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The US Monetary Base and Major World Equity Markets: An Empirical Investigation

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*A*bstract: This paper investigates the relationship between the US monetary base and the five largest equity indices of the world.   The mainstay of the study is the vector autoregressive approach (VAR).   Analyzing impulse response functions shows strong support for the notion that the US monetary base is associated with movements in the major equity markets.   For instance, positive shocks to the monetary base in the US, are responsible for positive changes in the world equity markets that may last up to six months.   Examining impulse responses of equity indices from a Markov Switching VAR, which takes regime changes into account, confirm these findings. Furthermore, we show that equity responses to the positive shocks to the monetary base may be much higher than those to negative shocks.   We conclude the US monetary base, and quantitative easing may have contributed to a positive business and credit climate in advanced economies of the world.

Keywords: Quantitative Easing, Equity Markets, Markov Switching VAR, Granger Causality

JEL Classifications: E44, E50, E52

1. Introduction

Volatility in asset prices in the US and the world in the decades of 2000 and 2010 has concerned financial institutions and policy makers. The equity and real estate bubbles have had serious implication for the financial sector, especially the banking industry, the world economic health, and economic growth in general.   Historically, the equity market crashes of the 1920s and the 1980s, as well as equity market bubbles of 1990, 2000, and the real estate market crash of late 2000 showed that booms and busts in various asset markets are usually followed by mild or severe recessions, thus posing a serious threat to world economies.

Researchers have studied the relationship and the link between "traditional" monetary policy, or policy announcements, the economy, and financial markets extensively.   Notable among pioneering papers are Friedman and Schwartz (1963), Sims (1972), Christiano and Ljungqvist (1988), Lynge (1981), Cornell (1983) and Pearce and Roley (1983), to name a few.   Similarly, Federal Reserve discount rate changes and its relationship with financial markets has been the topic of papers by Waud (1970), Smirlock and Yawitz (1985), Pearce and Roley (1985), Cook and Hahn (1988), among others.

Others offer a broader view of the monetary actions than studies above. For instance, Mishkin (2001) discusses stock market prices, real estate prices, and exchange rates in addition to bond and other debt instrument markets as conduits for the transmission of the effects of monetary policy on the economy.   He explains that the monetary policy through stock prices, real estate prices, and exchange rates, influences investment and consumption decisions of firms and households.

The Fed's quantitative easing (QE) maybe considered a "nontraditional" form of monetary action. QE may be associated with economic variables through several channels. One of the primary goals of the QE in the US was to depress the returns in financial assets including government bonds, thus, encourage bank lending and to ease the credit markets. Favorable credit markets, in turn, are expected to contribute to increased investments in various sectors which lead to economic growth and equity market

Leading economic indicators such as equity market indices of the US and the world may be employed to gauge the success of the Fed's monetary actions.   Examining the relationship between equity indices and the monetary base may provide information regarding the success of the Fed's monetary actions, especially actions such as QEs that affect the monetary base. The Fed engaged in QE as the near-zero federal funds rate made the traditional monetary policy seem ineffective. Quantitative easing was implemented by purchasing long-term bonds, mortgage-backed bonds, and other financial assets to increase the bank reserves without explicitly addressing interest rate targets in the market.

In the next section, we summarize some research related to the topic.

2. Related Research

Theoretical and empirical research show that real and financial assets may offer channels through which the monetary action influences the macro economy. For instance, the changes in short-term nominal interest rates or the liquidity effects of the monetary actions may alter equity valuations through the discounting of the expected future cash flows.

The aggregate demand shifts due to the wealth effect would depend on the household balance sheet. According to the OECD data on the household balance sheet, US households lead the rest of the most major economies in financial asset ownership by having over fifty present of their wealth in these assets in 2006.   Changes in the household balance sheets undoubtedly alter households'

and firms' ability to secure loans based on net worth, which in turn would influence the aggregate demand and economic activity (Bernanke, Gertler, and Gilchrist, (1998)). In the following, we summarize some research papers on the subject.

Some of the seminal research connecting monetary actions and policies with equities are as follows. Rozeff (1974) found that stock return variations were correlated with monetary policy decisions of the Fed. His findings are later corroborated by Fama (1981) and Kaul (1987). Jensen and Johnson (1995) present further evidence that expansionary monetary policy imparts a bullish effect on equities compared to contractionary policy stance. These findings corroborate those of Fama and French's (1989).

Jensen et al. (1996) show that equity market responses vary across the periods of expansionary and contractionary monetary stances of the Fed. Gilchrist and Leahy (2002) classify these effects in three categories of the wealth effect on consumption, Tobin's Q effect on investment and financial accelerator effect on investment. Poterba (2000) among others shows that households vary consumption expenditures with fluctuations in the value of their financial assets. Business firms also experience changes in market capitalization with equity market fluctuations. For instance, in a bull market, with the rise of market capitalization, firms may be moe inclined to invest with the expectation that these investments would increase their market value relative to their replacement cost of capital (Tobin (1969), (1978)).

Bernanke and Gertler (1989) suggest that with improvements in the balance sheet of entrepreneurs, they will be much more inclined to commit their funds to business investments.

Other researchers (see Kiyotaki and Moore (1997), Bernanke and Kuttner (2003), Bernanke and Blinder (1992), Bernanke and Gertler (1989)) reinforce this line of explanation and add that contractionary monetary action, will reduce the present value of revenue generating assets in the balance sheet, further weakening the earning power of credit- dependent firms, thus adversely affecting their equity prices. Bernanke and Mihov (1998) among others employ VAR modeling to show that monetary expansion results in the liquidity effect, i.e., lowers short-term nominal interest rates however, is neutral in the long-run. Perez-Quiros and Timmermann (2000)) examine various channels through which monetary policy may influence equity prices and the economy at large.

