**Stock market integration between the UK and the US: Evidence over eight decades**

Abstract

This study investigates how the impact made on stock market integration by macroeconomic determinants such as various measures of convergence and financial volatility, as well as crisis episodes, varies over the period 1935–2015. We gauge how the level of integration between the UK and US stock markets changes across three monetary regimes during this period: pre–Bretton Woods (BW), the BW fixed exchange rate, and the post-BW flexible rates. Our empirical results suggest that integration was strongest under the post-BW regime and weakest under the BW regime. We further demonstrate that stock market integration between the two markets has been driven largely by macroeconomic convergence and financial volatility as well as by crises, especially since the demise of the BW system.

*JEL classifications:*

C12

E44

F36

*Keywords:*

Stock market integration

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Economic policy uncertainty index

Co-integration

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# Introduction

Which international monetary system most induced stock market integration between the UK and US—the interwar/WWII system, the Bretton Woods (BW) system of fixed exchange rates, or the post-BW system of floating exchange rates? In a similar vein, how did macroeconomic convergence, financial volatility, and crisis episodes affect the evolution of stock market integration under BW, compared to periods before and since?

This study seeks to answer these fundamental questions. To answer the first question, we use a bivariate asymmetric BEKK GARCH model to investigate how different monetary regimes have fostered stock market integration between the UK and US over eight decades starting from 1935. We then use the model’s results to investigate the impact of macroeconomic determinants on the evolution of stock market integration over the full period and across the three monetary regimes. The dynamic nature of integration between the two oldest stock market indices, namely, the FT30 and Dow30, is markedly important in light of the changes in international monetary regimes since 1935.

The literature on stock market integration has continued to generate interesting findings in the last three decades. Seemingly, increasing correlation between stock markets suggests greater integration. A number of scholars have found co-movements to be time-varying and stronger in highly volatile periods (Ang & Bekaert, 2002; Aslanidis, Osborn, & Sensier, 2010; Longin & Solnik, 1995). Furthermore, excessive increases in cross-country correlation of financial assets during crises, as compared with tranquil periods, have been interpreted as evidence of “financial contagion” (see Baur, 2012; Chiang, Jeon & Li, 2007; Forbes & Rigobon, 2002). A matter of great concern for investors is that portfolio diversification is more difficult when financial markets move more in tandem.

Another strand of literature has shown that integration of equity markets is inseparable from the underlying economic fundamentals and financial factors, as well as from the arrival of news on specific political and economic episodes. Scholars have employed a wide range of methods to investigate the level of co-movement among various types of markets, including stock, foreign -exchange, and bond markets, as well as primary versus secondary markets (see Casalin & Dia, 2015; Kizys & Pierdziorch, 2006; Syllignakis & Kouretas, 2011).

In general, investors and policymakers use the direction of the stock market indices to gauge a nation’s economic health, which comprises its gross domestic product, consumer price index, interest rates, foreign exchange rates, employment, balance of payments, and government fiscal and monetary policies. Thus, the same indices can also serve as a good measure of financial integration.

Some scholars have argued that deep financial market integration carries advantages including increased foreign direct and portfolio investment, more efficient capital allocation, higher resilient market liquidity, reduced likelihood of asymmetric shocks, and overall improvement of global financial development (see Umutlu, Akdeniz, & Altag-Salih, 2010; Yu, Fung, & Tam, 2010). Others have argued that integration could increase the risk of financial contagion and financial instability (see Beine, Cosma, & Vermulen, 2010; Büttner & Hayo, 2011), and that the increasing transmission of global risk limits the autonomy of independent economies to make macroeconomic policy adjustments and regulatory reforms (Kearney & Lucey, 2004).

 Recently, Baker, Bloom, and Davis (2016) constructed an economic policy uncertainty (EPU) index to measure the extent and nature of economic policy uncertainties. The degree of policy uncertainty may affect the economy as well as stock market. Our study is the first to link the co-movement of EPU indices with stock market integration between the UK and US. We work on the hypothesis that EPU convergence, macroeconomic convergence, financial volatility, and various crises drive stock market integration.

Given that structural changes in the domestic or international political-economic environment can alter the dynamic nature of financial market integration, we partition the full sample into the following subsamples: the pre-BW system (July 1, 1935–September 2, 1945), the BW system (September 3, 1945–August 15, 1971) and the post-BW system (August 16, 1971–June 30, 2015). To the best of our knowledge, this is the first study to investigate the determinants of stock market integration between the UK and US within the frame of different monetary regimes over such a long period.

The scrutiny of such long data series of the world’s two major stock markets should yield an understanding of both long- and short-term dynamics of stock market integration, as well as a more detailed picture of how the evolving international financial architecture underscores the changing sensitivity of financial markets to macroeconomic news and innovations. This study will enable investors to make better decisions about the potential benefits of international portfolio diversification in increasingly integrated markets as well as to gauge the driving force behind the integration process over time. In a similar vein, it will help policymakers understand how macroeconomic convergence, financial volatility, and crises affect stock market integration in both the short and the long-run, so that they can implement mechanisms to contain cross-border financial instability.

The remainder of this study is organized as follows. Section 2 reviews the history of the international monetary system in the last eight decades and identifies a number of hypotheses pertinent to different monetary regimes. Section 3 reviews the theoretical and empirical arguments concerning the impact of macroeconomic convergence and financial volatility on the evolution of stock market integration. Section 4 sets out the empirical method. Section 5 describes the dataset and reports some preliminary statistics. Section 6 discusses the empirical results and their implications, while section 7 concludes.

1. **The** international monetary system

A fundamental question still being investigated by researchers is whether the BW regime was a period of international financial stability. A further interesting question we are putting forward is whether the years before and after the BW system promoted more or less stock market integration. We, therefore, investigate three hypotheses that explain stock market integration under these different international monetary regimes.

* 1. *Pre–Bretton Woods system (1935–1945)*

The interwar/WWII period was characterized by monumental global economic devastation and financial market instability, pervasive exchange rate controls, and controls on trade. The pre-BW system collapsed because of problems with adjustment, liquidity, and confidence (Bordo, 1993). Our hypothesis is that the prevalence of exchange controls, foreign ownership restrictions, and political instability limited stock market integration during this period.

