar to Table 2, the estimated ARCH and GARCH parameters provided by Table 3, are statistically significant and close to unity. Also, HYGARCH model is preferable, since *log(a)* terms are statistically significant and different to zero. In addition, all degrees of freedom (v) and asymmetry (ξ) terms are statistically significant, supporting the selection of skewed student's t distribution for our analysis. Finally, the Ljung-Box Q statistics in the standardized and the squared standardized residuals indicate the absence of linear and non-linear serial correlation (see Table 3, Panel B).

Table 3. Estimation results of the HYGARCH(1,d,1) during various phases of Greek crisis.

Panel A: Estimates of HYGARCH(1,d,1)			
	BPVIX	**EUVIX**	**JYVIX**
c_0 (mean)	0.0002	0.0039	-0.0041
t-stat.	0.003	0.408	-0.280
K_1 (mean)	0.0022	-0.0242	-0.0297
t-stat.	0.064	-0.656	-0.971
K_2 (mean)	-0.0040	0.0001	-0.0080
t-stat.	-0.247	0.004	-0.316
K_3 (mean)	-0.0198	-0.0621	0.0338
t-stat.	-0.588	-1.397	0.702
K_4 (mean)	0.0017	0.0075	0.0092
t-stat.	0.143	0.546	0.511
K_5 (mean)	-0.0045	0.0200	-0.0064
t-stat.	-0.115	0.355	-0.156
c_1 (variance)	0.0012	-0.0013	0.0073
t-stat.	0.560	-0.300	0.617
d	0.7347***	0.5171***	0.5005***
t-stat.	4.857	3.149	7.013
Arch-$\varphi(\lambda)$	0.1458***	0.2288***	0.2493**
t-stat.	3.056	4.817	2.101
Garch-$\beta(\lambda)$	0.8431***	0.7668***	0.7484***
t-stat.	4.559	6.981	3.453
log (a)	0.0369***	0.0495***	0.0706*
t-stat.	6.552	4.997	1.785
(v)	3.7926***	4.0188***	3.6731***
t-stat.	11.830	10.710	11.962
Asymmetry (ξ)	0.1074***	0.1246***	0.1584***
t-stat.	3.876	4.460	5.853
Panel B: Diagnostic tests			
Q(10)	19.5270	11.7314	13.7524
p-value	[0.521]	[0.297]	[0.595]
$Q^2(10)$	1.0325	1.7522	0.8214
p-value	[0.607]	[0.390]	[0.683]

The lag length is determined by the AIC and SIC criteria. (v) is student's distribution's degrees of freedom, while ξ is the asymmetry parameter (in logarithmic form). Q and Q^2 are the Ljung-Box Q-statistics up to the 10^{th}, order in the standardized and the squared standardized residuals, respectively.

***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

5. Empirical results and concluding remarks

Based on the results reported on Panel A of Table 2, the "negotiation" dummy ($K_{neg.}$) is not statistically significant for all three cases. This result indicates the immunity of BPVIX, EUVIX and JYVIX to Greek debt negotiations. Thus, the corresponding central banks have solidly established a firewall of protection. In other words, the danger of a potential "Grexit" does not seem to generate fears to the GBP, EUR and JPY markets. From another point of view, the results indicate that a potential threat of an intentional "Grexit" from the Greek side would be unwise, since the currency markets have already been protected against this event.

Furthermore, the results presented on Panel A of Table 3, indicate that during different periods of Greek crisis, all dummy variables (K_1, K_2, K_3, K_4 and K_5) are not statistically significant. These results, support the immunity of implied volatility currency indices, during the Greek crisis. This finding could be explained by the small size of Greek economy, as well as the protection of Eurozone banks against any type of Greek "failure". Thus, any potential threat of "Grexit", even at the beginning of the Greek crisis, would not lead to any "contagious" effect to exchange rate market. In other words, the Greece debt solely, has not the momentum to lead to the collapse of Eurozone.

As a result, due to small size of Greek economy and "firewall" measures taken by Eurozone and central banks, the Greek problem seems manageable. However, doubts about whether the Eurozone could manage sufficiently debt problems of larger economies (such as Italian) are still under question.

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