The decade of 2000 through 2010 witnessed yet further research examining the association of the fed funds rate targeting and equity prices. Notable among these papers are Ehrmann and Fratzcher (2004), Gurkaynak et al. (2004), Rigobon and Sack (2004), Detken and Smets (2004), Filardo (2004), Adrian and Shin (2009), Wongswan (2009), among others. However, scant little research on the topic has been offered since the late 2000s. We attribute this to the financial melt – down that started in 2008 and lasted at least until 2011, with the reverberations in the US and the world until late 2014.

Continuing along the lines of previous research, we investigate whether the Fed's monetary actions, particularly changes in the monetary base has any influence on equity markets. The paper is motivated by the late 2000 quantitative easing in the US and its association with equity markets of the world. Given the comovement in equity markets of the world (see Forbes and Rigobon (2002), among others), a related and inseparable issue is whether the Fed's monetary decisions influence returns and volatility in major equity markets of the world. The Fed's massive quantitative easing (QE) between 2008 through 2014 added three trillion dollars to the US monetary base (almost 21.5% of the US nominal GDP at the time). Partially encouraged by the results of the US QE, at that time the ECB also decided to start a quantitative easing. This paper in the only one we know that examines the reaction of the major world equity markets to the Fed's quantitative easing.

3. Methodology

The first step in analyzing the relationship between the monetary base and equity indices is to examine whether the variables under question are stationary. Based on visual examination of time series under consideration, we include trends and drifts in the formal testing for stationarity of each series.

We employ the Dickey-Fuller, the Augmented Dickey-Fuller, Phillips-Peron and Ng-Perron tests of stationarity which are modified Phillips –Perron tests based upon the GLS detrended data (Ng and Perron (2001)). The Johansen-Joselius Cointegration test is necessary as all series are non-stationary. If there is no cointegration, i.e., no long-term equilibrium relationship between the M0 and equity indices, then vector autoregressive models may be the most suitable approach to investigate the interaction between variables once they've been made stationary. In this paper, we compute the percentage changes because they are stationary and reflect the returns for equities. Three empirical models comprise the mainstay of our empirical investigation. Bivariate Vector Autoregressive models of M0 with each equity index is deployed to produce generalized impulse responses (GIR). The Markov regime switching VAR (MRSVAR) introduced by Hamilton (1989) is deployed to investigate the potential effects of regime changes by the Fed. Finally Bivariate EGARCH models enable us to investigate asymmetric responses of equity markets to M0 changes.

A vector autoregressive system of equations may be presented as follows:

$$Y_t = \sum_{i=1}^{L} \Phi_i Y_{t-i} + U_t \qquad (1)$$

where $E(U_t U_t^{'}) = \Lambda$, Y is an N×1 vector of endogenous variables, Φ is an N×N matrix of N^2L coefficients to be estimated, and Λ signifies the covariance matrix of VAR residuals. We employ the Akaike Information Criteria (AIC), Schwarz Bayesian Criteria (SBC) and the log-likelihood ratio test LR to determine the optimal lag order of the VAR. We choose lag orders based on the ones suggested by two or more of these criteria. Once a VAR is estimated, block causality tests and impulse response analysis are the most common estimation results that are reported. The block causality tests are a multivariate version of the Granger causality test (see Granger 1969).

The MSVAR is similar to equation (1) but with the addition of the regime dependent matrix R_g where g = 1,…., m regimes, $Y_t = \sum_{i=1}^{L} \Phi_i Y_{t-i} + R_g U_t$.

The parameters and the hidden Markov-chain can be estimated jointly by applying the Expectations– Maximization Algorithm (Hamilton, 1990).

The regime-switching impulse response function of an endogenous variable at time t+w to one standard deviation shock to the Vth shock at time t, given regime g is given by $\dfrac{\partial E_t Y_{t+w}}{\partial u_{v,t}}\Big|_{g=i} = \Omega_{vi,w}$.

Note that there are a series of vectors $\Omega_{vi,w}$ where w=1…w for each endogenous variable.

The bivariate EGARCH, BVAR-EGARCH model is comprised of equation (2) through (5).

$$R_{it} = \alpha_{i,0} + \sum_{j=1}^{2} \alpha_{ij} R_{i,t-1} + \varepsilon_{i,t} \quad (\text{i=1,2}) \qquad (2)$$

$$Ln(\sigma_{i,t}^2) = \beta_{i,0} + \sum_{j=1}^{2} \beta_{ij} \varphi_j(z_{j,t-1}) + \gamma_i \ln(\sigma_{i,t-1}^2) \quad (\text{i=1,2}) \qquad (3)$$

$$\varphi_j(z_{j,t-1}) = (|z_{j,t-1}| - E(|z_{j,t-1}|) + \delta_j z_{j,t-1}) \quad (j=1,2) \qquad (4)$$

where $z_{j,t} = (|u_{j,t}/\sigma_{j,t}| - \sqrt{2/\pi}) + \delta_j u_{jt}/\sigma_{j,t}$

and

$$\sigma_{i,j,t} = \rho_{i,j}\sigma_{i,t}\sigma_{j,t} \qquad (i,j=1,2) \qquad (5)$$

R_{it} is the monthly percentage changes in the monetary base and the equity market at time t, $\sigma^2_{i,t}$, and $\sigma_{i,j,t}$ are the conditional variance and covariances between monetary base (i) and equity market j, at time t, respectively, ρ_{ij}, the conditional correlation coefficient between the two variables, $z_{i,t} = \varepsilon_{it}/\sigma^2_{i,t}$, is the standardized innovations of market i at time t.

As explained be Adrangi, et al. (2015) the asymmetric responses of equity market to positive and negative shocks may be examined using the coefficient estimates of equations (2) through (4).

The log likelihood function to be maximized is given by

$$L(\Omega) = -.05*(n*T) \, Ln \, (2\pi) - 0.5 \sum_{t=1}^{T}(Ln|\Lambda_t| + \varepsilon_t'\Lambda_t^{-1}\varepsilon_t)$$

which is maximized using a combination of the simplex method and Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm.