* 1. *The Bretton Woods System (1945–1971)*

The end of WWII saw the establishment of the BW system, with the objective of facilitating international trade and improving capital flows through an international system of fixed exchange rates. Under the BW system, only the US fixed the price of the dollar in terms of gold, while other convertible currencies were pegged to the US dollar. The adoption of a fixed exchange rate regime is supposed to be associated with stability of real exchange rates, interest rates, output, and prices (Bayoumi & Eichengreen, 1992). Hence, as macro-finance indicators converge among countries, we expect international financial integration to increase. If the goal of BW was to achieve macroeconomic stability, then it should also have increased macroeconomic convergence, stimulating stock market integration.

* 1. *The post–Bretton Woods system (1971–2015)*

BW ended on August 15, 1971, when the US unilaterally aborted convertibility of the US dollar to gold (that is, the fixed exchange rate regime was abolished), thereby making the US dollar a fiat currency and at the same time a reserve currency for many countries. According to Eichengreen and Sussman (2000), since the repeal of the BW agreement, there has been increasing capital mobility and significant exchange rate flexibility. New waves of international financial liberalization and globalization have paved the way for the cross-listing of stocks and for greater portfolio investment in the global stock markets.

Of our three subperiods, this one witnessed the most prolonged cycles of economic growth, reduced unemployment and low inflation in both the UK and US. However, Bordo, Schwartz, and Darby (1989) argued that in the presence of capital mobility, currency substitution, economic policy reaction, and interdependence, floating rates no longer necessarily provide insulation from either real or monetary shocks. In the new paradigm, currency floats act as an adjustment mechanism so that macroeconomic policies are geared towards controlling inflation, deepening financial markets, and stimulating economic growth. Our final hypothesis is that international stock markets have become more integrated under the post-BW system, characterized by stronger economic ties, deepening financial liberalization, and heightened market turbulence.

# Macroeconomic convergence and financial volatility: theory and evidence

The convergence hypothesis suggests that with stronger economic ties among countries, we would expect that the synchronization of business cycles, interest rates, and inflation should yield deeper financial integration over time (see Kose, Otrok, & Prasad, 2012). However, given the long time span of our data, during which a series of different monetary regimes were in place, and given the contribution of both real and financial variables, the process of financial integration, and therefore the relationship between the UK and US stock markets, should vary over time.

In dynamic asset pricing models, the future state of the economy is the fundamental driver of time-varying expected stock returns (Neely, Rapach, Tu, & Zhou, 2014). According to Pretorius (2002), explanations of stock market integration fall into three categories. The first posits a “contagion” effect that is unexplained by economic fundamentals. The second refers to the “economic integration” of the two economies (e.g., industrial output, interest rates, inflation, and other macroeconomic factors). The third focuses on “stock market characteristics” such as industrial similarity, market volatility, and market size. In this study, we provide theoretical reasoning and empirical evidence that macroeconomic convergence and financial volatility, as well as crisis episodes, explain the integration between the UK and US stock markets.

*3.1. Macroeconomic convergence*

*3.1.1. Business cycle convergence*

We use growth rates in industrial production as a proxy for business cycle convergence. According to Kim, Moshirian, and Wu (2005), when countries are in similar phases of the business cycle, shocks will be more fully transmitted across financial markets, boosting integration. Phengpis, Apilado, and Swanson (2004) found that correlation of business cycles was the main driver of stock market integration between the Economic and Monetary Union (EMU) and the UK over the period 1979–2002 (see Büttner & Hayo, 2011; Syllignakis & Kouretas, 2011). Kizys and Pierdzioch (2006) investigated the linkage between international stock correlations and business cycle convergence in the G7 countries over the period 1970–2004, finding less clear-cut results.

 *3.1.2. Interest rate convergence*

We proxy interest rate convergence by the conditional correlation between UK and US yield spreads.[[1]](#footnote-1) If the yield spreads between the UK and US converge, possibly owing to similar monetary policies, then their stock markets should also converge. Kim et al. (2005) found that convergence towards a single interest rate significantly increased integration between the EMU and the US over the period 1989–2003 (see also Syllignakis & Kouretas, 2011). Conversely, Wang and Moore (2008) showed that monetary convergence did not affect stock market integration between Central Eastern European (CEE) economies and Eurozone countries over the period 1994–2006.

*3.1.3. Inflationary convergence*

We proxy inflation convergence by the conditional correlation between UK and US CPI inflation. The higher the convergence between UK and US inflation rates, the stronger is the link between their stock markets. Kim et al. (2005) found that CPI inflation had contributed to the integration of stock markets between the EMU and US. Similarly, Syllignakis and Kouretas (2011) found that inflation convergence between CEE economies and the German economy played a key role in explaining their stock market correlations over the period 1997–2009.

*3.1.4. Economic policy uncertainty convergence*

In measuring the impact of policy uncertainty convergence on stock market integration, we use the Economic Policy Uncertainty (EPU) index. Unlike the volatility index (VIX), which captures only uncertainty about equity returns, the EPU index broadly reflects policy uncertainty. According to Baker et al. (2016, p. 16), “higher policy uncertainty leads to a greater frequency of large equity market moves triggered by policy-related news.” Using a dataset over the period 1985–2013, Antonakakis, Chatziantoniou and Filis (2013) found that increases in stock market conditional volatility intensify policy uncertainty and reduce stock market returns, and conversely increases in the volatility of policy uncertainty lead to negative stock market returns and worsened policy uncertainty (see Brogaard & Detzel, 2015). It is important to note that the above studies analyse countries individually, therefore omitting to model any form of co-movement in EPU indices. We contribute to the existing literature by measuring the co-movement of EPU indices between two markets. All the above measures of macroeconomic convergence are obtained by applying standard Dynamic Conditional Correlation (DCC) GARCH models.