Our preliminary empirical results indicate that the relationship between the monetary base and equity indices is dynamic and regime- sensitive over time. To account for this observation, we introduce and estimate the dynamic conditional correlation (DCC) or time-varying correlations suggested by Engle (2002). The dynamic conditional correlation coefficients are given by $\rho_{ij}(t) = \sigma_{ij}(t)/\sqrt{\sigma_{ii}(t)\sigma_{jj}(t)}$, and the covariance matrix is generated by univariate GARCH models for variances combined with the correlation coefficients.

4. Data

Our data consist of the equity indices of US, UK, France, Germany, and Japan. Monthly observations on the monetary base, S&P500, FTSE100, CAC40, DAX, and NIKKIE, for March 1993 through May 2014 comprise our time series data. We choose indices as leading economic indicators that may reflect trends in the aggregate market movements, rather than individual firm equities. The percentage change in monthly equity indices are computed as $R_t = Ln(I_t/I_{t-1})$, where R_t and I_t represents percentage returns, and the value of an index at time t, respectively.

In this paper, we use M0, the monetary base or the high power money as the indicator of the Fed's monetary action. Other papers that have examined the "traditional monetary policy," have used the fed funds rate or narrative indicators on the monetary policy stance. (see Benenke and Mihov (1998), Cosimano and Sheehan (1994), among others).

Expansionary M0 would indicate an expansionary stance while a shrinking M0 would signal a tightening of money supply and credit markets. The changes in the monetary may affect the economy through diverse channels similar to those explained above. We exclude variables such as interest rates, inflation rates and earning indices from our bilateral models of M0 and equity indices because of high correlations between these variables and the monetary base, as well as their high bilateral correlations.

5. Empirical Findings

Table 1 offers summary statistic and the results of the stationarity tests. We deploy augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) and Ng-Perron (of detrended series) tests of stationarity. Upon examining the graphs of the monetary base and each index series, we determine that including a drift and a trend in estimated regressions is necessary. Based on the stationarity tests, all indices and the monetary base are non-stationary in levels and stationary in first difference. The Johansen and Juselius cointegration test results, show that there is no long-run equilibrium relationship between the monetary base and equity indices. Thus, we turn our attention to the stationary percentage changes of all the series and the bilateral short-run dynamics between the M0 and equity index series.

Table 1. Summary statistics and Stationarity Tests

	Mean	Max	Min	S.D.	SK	K	JB
MBS	1084689.00	38333447.00	368849.00	688789.00	1.47	-0.07	99.27[a]
CAC	3772.43	6625.42	1776.85	1208.89	0.25	-1.56	5.94[b]
DAX	96.30	213.3	10.50	53.16	0.33	-1.50	7.26[b]
FTSE	5096.96	6930.20	2813.10	1114.93	-0.41	-1.97	17.25[a]
NIK	14135.75	22530.75	7568.42	4003.13	0.18	-2.21	16.97[a]
SP	1106.70	1943.89	440.19	347.60	-0.26	-1.47	4.36

	Levels				First Difference			
Series	ADF	PP	MZ_a	MZ_t	ADF	PP	MZ_a	MZ_t
MBS	1.40	1.13	-0.15	-0.06	-9.26	-7.76	-80.35	-6.30
CAC	-1.67	-1.93	-0.89	-0.50	-14.22	-14.41	-120.11	-7.75
DAX	-2.37	-2.20	-10.93	-2.34	-17.51	-17.78	-125.91	-7.93
FTSE	-2.02	-2.11	-5.57	-1.66	-16.20	-16.20	-126.99	-7.97
NIK	-1.90	-2.16	-8.87	-1.99	-15.27	-15.27	-7.18	-1.85
SP	-1.35	-1.63	-4.18	-1.37	-14.82	-14.48	-126.10	-7.94

Notes: MBS,CAC, DAX, FTSE, NIK, SP, stand for the monetary base (millions of current dollars), CAC40 (France), DAX (Germany), FTSE100 (UK), and S&P500 (US) indices. Tests include a trend and intercept in the test regressions.

S.D., SK, K are standard deviation, skewness and the excess Kurtosis.

[a], [b], and [c], represent statistical significance at .01, .05, and .10, respectively.

In the next stage of investigation, we estimate multivariate and bivariate vector autoregressive (VAR) models of the monetary base and equity indices. Prior to these estimations, the order of lags in each VAR is determined using Akaike, Schwarz Bayesian information criteria (AIC, SBC) and the likelihood ratio tests. The VAR lag order is determined to be two in all cases except for DAX. Having determined the lag orders, we estimate each VAR and carry out block Granger causality tests. It is shown that there is evidence of causality in the case of Nikkie and limited signs of monetary base causing returns of DAX and S&P 500, at ten percent confidence level.

In the interest of brevity, we summarize the findings for the generalized impulse responses of equity indices from multivariate VARS up to ten months reported in Figure 1.

A one standard deviation shock to the percentage change in the monetary base is associated an upward return path in all equity indices. Except the DAX index, every index returns settles in about six or seven months. We conclude that the US monetary base may be triggering favorable interest rates and credit environment in the US.