*3.2. Financial volatility*

*3.2.1. Real exchange rate volatility*

Theoretically, there is an inverse relationship between stock market correlation and exchange rate volatility, because exchange rate risk is a critical source of risk priced on financial markets (see Bodart & Reding, 1999). For instance, Fratzscher (2002) argued that the more turbulent and unpredictable exchange rates are, the more expensive hedging against such uncertainty is, the stronger the degree of market segmentation, and the lower the degree of cross-market correlation. Syllignakis and Kouretas (2011) found that exchange rate movements have a significant impact on stock market integration, though the effect is positive in some periods and negative in others (see also Büttner & Hayo, 2011).

*3.2.2. Commodity price volatility*

The crude oil and gold markets play a significant role in the commodity markets. Many investors choose gold as a safe-haven asset whenever other assets exhibit extremely negative returns. But gold might not prove to be a safe-haven asset if it co-moves with other risky assets, such as stocks, real estate, etc. Still, according to Baur and Lucey (2010), gold is a hedge against stocks on average and a safe haven in extreme stock market conditions or negative market shocks.

Shocks to the oil market are global shocks, as the oil industry is affected by economic and institutional factors such as business cycle fluctuations, OPEC oil production policy, and extreme political events. Oil price volatility affects the real economy through consumer and firm behaviours; hence the link between oil and stock markets (see Kilian & Park, 2009; Park & Ratti, 2008). We compute the conditional volatilities of real exchange rates, oil prices, and gold prices over 80 years using univariate GARCH (*1,1*) models.

*3.2.3. Stock market volatility*

Volatility is a measure of risk and remains an important feature of stock markets. High stock market volatility arises when economic agents are uncertain about the future. Cai, Chou, and Li (2009) found a significant relationship between stock correlation and stock volatility among six developed markets (US, UK, France, Germany, Hong Kong, and Japan) over the period 1991–2007. We measure stock market volatility as the ratio of conditional variances (obtained from the asymmetric BEKK model) of US and UK stock returns. Since international investors always react to information, we expect that if the volatility in the two markets is similar, then their stock markets will converge as well.

*3.3. Noneconomic fundamentals: political and economic episodes*

Various political, economic, or financial crises in the last eight decades may have influenced the linkages of international stock markets. Empirical studies have documented the impacts of several financial crash, currency crisis, oil shock and debt crisis episodes on stock market integration (Wang & Moore, 2008; Syllignakis and Kouretas*,* 2011). We expect that such episodes of crisis may increase stock market integration through financial contagion.

4. Method

Engle and Granger (1987) propose an error correction model (ECM) on the basis that if, for instance, $lnP\_{UK,t}$ and $lnP\_{US,t}$ are *I*(1) variables and co-integrated *CI*(1,1), then an ECM exists, or else the model that does not incorporate the ECM is mis-specified. We, therefore, model the UK and US series by means of a VECM in which the first difference of the natural log of stock indices depends on a constant, on the speed of adjustment, on their own lags and cross-lags, and on the disturbance terms that capture the unexpected shocks on the endogenous variables. On the assumption that the mean equations follow a VECM(*p*) stochastic process, we specify each equation as follows:

$R\_{UK,t}= α\_{UK}+ δ\_{UK}z\_{t-1}+\sum\_{p=1}^{p\_{UK}}β\_{UK,i}R\_{UK,t-p}+\sum\_{p=1}^{p\_{US}}β\_{US,p}R\_{US,t-p}+ ε\_{UK,t}$ (1)

$R\_{US,t}=α\_{US}+δ\_{US}z\_{t-1}+\sum\_{p=1}^{p\_{US}}β\_{US,p}R\_{US,t-p}+\sum\_{p=1}^{p\_{UK}}β\_{UK,p}R\_{UK,t-p}+ ε\_{US,t}$ , (2)

where $z\_{t-1}$ is the error correction term that measures how the dependent variables adjust to the last period’s deviations from the long-run equilibrium path. The speed of adjustment to the long-run equilibrium is captured by $δ\_{UK }$and $δ\_{US}$, which must be of opposite sign and at least one of which must be statistically significant.

Given that the residual vector $ε\_{t}$ *= (*$ε\_{UK,t},ε\_{US,t}) $is distributed $ε\_{t}$*|*$I\_{t-1}\left(0,H\_{t}\right),$we model the conditional covariance matrix $H\_{t}$ by means of an Asymmetric GARCH BEKK model (Kroner & Ng, 1998) specified as follows:

$H\_{t}$ = $CC'$ + $A'ε\_{t-1}ε\_{t-1}^{'}A+B'H\_{t-1}B+D'η\_{t-1}η\_{t-1}^{'}D$ , (3)

where the matrix *C is* restricted to be upper triangular, and the matrices *A*, *B*. and *D* are unrestricted (see, e.g., Caporale, Pittis, & Spagnolo, 2006; Panopoulou & Pantelidis, 2009).

For the explanatory variables, we use the standard GARCH (*1,1*) specification to compute the volatility of foreign exchange rates, oil prices, and gold prices. The conditional correlations between UK and US macroeconomic variables (industrial output, CPI inflation, interest rate, and EPU index) are estimated by means of bivariate DCC GARCH models (Engle, 2002). We therefore compute the conditional correlations as follows:

$ρ\_{12,t}=\frac{h\_{12, t}}{\sqrt{h\_{11, t} × h\_{22, t}}}$ , (4)

where $ρ\_{12,t}$ is the estimated conditional correlation coefficient between the UK and US indicators under scrutiny, $h\_{12, t}$ is the conditional covariance, and $h\_{11, t}$ and $h\_{22, t}$ are the conditional variances for the UK and US, respectively.

We then use the above GARCH-based indicators of correlation and volatility to explain the nature of stock market integration between the UK and US. We regress the time-varying stock correlation coefficient against indicators for the business cycle, monetary policy, policy uncertainty, and financial volatility, as well as crisis episodes. More specifically, we carry out empirical estimates of the following linear regression:

$ρ\_{12,t} = α\_{0} +β\_{1}Corr\_{IPX}\_{t}+β\_{2}Corr\_{CPI}\_{t}+β\_{3}Corr\_{YS}\_{t}+β\_{4}Corr\_{EPU}\_{t}+β\_{5}Vol\_{FX}\_{t}+ +β\_{6}Vol\_{OIL}\_{t}+β\_{7}Vol\_{GOLD}\_{t}+β\_{8}Vol\_{STOCK}\_{t}+\sum\_{k=1}^{15}δ\_{k}DM\_{k,t}+ε\_{12,t}$ (5)

where $ρ\_{12,t}$ is the estimated correlation coefficient between the UK and US stock markets, $Corr\_{IPX}\_{t}$, $Corr\_{CPI}\_{t}$,$ Corr\_{YS}\_{t}$, and $Corr\_{EPU}\_{t}$ are, respectively, the estimated correlation coefficients between the UK and US for the growth rate of seasonally adjusted industrial production indices, CPI inflation, yield spreads, and EPU indices. $Vol\_{FX}\_{t}$, $Vol\_{OIL}\_{t}$, $Vol\_{GOLD}\_{t}$, and $Vol\_{STOCK}\_{t}$ are the estimated conditional volatilities of exchange rates, oil, gold, and stock prices.

In order to investigate the impact of a number of crisis episodes on the degree of integration between the two markets, we consider a set of dummy variables such as $DM\_{1,t}$ for World War II (Sep 1939–Apr 1942), $DM\_{2,t}$ for the Korean War (Jun 1950–Jul 1957), $DM\_{3,t}$ for the Vietnam War (Mar 1959–Apr 1974),$ DM\_{4,t}$ for the first global oil shock (Oct 1973–Mar 1974), $DM\_{5,t}$ for the second global oil shock (Jan 1979–Dec 1980), $DM\_{6,t}$ for the 1987 stock market crash (Sep 1987–Nov 1987), $DM\_{7,t}$ for the Iraq-Kuwait War (Aug 1990–Feb 1991), $DM\_{8,t}$ for the European currency crisis (Sep 1992–Aug 1993), $DM\_{9,t}$ for the Mexican currency crisis (Dec 1994–Nov 1995), $DM\_{10,t}$ for the Asian and Russian crisis (Jun 1997–Oct 1998),$ DM\_{11,t}$ for the dot-com burst (Mar 2000–Sep 2002), $DM\_{12,t}$ for the 9/11 terrorist attack and Afghanistan War (Sep 2001–Dec 2013), $DM\_{13,t}$ for the Iraq War (Mar 2003–Dec 2011), $DM\_{14,t}$ for the global financial crisis (Aug 2007–Jun 2009), and finally $DM\_{15,t}$ for the Eurozone debt crisis (May 2010–Dec 2015).

# Dataset

We consider the daily closing prices of the FT30 and Dow30 indices over the period July 1, 1935 to June 30, 2015.[[2]](#footnote-2) The FT30 index was launched on July 1, 1935, and is the geometric average weighting of 30 UK blue-chip companies. The Dow was expanded to 30 blue-chip companies in October 1928 and is a price-weighted index of 30 large and diverse companies. The stock prices are denominated in local currency in order to isolate the direct linkages between the markets under scrutiny from exchange rate risk. Our dataset also includes monthly series of the yield spread, CPI inflation, industrial output, Baker et al.’s (2016) index of economic policy uncertainty, foreign exchange, and gold and oil prices.[[3]](#footnote-3)

Figure 1 displays the natural logs of UK and US stock prices. Over time, they follow similar patterns. Crises such as the October 1987 stock market crash, 2000 dot-com bubble burst, and 2008 stock market crash all caused these prices to plunge from peaks to historic lows.

We report the statistical properties of the UK and US stock returns during the full sample and the three subperiods under scrutiny in Table 1. The stock returns of both markets recorded significant positive returns over the full period and in the BW subperiod. However, the US has the highest daily average returns whereas the UK has been more volatile, suggesting that the risk-return profile is far better in the US than in the UK. The skewness values suggest that negative shocks are more prevalent than positive shocks in all the subperiods. The high kurtosis in the return series indicates fat-tailed distributions, the presence of extreme values, and possibly volatility clustering. This further suggests that large shocks are common features of the sample. Moreover, the Jarque-Bera test for the null of normality indicates that the daily stock returns are not normally distributed, as is typical for high-frequency financial data. The Ljung-Box test statistics show significant serial correlation in the returns of both markets. In addition, the serial correlation of the squared returns suggests high persistence and time-varying volatility. In fact, the McLeod-Li test indicates strong ARCH effects for both the series under scrutiny.

Table 2 reports the test for equality of means, medians, variances, and distributions between the subperiods. Empirical results show a strong difference in volatility and median as well as distribution, whereas no significant differences in mean occur. Overall, the UK and US series behave differently over time, so we must partition the empirical analysis.

We then test for the presence of co-integration between the UK and US indices. Table 3 sets out the results of this analysis using the log prices of UK and US stock indices.[[4]](#footnote-4) The Engle-Granger (E-G) test indicates the presence of a co-integrating relationship in the post-BW period. In addition, both Fully Modified OLS (F-OLS) and Canonical OLS (C-OLS) methods show one co-integrating relationship in the full and subperiods. However, both the Johansen and Gregory-Hansen (G-H) statistics indicate no co-integrating relationships at conventional levels in either full sample or any of the subperiods.

As expected, the estimates of the two speed-of-adjustment indicate that $δ\_{UK}$ is negative and significant while $δ\_{US}$ is positive and significant, suggesting a joint error correction to restore the long-run equilibrium. The coefficients of the speed of adjustment suggest that UK returns are on average lower than the level predicted by the long-run equilibrium, and they adjust by rising toward US returns. By the same token, US returns tend to exceed UK returns, and therefore decrease to restore long-run equilibrium. This further demonstrates the existence of a co-integrating relationship between the two markets.

In conclusion, the evidence largely confirms a co-integrating relationship between the UK and US in the post-BW subperiod. The long-run relationship between the UK and US is further supported by the evidence of co-integrated mature markets (i.e. US, UK, Japan) provided by Floros (2005) and Hatemi (2008). Given the presence of conditional heteroscedasticity, serial correlation, non-normality, and a co-integrating relationship, we employ multivariate volatility models to evaluate the nature of stock market integration across multiple sample periods.