The improving equity markets in the US may help create a wealth effect which improves the aggregate demand and the GDP growth in the US. The positive equity market effects may lend a boost to other equity markets due to the interdependence and comovements of the primary equity markets in the world (Forbes and Rigbond (2002) and Connolly and Wang (2003), among others). Equities return to higher or initial levels after a time lag of about six to seven months.   One may conclude that one-time shocks to the US monetary base may be neutral in the long-run.   These results lend support to the monetarist views of the monetary actions

Response to Generalized One S.D. Innovations ± 2 S.E.
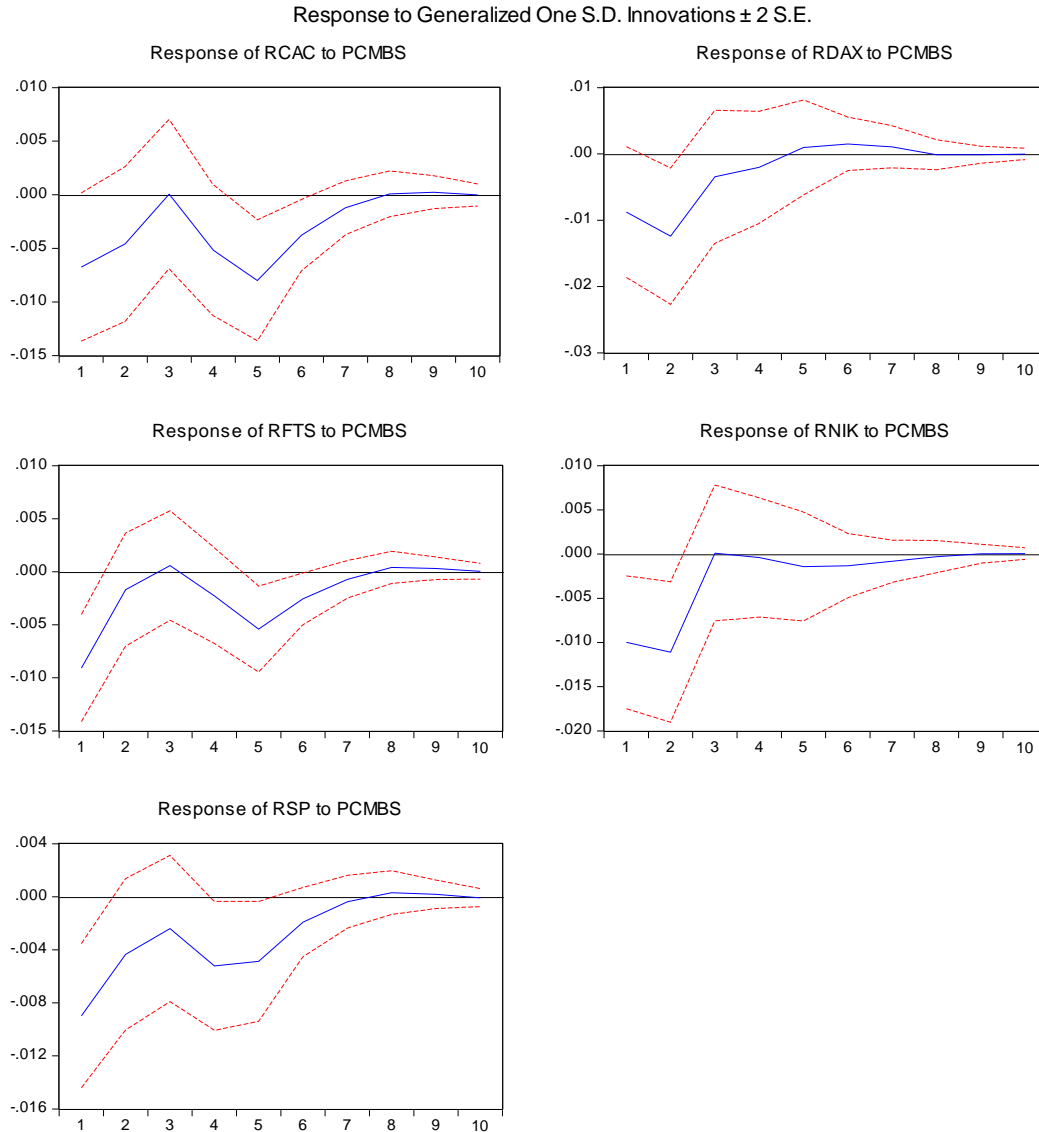
Figure 1. Generalized Impulse Responses of Multivariate VAR: PCMBS and CAC, DAX,
         FTSE100, NIKKEI, S&P500

Our findings also suggest that the quantitative easing during the extraordinary period of 2008-2014, though not targeting equity markets, might have been instrumental in creating a wealth effect for consumers, and positive balance sheet effect for businesses, and thus acceleration effect as well as Tobin's Q effect. The continued boost in the monetary base and the Fed's bond buying, which was not tapered until the second half of 2014, may be one of the reasons for the bull market in the

US equities through 2015.

Returning to regime changes within the range of our data, two important observations stand out. The first important date that may be considered a regime change is December 1996, which marks the end of the Chairman Volker regime, the beginning of the Fed Chairman, Greenspan era as well as the contemporaneous reserve accounting. The second date is the end of the Greenspan era and the beginning of the Bernanke Chairmanship. We test the stability of the coefficients across both regime change dates using a Chow breakpoint test. In all cases for first regime change, we find no evidence of coefficient instability. However, for the end of Greenspan regime, we find that model coefficients for Nikkei and DAX are not stable across the date of the regime change. Given these inconclusive findings, we resort to more statistical tools.
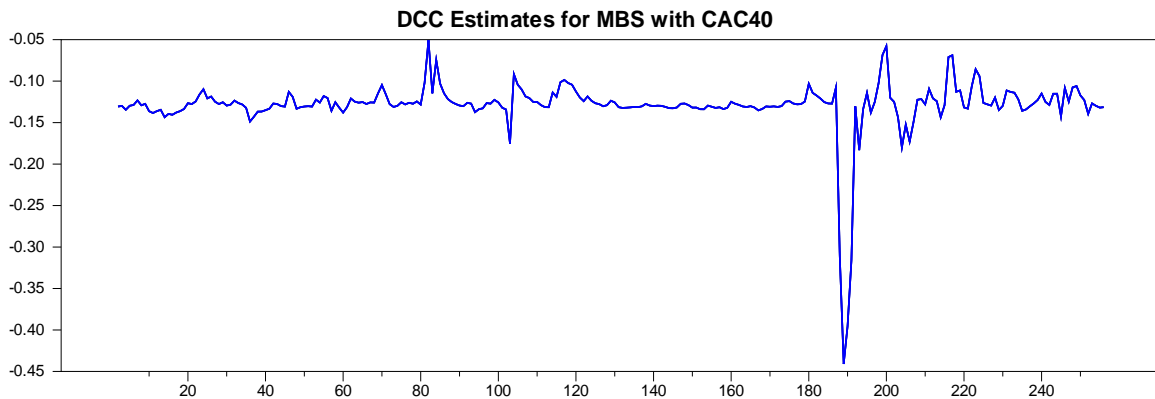
Figure 2. Dynamic Conditional Correlation (DCC)

To model the relationship between the monetary base and equity indices within this context, we employ a Markov regime switching VAR. As the first step to this end, we compute the dynamic correlation coefficients (DCC) between the growth in the monetary base and the equity index returns. In some cases such as the S&P 500 and DAX returns the DCC appears to fluctuate wildly. In remaining cases, the fluctuation in the DCC while somewhat subdued, are not constant. A sample of DCC graphs are presented in Figures 2 to 4. Observing the changing correlations between the monetary base and equity indices suggests that equity responses to monetary bases may be sensitive to methodology and examine the impulse responses derived from these models. Regime changes are detected by the changes in the variations in the growth rates of the monetary base.
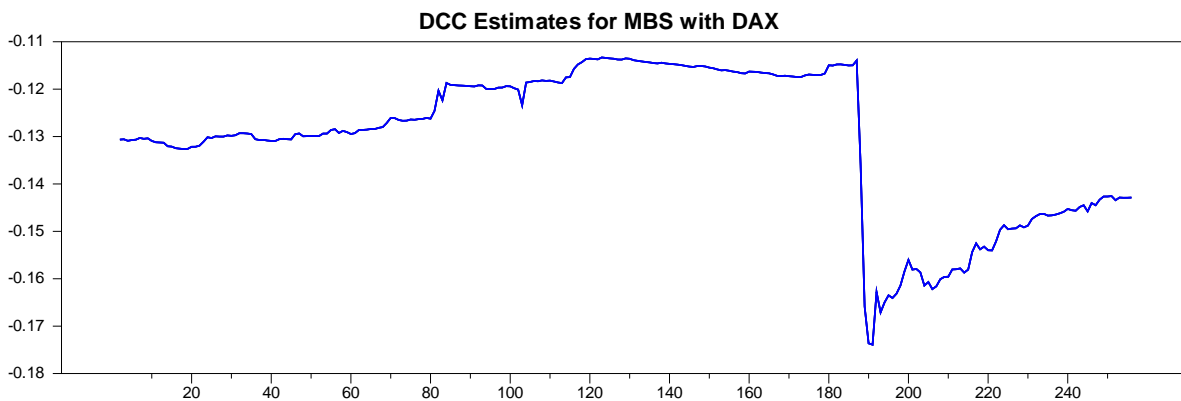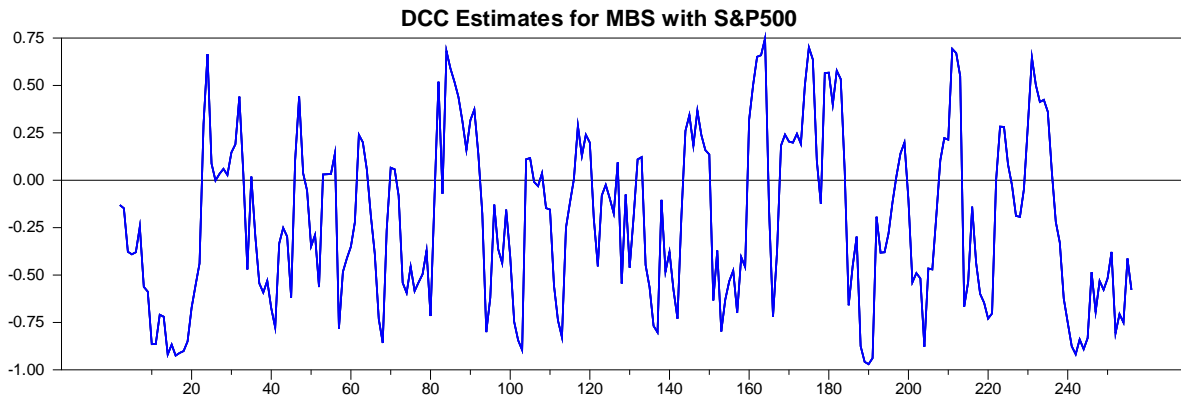

Figure 3. Dynamic Conditional Correlation (DCC)

DCC Estimates for MBS with S&P500

**Figure 4.** Dynamic Conditional Correlation (DCC)

Based on these observations, we re-estimate bivariate VARs using Markov switching model to capture the effects of the regime changes in the impulse responses. We identify two regimes, low variation versus high variation in the monetary base in the US. The Markov Chain Monte Carlo algorithm (MCMC) estimates of the transition probability matrix (not presented for the reason of brevity) and the expected durations provide information on the probability and duration of equity index responses to each regime. It is noted that there is a visible difference in the probabilities of each index reaction to regime changes in the monetary base. It appears that there is a relatively high probability of equity markets remaining in the low volatility for long stretches of time. On the other hand, high volatility in equity markets become very likely for short periods of time. These coincide with periods of economic slow-down or severe recessions. Asymmetric response of the equity markets in general to the monetary base regime changes may be noted from the transition probabilities.