Fig.1. Natural logarithm of daily observations for the FT30 (dotted line) and Dow30 (solid line) for the period 1935–2015.

Table 1

Descriptive statistics of UK and US stock market returns for the full sample (1935-2015), and across the subperiods1935-1945 (pre-BW), 1945-1971 (BW), and 1971-2015 (post-BW).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Mean(x10-3) | Standarddeviation | Skewness | Kurtosis | Jarque Bera test | Q (12) | Q2 (12) | ARCH effect(4 lags) |
| Full PeriodUKUS | 0.161\*\*0.240\*\*\* | 0.0100.009 | -0.201\*\*\*-1.112\*\*\* | 11.23\*\*\*35.06\*\*\* | 3363\*\*\*8911\*\*\* | 235.7\*\*\*60.34\*\*\* | 13276\*\*\*2230\*\*\* | 2618\*\*\*837.7\*\*\* |
| Pre-BWUKUS | 0.0470.145 | 0.0070.011 | -0.322\*\*\*-0.493\*\*\* | 21.49\*\*\*10.37\*\*\* | 680.7\*\*\*487.4\*\*\* | 305.2\*\*\*36.17\*\*\* | 897.6\*\*\*725.9\*\*\* | 258.7\*\*\*120.5\*\*\* |
| BWUKUS | 0.192\*\*0.236\*\*\* | 0.0080.007 | -0.135\*\*\*-0.523\*\*\* | 10.82\*\*\*9.093\*\*\* | 1034\*\*\*1135\*\*\* | 314.7\*\*\*135.0\*\*\* | 581.4\*\*\*1105\*\*\* | 188.6\*\*\*319.6\*\*\* |
| Post-BWUKUS | 0.1690.265 | 0.0120.011 | -0.189\*\*\*-1.311\*\*\* | 8.949\*\*\*40.12\*\*\* | 1468\*\*\*5314\*\*\* | 92.19\*\*\*30.79\*\*\* | 7529\*\*\*1074\*\*\* | 1466\*\*\*440.5\*\*\* |

Notes: Daily stock returns calculated as $R\_{t}$ *= ln(*$P\_{t})-ln(P\_{t-1})$. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively. Jarque-Bera test used to test for normality in distribution. Ljung-Box test (Q) applied to raw and squared returns to test for serial correlation using 12 lags. McLeod and Li’s test used to test for ARCH effects.

Table 2

Test for equality of means, medians, variances, and distributions of stock market returns across the subperiods 1935-1945 (pre-BW), 1945-1971 (BW), and 1971-2015 (post-BW).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Equality of means (x10-3) | Equality of medians | Equality of variances | Equality of distributions |
| UK: BW =Pre-BWUS: BW = Pre-BW | 0.1510.231  | 8.601\*\*\*0.064 | 0.007\*\*\*0.008\*\*\* | 0.071\*\*\*0.066\*\*\* |
| UK: Post-BW = BWUS: Post-BW = BW | 0.0100.080  | 57.82\*\*\*1.257 | 0.008\*\*\* 0.010\*\*\* | 0.129\*\*\*0.072\*\*\* |
| UK: Post-BW = Pre-BWUS: Post-BW = Pre-BW | 0.037 -0.150  | 5.361\*\*0.065 | 0.009\*\*\*0.011\*\*\* | 0.181\*\*\*0.024 |

Notes: \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively. 2-sample *t*and Levine tests assess the null of equality of means, and equality of variances. For such tests the figures reported are the differences between means, and between variances. *k*-sample and Kolmogorov-Smirnov tests assess the null of equality of medians, and equality of distributions.

Table 3

Co-integration tests between the UK and US stock indices and related speed of adjustments to long-run equilibrium for the full sample (1935-2015), and the subperiods 1935-1945 (pre-BW), 1945-1971 (BW), and 1971-2015 (post-BW).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Co-integration tests | Engle-Granger  | Fully modified OLS | Canonical OLS | Johansen $λ\_{TR}$/$λ\_{MAX}$ | Gregory-Hansen Test | Speed of adjustments |
| $$δ\_{UK}$$ | $$δ\_{US}$$ |
| Full period | -2.011 | 0.635\*(0.351) | 0.774\*\*\*(0.085) | 6.772/6.638 | -47.22 | -0.224\*\*\*(0.007) | 0.464\*\*\*(0.006) |
| Pre-BW | -1.746 | 1.464\*\*\*(0.443) | 0.508\*\*(0.235) | 9.684/7.185 | -32.81 | -0.051\*\*\*(0.009) | 0.487\*\*\*(0.015) |
| BW | -2.014 | 0.508\*\*(0.235) | 0.748\*\*\*(0.075) | 12.86/10.83 | -36.70 | -0.052\*\*\*(0.005) | 0.218\*\*\*(0.004) |
| Post-BW | -4.057\*\*\* | 1.244\*\*\*(0.475) | 0.601\*\*\*(0.142) | 6.731/5.731 | -46.54 | -0.368\*\*\*(0.012) | 0.496\*\*\*(0.010) |

Notes: \*, \*\*, and \*\*\* denote significance at 10%, 5%, and 1% levels, respectively. We specify the type of co-integration relationship that incorporates a constant trend with two lags based on SBIC. The critical values for the maximum Eigenvalue statistics ($λ\_{max}$) for 1% and 5% are 15.41 and 20.04, and those of Trace statistics ($λ\_{trace}$) are 14.07 and 18.63 based on zero co-integrating relationship. For one co-integrating relationship, their critical values are 3.76 and 6.65. The Engle-Granger residuals-based test for the null of no co-integration with critical values at 1%, 5%, and 10% are -3.96, -3.41, and -3.12, respectively. The critical values for the Gregory-Hansen (1996) test are -69.37 for 1%, -58.58% for 5%, and -53.31 for 10%. The standard errors for Phillips and Hansen’s (1990) Fully Modified OLS and Park’s (1992) Canonical OLS are reported in parentheses. The speeds of adjustment of the UK and US indices are represented by $δ\_{UK}$ and $δ\_{US}$, respectively.