The Monte Carlo Markov Chain (MCMC) impulse responses from these estimations are presented in figure 5, panels (a) through (e). Impulse responses under low (regime 1) and high (regime 2) variance in monetary base confirm the generalized impulse responses.
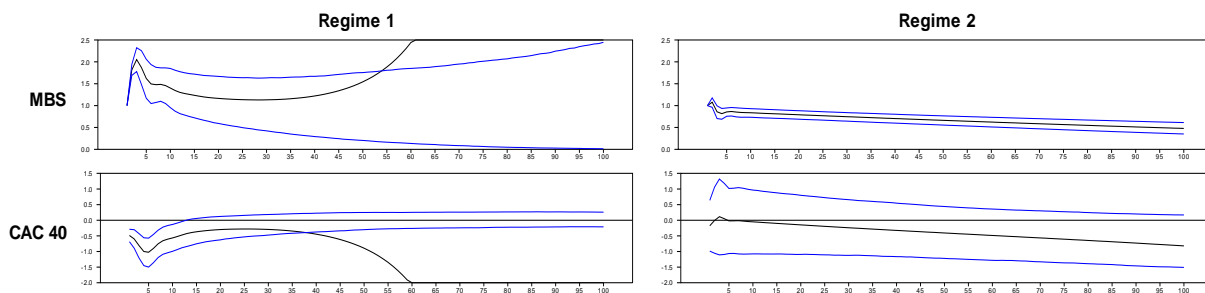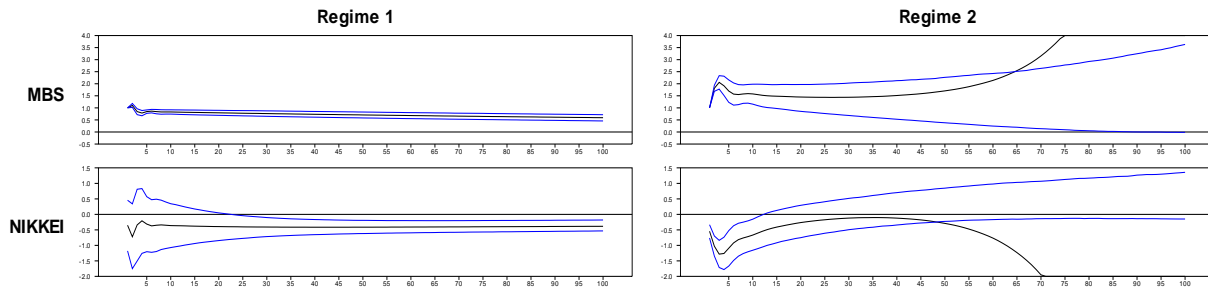
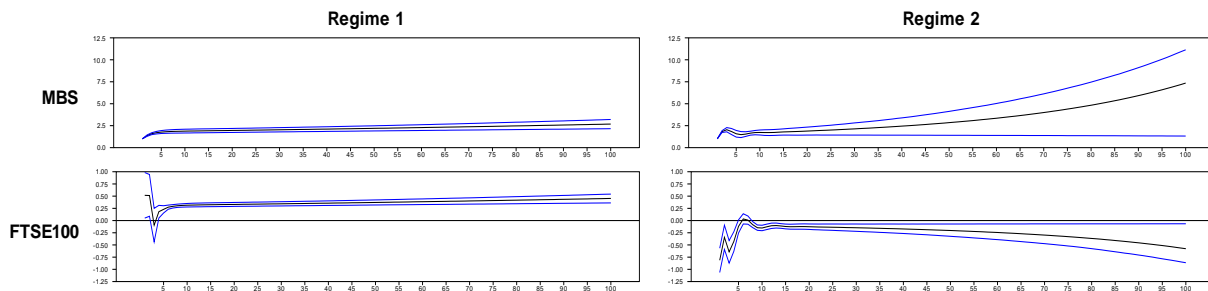

Responses to MBS Shock

(a) Responses to MBS shock_CAC 40
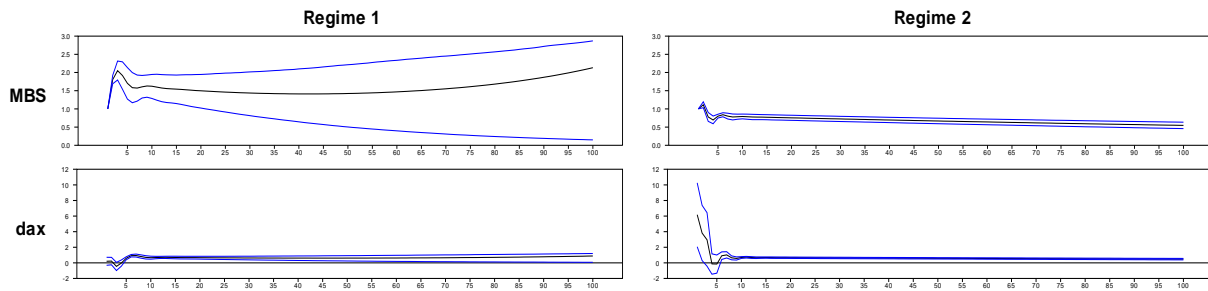
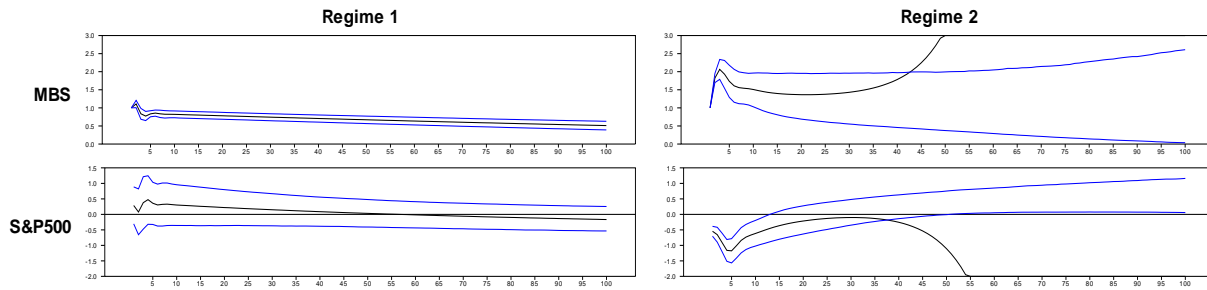Responses to MBS Shock