# Empirical results

## *6.1. Stock market integration between UK and US*

Figure 2 displays the evolution of stock market integration and policy uncertainty convergence between the UK and US stock markets during the BW period, compared to the preceding and following periods. The estimated conditional correlations of stock returns and policy uncertainty exhibit substantial variation throughout the periods, with varying degree of intensity. The pre-BW period (1935–1945) witnessed severe variability between negative and positive values, with an estimated average stock correlation of 0.205 and EPU correlation of 0.234. This suggests that, as economic policy changes in the UK and US became extremely uncertain because of WWII, isolationist economic policies, and financial market instability, their stock returns became more volatile because of high risk premia, and hence that integration between the markets was limited. Accordingly, the evidence seems supportive of our hypothesis and corroborates Goetzmann’s (2005) finding that periods of war and significant tension lead to weak stock market integration.

Furthermore, a wide positive variation in stock correlations prevailed during the BW period (1945–1971), though the estimated average stock correlation declined slightly to 0.192. Similarly, the EPU correlation dropped to an average of 0.215. These decreases may be attributed to exchange rate constraints, excessive capital controls, and divergent macroeconomic policies prevalent under the BW fixed exchange rate regime. We attribute the further weakening of stock market integration to the escalation of the Vietnam War and the simultaneous establishment of the Great Society program, which led to faster global inflation and rising balance-of-payment deficits (Eichengreen & Sussman, 2000). Thus, the evidence does not support the hypothesis that a fixed exchange rate regime, macroeconomic stability, and low financial volatility lead to higher stock market integration.

The collapse of the fixed exchange rate regime in 1971 triggered more volatility, with average stock correlation increasing significantly to 0.381. In contrast, the EPU correlation declined further to 0.201. Seemingly, many developed countries adopted floating exchange rates, which inevitably increased the unpredictability of exchange rates, economic volatility, and policy uncertainty. However, since the end of the BW system the central banks of the leading developed economies (US, UK, Japan, and Germany) have cooperated informally to safeguard the integrity of the international monetary system, prevent financial instability, and stabilize exchange rates through interventions in the currency markets. The *prima facie* evidence seems to indicate that crises (e.g. the October 1987 stock market crash, Asian and Russian crisis, dot-com bubble burst, 2008 stock market crash, and Eurozone debt crisis) cause economic policy uncertainty, stock market volatility, and equity indices to move hand in hand. Therefore, the evidence seems to show that periods of macroeconomic convergence, currency floats, financial liberalization, and financial contagion cause higher stock market integration.

Table 4 reports tests for equality of means, medians, variances, and distributions for the conditional correlations between the subperiods. The empirical results show a strong difference in means, variances, medians, as well as distributions between the BW and post-BW periods. Thus, the significant increases in correlation in the post-BW period - characterized by financial liberalization, floating exchange rate regimes, and the gradual phasing-in of the European Monetary Union - suggests that the two markets had been integrating.

In a similar vein, Table 5 reports tests for equality of means, medians, variances, and distributions between stable and crisis periods.[[5]](#footnote-5) The trends indicate strong differences in means and medians as well as distributions for half of the crisis periods, but no significant differences in variance. No significant differences in means, medians, variances, or distributions occur with respect to the 1979/80 second global oil shock, the 1992/93 European monetary system crisis, or the 2000/02 dot-com bubble burst. However, the difference in means is strongly significant so that the correlation between the UK and US increased significantly during the 1973/74 oil shock, 1987 stock market crash, 1997/98 Asian/Russian crisis, and 2007/09 global financial crisis (GFC). The substantial increases in market correlation during crisis periods as compared to stable periods support the “contagion” argument proposed by Forbes and Rigobon (2002; see also Bekaert, Harvey, & Ng*,* 2005; Dimitriou, Kenourgios, & Simos, 2013).

In sum, the low correlation in the first four decades can be attributed to the rule-based monetary system, macroeconomic divergence, economic regionalism, and protectionism, whereas the rising correlation since the 1970s can be associated with flexible exchange rates, economic integration, financial liberalization, and the introduction of the euro currency. The fact that integration between the UK and US markets is weak in the early period of the sample and becomes strong in the post-BW period suggests that macroeconomic convergence, stock market characteristics, and crises may have played a crucial role.

**Table 4**

Test for equality of means, medians, variances, and distributions of conditional correlations across the subperiods 1935-1945 (pre-BW), 1945-1971 (BW), and 1971-2015 (post-BW).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Equality of means | Equality of medians | Equality of variances | Equality of distributions |
| BW = Pre-BW | -0.056\*\*\* | 0.102 | 0.196\*\*\* | 0.093 |
| Post-BW = BW | 0.126\*\*\* | 205.9\*\*\* | 0.311\*\*\* | 0.534\*\*\* |
| Post-BW = Pre-BW | 0.075\*\*\* | 79.12\*\*\* | 0.347 | 0.479\*\*\* |

Notes: \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively. 2-sample *t*and Levine tests assess the null of equality of means, and equality of variances. For such tests the figures reported are the differences between means, and between variances. *k*-sample and Kolmogorov-Smirnov tests assess the null of equality of medians, and equality of distributions.

Table 5

Test for equality of means, medians, variances, and distributions of conditional correlations between crisis and stable periods.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Equality of means | Equality of medians | Equality of variances | Equality of distributions |
| First global oil shock (1973–1974) | 0.153\*\* | 5.333\*\* | 0.176 | 0.667 |
| Second global oil shock(1979–1980) | -0.050 | 1.333 | 0.282 | 0.250 |
| 1987 stock market crash | 0.272\*\* | 0.667 | 0.349 | 0.667 |
| European monetary system crisis (1992–1993) | -0.043 | 0.154 | 0.269 | 0.308 |
| Mexican currency crisis (1994–1995) | -0.054 | 3.846\* | 0.270 | 0.462 |
| Asian and Russian crisis (1997–1998) | 0.144\*\*\* | 11.11\*\*\* | 0.310 | 0.667\*\*\* |
| Dot-com bubble burst(2000–2002) | 0.010 | 0.065 | 0.377 | 0.194 |
| Global financial crisis (2007–2009) | 0.156\*\*\* | 27.00\*\*\* | 0.427 | 0.792\*\*\* |

Notes: \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively. 2-sample *t*and Levine tests assess the null of equality of means, and equality of variances. For such tests the figures reported are the differences between means, and between variances. *k*-sample and Kolmogorov-Smirnov tests assess the null of equality of medians, and equality of distributions.

Fig.2. Monthly time-varying conditional correlations of stock indices and policy uncertainty indices between the $UK\_{t}$ and $US\_{t}$ over the periods 1935–1945 (Pre-BW), 1945–1971 (BW), and 1971–2015 (Post-BW). Solid lines represent stock correlations, whereas dotted lines represent policy uncertainty correlations.







## *6.2. The determinants of stock market integration*

In this section, we identify potential macro-finance indicators and crises that could explain the dynamic nature of stock market integration between the UK and the US. Table 6 reports the empirical estimates of equation (5) for the full sample and subperiods. For the subperiod analysis, we drop financial variables such as exchange rates, gold prices, and oil prices for the pre-BW and BW periods of fixed exchange rates. In fact, unlike the post-BW period of floating exchange rates and financial liberalization, the period between 1935 and 1971 featured low volatility in the currency and commodity markets. Given the values of R-squared, we provide evidence that the macroeconomic fundamentals, policy uncertainty, and financial indicators, as well as various crises, explain a sizable share of the variability in stock correlation coefficients.

Over the full period (1935–2015), interest rate convergence increased stock market integration, which suggests that convergence in monetary policy has played a significant role, as Kim et al. (2005) and Syllignakis and Kouretas (2011) also found. The convergence in EPU indices has a positive and significant impact on stock market integration. This may suggest that the policy uncertainties in both economies elicited similar policy reactions to mitigate increasing risk, propelling integration. In contrast, we find no linkage between stock market integration and inflation/business cycle convergence, perhaps because the monetary authorities in both countries exhibited inconsistent anti-inflationary commitments.

Our results further show that peaks in gold and oil price volatilities have significantly increased integration. Since these commodities serve as hedges against high stock market volatility, higher demand could increase the volatility of their prices and hence increase stock market integration. During financial crises, the “flight to quality” phenomenon increased gold’s volatility, making a positive relationship between stock market integration and gold price volatility plausible under both fixed and floating exchange rates. This is consistent with Baur and Lucey’s (2010) finding that the gold market plays an important role as a safe-haven in changing market conditions. In contrast, the relationship between market integration and exchange rate volatility is not significant, corroborating Kim et al.’s (2005) evidence that stock market integration is not very sensitive to exchange rate volatility. We also find that stock market volatility is an important driver of stock market integration, thereby supporting the evidence that financial market linkages strengthen when market risk is higher (see Cai et al*.*, 2009; Pastor & Veronesi, 2012). We make sense of this result by noticing that the US market volatility has historically been higher than that of the UK, so that—the US being the larger market—export volatility to the UK and integration between the two markets heightens.

The 1987 stock market crash, 1992 European monetary system crisis, 1997/1998 Asian and Russian crisis, 2000/2002 dot-com bubble burst, 2003/2011 Iraq War, 2007/2009 global financial crisis, and 2010/2015 Eurozone debt crisis all significantly boosted integration. The increases in stock market correlation in times of currency crisis (e.g., the European and Asian currency crises) corroborate Baele’s (2005) findings. The influence of these episodes on stock market integration indicates some form of market contagion, in accord with Wang and Moore’s (2008) findings. Particularly, the crises originating from the US confirm that the US economy is an epicentre for transmitting financial shocks, hence strengthening the integration between the UK and US.

During the pre-BW period (1935–1945), convergence in business cycles stimulated stock market integration, while convergence in interest rates weakened it. A small caveat applies to the negative link between interest rates convergence and stock market integration, which, limitedly to the pre-BW period, turns out to be negative and marginally significant at the 10% only. But convergence in inflation rates and economic policy uncertainty shows no links with stock market integration. This suggests that expectations of rising inflation during the period of political and economic uncertainties caused convergence in the expansionary monetary policies of both economies, but with little or no effect on stock market integration.

Unexpectedly, the BW fixed exchange rate regime (1945–1971) showed no link between macroeconomic convergence and stock market integration. The fixed exchange rate regime adopted by the UK and US exacerbated divergence in macroeconomic policies, weakening integration. The inflationary economic policies pursued in the US diverged from the UK’s non-inflationary monetary policy. However, stock volatility increased integration. Overall, pegged exchange rates did little to promote stock market integration. This result is consistent with findings that financial market integration was limited under the BW fixed exchange rate regime (see Bordo, 1993; Marston, 1997). Thus, this evidence seems to invalidate our hypothesis that a fixed exchange regime should improve macroeconomic stability and then stimulate stock market integration.

During the post-BW period (1971–2015), convergence in interest rates significantly affected integration, suggesting that the stock markets were more sensitive to interest rates than to other macroeconomic indicators. We argue that the effect of positive shocks on yield spreads is associated with expectations of an expansionary cycle, so stock correlation increases when financial markets anticipate economic growth. Like Kizys and Pierdziorch (2006), we find no link between stock market integration and business cycle convergence. Also in this subperiod, we find that stock market volatility is positively associated with stock market integration. Similar to the results for the full period, the Asian and Russian crisis, dot-com burst, Iraq War, global financial crisis, and Eurozone debt crisis exerted positive and significant impacts on stock market integration.

In summary, our evidence shows that macroeconomic fundamentals, financial volatility, and crises episodes have influenced the evolution of stock market integration. Over time, the relative importance of the macroeconomic determinants of stock market integration varies, with different indicators becoming more or less influential depending on the features of the underlying regimes.

## *6.3. Robustness checks*

To investigate whether our results are driven by outliers in the correlation index, we first re-estimate equation (5) using alternative methods such as Least Absolute Deviations and Weighted Least Squares. The results obtained by applying such methods are in line with those of Table 6. Second, we restrict the dependent variable to values within its mean plus/minus three times its standard deviation. The number of observations available, in this case, drops from 956 to 950. Overall, the sign, magnitude, and statistical significance of the estimated parameters are consistent with those set out in Table 6. We then repeat the same exercises for the three partitioned samples, obtaining results similar to those already reported.