(b) Responses to MBS shock_dax

Responses to MBS Shock

(c) Responses to MBS shock_NIKKEI

Responses to MBS Shock

(d) Responses to MBS shock_FTSE100

Responses to MBS Shock

(e) Responses to MBS shock_S&P500

Figure 5. Markov Regime Switching Impulse Responses estimated by Monte Carlo Algorithm (MCMC), panels (a) through (e)

The dynamic responses of returns of the CAC 40 and FTSE 100 do not settle after one standard deviation shock to the innovations of the monetary base. The same is true under regime two for CAC 40, FTSE 100, S&P500 and NIKKEI. The conclusion to be drawn is that except the DAX, all major equity markets in the study are affected by high variations in the US monetary base. The same is true only for two equity markets under low variations regime. The dynamic responses of equity markets are quite different under high and low variation regimes. Markov switching VAR models lend further support to the hypothesis that the world equity markets are reacting to the US monetary base. The variations in the monetary base which may be viewed as subtle regime changes are associated with variations in the time path of equity returns. Equities tend to behave differently under the low and high variation regimes in the US monetary base.

Examining the graphs of the equity returns and the growth rates in the US monetary base indicates that the variations in all of these series exhibit time-varying volatility. Combined with the evidence from regime switching VAR, we conclude that the bivariate relationships are asymmetric with respect to high and low variations in the monetary base.

Table 2 reports the estimation results of the VAR-EGARCH model of equations (2)–(5) for bivariate EGARCH models that examine the reaction of major world equity indices to the changes in the US monetary base. β_{12} and β_{21} are mostly positive. Combined with $\delta_2 < 0$ in some cases, there is confirmation that at least for some equity markets the volatility transmission is asymmetric. Statistically significant and $\delta_j < 0$ confirms the presence of asymmetric volatility transmission in four out of five equity markets. Thus, negative shocks to the US monetary base genders higher volatility in these equity markets than positive innovations.

The size effects (the degree of asymmetry) measured by $|-1+\delta_j|/(1+\delta_j)$, are in the range of 0.382 for Nikkei to 24.979 for CAC40, indicating that asymmetric shock effects vary across these equity markets. The differences in the size effects could be due to the degree of market efficiency in weathering negative news as well as investor confidence in the general health of each underlying economy. The unconditional volatility in all cases are finite and taper off given γ_1 and $\gamma_2 < 1$.

Table 2. Bivariate Asymmetric CC-VAR- EGARCH Model With Volatility Spillovers
(M0 and Equity Indices)

Mean Equation	M0	CAC40	M0	DAX	M0	FTSE100	M0	Nikkei	M0	SP500
Intercept α_{10}, α_{20}	0.315[a] (0.004)	0.371[a] (0.305)	0.321[a] (0.016)	1.521[a] (0.357)	0.341[a] (0.001)	0.428 (0.269)	0.432[a] (0.026)	-0.320[a] (0.011)	0.487[a] (0.001)	0.459[b] (0.205)
Own Lagged Return α_{11} α_{21}	0.263[a] (0.057)	0.269[c] (0.166)	0.463[a] (0.028)	0.326[a] (0.147)	0.248[a] (0.026)	0.288 (0.132)	0.106[a] (0.043)	0.072[a] (0.003)	0.226[a] (0.001)	0.041[c] (0.126)
Cross Lagged α_{12}, α_{22}	0.009 (0.009)	-0.022[a] (0.061)	-0.003[a] (0.001)	-0.118[b] (0.064)	0.017[a] (0.002)	-0.131 (0.077)	-0.018[a] (0.004)	0.086[a] (0.004)	-0.016[a] (0.0001)	0.123 (0.068)
Variance Equation	M0	CAC40	M0	DAX	M0	FTSE100	M0	Nikkei	M0	SP500
Intercept β_{10}, β_{20}	0.002 (0.049)	1.154[a] (0.269)	0.292 (0.627)	0.197[a] (0.012)	0.017 (0.058)	0.649[a] (0.214)	0.016 (0.012)	0.334[a] (0.001)	0.242[a] (0.073)	0.518[a] (0.197)
Asymmetric Effect β_{11}, β_{21}	0.601[a] (0.108)	0.397[a] (0.101)	1.659[a] (0.132)	-0.084 (0.058)	0.601[a] (0.118)	0.128[a] (0.060)	-0.526[a] (0.082)	0.007[a] (0.0004)	1.738[a] (0.157)	0.008 (0.082)
Asymmetric Effect β_{12}, β_{22}	0.094 (0.067)	0.343[a] (0.113)	-0.624[a] (0.127)	0.236[a] (0.069)	0.464 (0.140)	0.274[a] (0.086)	-0.569[a] (0.051)	-0.278[a] (0.007)	-0.327[a] (0.099)	0.374[a] (0.095)
Lagged Conditional Variance γ_1 γ_2	0.833[a] (0.027)	0.647[a] (0.079)	0.641[a] (0.049)	0.947[a] (0.005)	0.824[a] (0.024)	0.758[a] (0.078)	0.826[a] (0.033)	0.905[a] (0.001)	0.764[a] (0.037)	0.812[a] (0.071)
Lagged stand. Shock δ_1 δ_2	0.761[a] (0.234)	-0.923[a] (0.301)	0.032 (0.043)	-0.168 (0.147)	-0.774[a] (0.278)	-0.540[a] (0.221)	0.981[1a] (0.117)	0.447[a] (0.002)	0.178[a] (0.049)	-0.667[a] (0.269)
Leverage Effect $|-1+\delta_i|/(1+\delta_i)$	0.136	24.974	0.938	1.404	7.849	3.348	0.009	0.382	0.698	5.006
Conditional Correlation		-0.049 (0.061)		-0.085 (0.063)		-0.046 (0.061)		-0.058 (0.063)		-0.026 (0.063)
Unconditional Correlation		-0.131[a]		-0.181[a]		-0.163[a]		-0.214[a]		-0.204[a]
Response to Positive Shocks		0.026		0.196		0.126		0.402		0.124
Response to Negative Shocks		0.317		0.276		0.422		0.154		0.623
Diagnostics on Standardized residuals										
Q (12), ε_t/σ	44.940[a]	11.625	36.093[a]	8.361	13.058	10.303	4.159	16.220	27.410[a]	6.546
Q^2 (12), ε_t/σ	9.587	30.564[a]	19.482	5.822	23.514	22.385	11.738	9.954	15.468	4.894
E(ε_t/σ)	0.119	-0.028	0.044		-0.010	0.007		0.004	0.127	0.011
E(ε_t/σ)^2	0.994	1.001	0.998		1.001	0.995		0.997	0.998	1.000
System Log Likelihood	-1152.738		-1250.960		-1072.193		-1184.096		-1097.376	