Finally, in the reported analysis, we used a VECM for modelling our mean equations, as specified in equations (1) and (2). Given that the evidence of co-integration is not unequivocal, we take the opposite stance and model the mean equations by means of VAR rather than VECM specifications. We then feed the usual ASY BEKK specification with the residuals obtained from the VAR model and apply equation (4) in order to obtain an alternative measure of conditional correlation. The correlation indices with and without ECM deliver similar results in tests for equality of means, medians, variances, and distributions. We then re-estimate equation (5) using the no-ECM correlation index as the dependent variable for the full sample, and we obtain results similar to those in Table 6.[[6]](#footnote-6)

Table 6

Empirical estimates of equation (5) for the full sample (1935-2015), and the subperiods 1935-1945 (pre-BW), 1945-1971 (BW), and 1971-2015 (post-BW).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Explanatory Variables | Full | Pre-BW | BW | Post-BW |
| *Macroeconomic Convergence* Output convergenceInflation convergenceInterest rate convergenceEconomic policy uncertainty convergence | 0.018(0.029)0.049(0.049)0.137\*\*\*(0.029)0.052\*(0.031) | 0.195\*\*\*(0.064)0.135(0.169)-0.481\*(0.275)0.091(0.086) | 0.040(0.051)-0.006(0.072)-0.039(0.041)0.055(0.042) | -0.029(0.041)0.003(0.085)0.135\*\*\*(0.047)0.041(0.049) |
| *Financial Volatility*Stock volatilityForeign exchange volatilityGold volatilityOil volatility | 0.014\*\*\*(0.004)-0.042(0.181)0.246\*\*\*(0.077)0.328\*\*\*(0.100) | 0.163\*\*\*(0.042)-(-)-(-)-(-) | 0.025\*\*\*(0.006)-(-)-(-)-(-) | 0.009\*\*(0.004)-0.065(0.163)-0.061(0.109)0.297\*\*\*(0.103) |
| *Crisis Episodes*World War IIKorean WarVietnam WarFirst global oil shock 1973/74 Second global oil shock 1979/801987 market crashIraq-Kuwait WarEuropean monetary system crisisMexican currency crisisAsian and Russian crisisDot-com burstAfghanistan WarIraq War Global financial crisisEurozone debt crisis | -0.001(0.023)-0.039\*(0.022)-0.015(0.013)-0.064(0.047)0.006(0.026)0.176\*(0.106)0.019(0.062)0.066\*\*\*(0.025)0.039(0.025)0.179\*\*\*(0.025)0.093\*\*\*(0.025)-0.002(0.029)0.110\*\*\*(0.027)0.095\*\*\*(0.024)0.094\*\*\*(0.024) | -0.053(0.055)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-) | -(-)-0.026(0.024)0.008(0.017)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-)-(-) | -(-)-(-)-(-)-0.031(0.042)0.002(0.027)0.143(0.106)0.016(0.063)0.031(0.027)-0.016(0.028)0.140\*\*\*(0.025)0.069\*\*\*(0.026)-0.018(0.031)0.107\*\*\*(0.028)0.111\*\*\*(0.028)0.092\*\*\*(0.025) |
| InterceptAdjusted R-squared | 0.157\*\*\*(0.024)0.457 | 0.898\*\*(0.443)0.308 | 0.138\*\*(0.053)0.246 | 0.279\*\*\*(0.040)0.362 |
| Observations | 956 | 122 | 311 | 523 |

Notes: The dependent variable in equation (5) is the estimated monthly correlation between the UK and US stock markets. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively. The method used to carry out estimations of the equation is OLS with White’s HAC covariance matrix. Standard errors in parentheses. Adjusted R-squared computed as $1- \frac{ee^{'}}{(N-k)} /\frac{\hat{y}\hat{y}^{'}}{(N-1)}$, where *e* and *ŷ* represent the residual and interpolated terms.

# Conclusions

This study demonstrates the influence of the international monetary system on stock market integration between the UK and the US from 1935 to 2015 and identifies the key drivers of this integration process. The evidence validates our hypothesis that periods of flexible exchange rates, deepening financial liberalization and macroeconomic policy convergence, and the phase-in of the European monetary union have led to higher stock market integration.

Since the end of the Bretton Woods system, the key drivers of integration have been convergence in interest rates, oil price volatility, and crises; only before that system existed did output convergence contribute to integration. Stock volatility remains a main driver across all three regimes. Surprisingly, EPU convergence is significant only in the very long run, when all 80 years are considered—perhaps because of increasing lack of autonomy in policy responses to levels of risk and uncertainty in the global economy. More interestingly, interest rate convergence exerts the greatest impact probably because—as a proxy of co-movement in the term structure of interest rates in the US and UK—it gauges co-movement in expectation of future economic growth and inflation. The BW fixed exchange rate regime was supposed to be the most stable monetary regime and thus to facilitate higher stock market integration, yet its macroeconomic fragility did otherwise. During this period, in fact, none of the convergence measures played a role in the process of market integration.

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1. Yield spread is defined as the difference between yields on 10-year Treasury notes and 3-month Treasury bills. [↑](#footnote-ref-1)
2. The two indices are obtained from Thomson Financial DataStream. [↑](#footnote-ref-2)
3. We extracted the monthly macro and financial data from the Federal Reserve Bank of St. Louis and from Global Financial Data. Series for the EPU indices are obtained fromwww.PolicyUncertainty.com. [↑](#footnote-ref-3)
4. Johansen tests incorporate both a linear trend and a constant, with lags selected by using BIC. [↑](#footnote-ref-4)
5. Such tests are computed by setting the time spans of stable periods equal to those of crisis periods. For instance, the stable period prior the GFC spans from September 2005 to July 2007, while the GFC period spans from August 2007 to June 2009.” [↑](#footnote-ref-5)
6. The results of the robustness checks are not reported but are available from the authors upon request. [↑](#footnote-ref-6)