Notes: Returns and conditional variance equations are estimated in a system assuming variance correlations are constant. Q and Q^2 are the Ljung-Box statistics of the autocorrelation in the standardized residuals ($\varepsilon_{it}/\sqrt{\sigma_{it}}$) and their squared values. The sign bias test shows whether positive and negative innovations affect future volatility differently from the model prediction (see Engle and Ng (1993)).

[a], [b], and [c], represent statistical significance at .01, .05, and .10, respectively.

The time varying correlation coefficients are quite low and unanimously negative but statistically insignificant. Time-varying correlation coefficients are much smaller than unconditional correlation coefficients. However, these correlation coefficients are expected to change over time as indicated before. The diagnostics statistics reported in Table 2 confirm that an EGARCH model which accommodates asymmetry of shock transmission is the appropriate model for our purposes. Finally, we use the estimated δ_j and β_{ij} coefficients to compute the impact of negative and positive shock transmission among markets and report these findings in Table 2.

The empirical findings reported in Table 2 show that transmission of monetary effects to equity markets is asymmetric. Positive shocks to monetary base tend to trigger a smaller reaction in equity markets than the negative shocks of the same size. Except Nikkei index, equity markets under study show a significant response to negative shocks to the US monetary base relative to positive shocks. Measured in absolute value, the S&P and FTSE 100 react more drastically to the negative shocks as well as positive shocks. This finding could mean that there is comovement between two equity markets, not too surprising as UK firms are one of the top investors in the US markets as producers of goods and services. The average percentage response of all markets to a one percent positive and negative shocks in the previous period to the monetary base are 0.014 and 0.297, respectively. Thus, equity markets as a whole are much more sensitive to the negative news in the US monetary actions than the positive ones.

Negative innovations or shocks to the monetary base may be regarded as negative news by market participants. For instance, tight monetary policy or stance, which may result in higher interest rates, often present headwinds in equity markets. It also indicates that investors may see the tight monetary stance as a harbinger of an economic slowdown shortly, thus falling cash flows, and lower present value of equities.

6. Summary and Conclusions

This paper investigates the possible reaction of the major world equity markets to the Fed's monetary actions, specifically the growth in the US monetary base. The main motivation for the research is the efficacy of the quantitative easing during periods of extreme financial instability similar to the one witnesses by the world economies in the aftermath of the financial crisis of 2008. The actions of the US Federal Reserve Bank during 2008 through December 2015 ran contrary to the views that monetarist school of thought has espoused. The Fed not only maintained a fed funds rate target of 0-25 basis points; it aggressively pursued a quantitative easing policy that pumped billions of dollars in various assets and bonds. The main objective during that period remained to be shoring up the financial institutions and the financial infrastructure of the major economies of the world. Financial markets enjoyed a rebound from the melt-down of the mid-2008 and in return appeared to have fueled economic recovery in the US and other major economies. The unemployment rate has fallen from the high of around thirteen percent in the US to the current rate of around 5.5 percent, which is widely considered the natural rate of unemployment. Other major economies have not recovered at the same speed, perhaps partially due to their central banks' less aggressive stance. For instance, the European Central Bank (ECB) did not follow the Fed's actions until around 2014.

The resilience of the dollar as the "haven" currency initially, and later, supported by the recovery of the US economy has shown that the aggressive traditional and non-traditional monetary actions of the Fed have not compromised the exchange rate of the dollar. The inflation in the US has remained tamed while the economy has modestly grown. In short, the period of post-2008 may be considered a perfect implementation of the Fed's dual mandates, economic growth while maintaining low or target in inflation rates in the US. An aggressive quantitative easing, which has spurred economic stability,

low unemployment rate, a strong exchange rate of the dollar, and low inflation rate in the US, may be viewed as paradoxical.

In this paper, we examine the changes in the monetary base and its association with major world equity market indices. The VAR and Markov Switching VAR, and VAR-EGARCH models are employed to test these relationships. The impulse response analyses show that the major world equity markets respond to the US monetary base. However, the dynamic path of equity indices returns to the steady path within six months. This finding may lend support to the short-run neutrality of a one-time shock to the US monetary base in relation to the world equity markets.

The Markov Switching VAR (MSVAR) transition probabilities and impulse responses confirm that the major equity indices of the world are sensitive to the changes in the US monetary base. We attribute this to movements in the equity markets as documented by other researchers.

Examining the dynamic correlation coefficients, MSVAR findings, as well as other suggestive evidence, we conclude that the reactions of the equity markets to positive and negative shocks to the monetary base may be asymmetric. The estimated VAR-EGARCH model confirms this. Positive shocks to the monetary base are associated with the much smaller reaction in the equity indices than negative shocks. Negative shocks may be interpreted as a tight monetary stance which may impact the economic and credit climate, thus, adversely affecting equity markets.

The empirical findings of the paper confirm that the quantitative easing remains a useful tool in the arsenal of central banks as shown by the Fed's actions. While the inflation targeting may remain as one of the dual mandates of the Fed, the Fed enjoys ample leeway in deploying monetary actions that can affect real macroeconomic variables such as unemployment and GDP growth. We conclude that the inflation targeting does not limit the Fed's ability to stimulate the economy by quantitative easing to combat recessions and severe economic and financial downturns.

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