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Abstract

This paper explores the influence of monetary policies, US influences, and other factors affecting stock prices in Japan from the beginning of the 1980s. The data set consists of monthly time series, largely taken from the Federal Bank of St. Louis (FRED) database in the USA. A variety of modelling and statistical techniques are applied which include regression analysis (OLS), cointegration and VECM analysis, plus the application of ARDL analysis and simulations. The results suggest that the adoption of QQE policy by the Japanese monetary authorities led to an upswing in Japanese share prices in the post-GFC period, whereas no such effect was apparent in the pre-GFC period.

Keywords: QQE, Japanese Share Prices,, Cointegration, VECM, ARDL, Simulations.
JEL: E52, G01, G12

1. Introduction

The financial crisis of 2007–2008, frequently termed the global financial crisis (GFC), was a severe worldwide economic crisis. Prior to the COVID-19 recession, it was considered by many economists to have been the most serious

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financial crisis since the Great Depression. It provoked some radical responses from the various national monetary authorities in countries around the world.

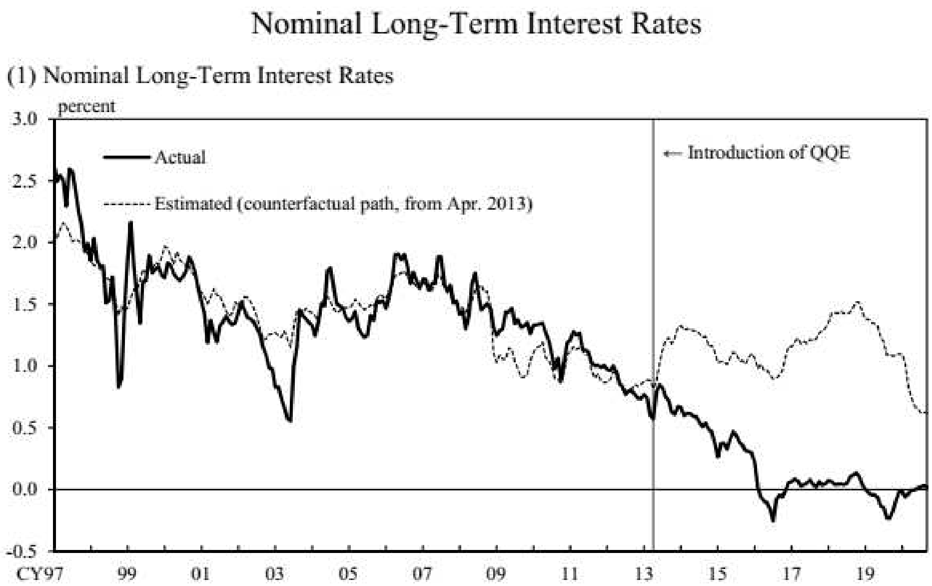
This paper focusses on the impact of the impact of the GFC in Japan via the responses it evoked from monetary authorities and assesses the impact of these policies, in combination with the impact of related changes in key economic variables, both in the USA and in Japan, with reference also to the recent economic shock produced by the global COVID-19 pandemic.

The GFC marked the second financial crisis faced by Japan in the course of two successive decades. However the two crises had different origins. The GFC and resultant financial stress in Japan had its origins in the the collapse of the housing and securitization markets in the United States, among others. By contrast, the crisis in the 1990s was the result of an internal or endogenous shock, since Japanese financial firms had then been deeply involved in the creation of a bubble in the domestic property market. This meant that Japanese Bank exposure to problem loans was much greater in the 1990s.

In April 2013, the BoJ introduced Quantitative and Qualitative Monetary Easing (QQE), which focused on the large-scale purchases of assets, primarily long-term Japanese Government Bonds (JGBs) and Exchange Traded Funds (ETFs). Consequently, the JGB long-term (10-year) nominal interest rates significantly declined as shown in Figure 1, which is taken from Kawamoto et al. (2021, p. 25).

Figure I shows a plot of nominal long-term interest rates and the more recent trend since the introduction of the policy of QQE. The dotted line depicts the counterfactual path for real interest rate is defined as the difference between the counterfactual paths for the nominal long-term interest rate and medium- to long-term inflation expectations, as modelled by Kawamoto et al. (2021).

Figure 1: Japanese Long Term Interest Rates



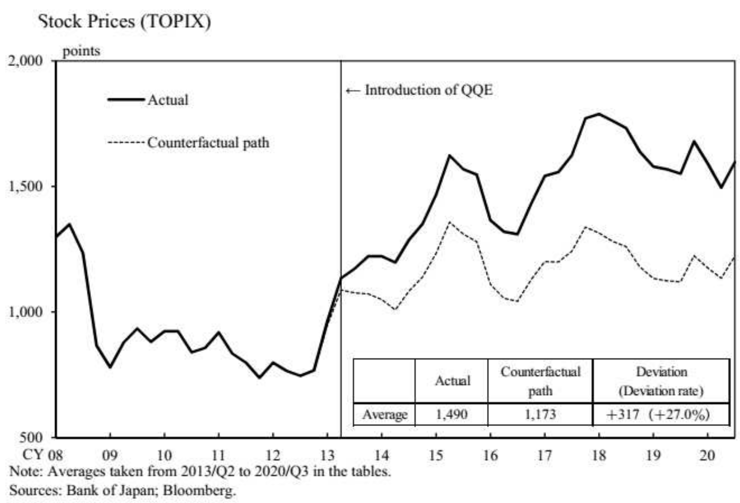
Source:Kawamoto, T., T. Nakazawa, Y. Kishaba, K. Matsumura, and J. Nakajima, (2021), Estimating effects of expansionary monetary policy since the introduction of Quantitative and Qualitative Monetary Easing (QQE) using the Macroeconomic Model (Q-JEM), supplementary paper series, Bank of Japan Working Paper Series, No.21-E-4, Chart 5.

There is a long history of prior work on the interactions between the US share market and the Japanese one. Campbell and Hamao (1992) examined the predictability of monthly excess returns on equity portfolios over the domestic short-term interest rate in the U.S. and Japan during the period 1971-1990. They suggested that similar variables, including the dividend-price ratio and interest rate variables, help to forecast excess returns in each country. In addition, in the 1980's U.S. variables help to forecast excess Japanese stock returns leading to their suggestion that the two markets are integrated. Karolyi and Stulz (1996) also explored the links between US and Japanese capital markets suggesting that large shocks to either market positively impact the magnitude and the persistence of return correlations.

Mizuno (2021) has examined the influence of QQE on the behaviour of

Japanese stock price trends and suggested that purchases under the QQE policy have lead to an upswing in Japanese share prices and that net-selling will potentially reverse this pattern. The Bank of Japan has also explored this issue in a time series Error-Correction (ECM) framework and has produced the analysis shown in Figure 2, (See: Kawamoto et al. (2021, p. 29). Their analysis suggests that Japanese share prices have been 27% higher than they otherwise would have been since the introduction of QQE.

Figure 2: Potential impact of QQE on Japanese Share Prices as modelled by the Bank of Japan



Source:Kawamoto, T., T. Nakazawa, Y. Kishaba, K. Matsumura, and J. Nakajima, (2021), Estimating effects of expansionary monetary policy since the introduction of Quantitative and Qualitative Monetary Easing (QQE) using the Macroeconomic Model (Q-JEM), supplementary paper series, Bank of Japan Working Paper Series, No.21-E-4, Chart 9.

The focus of this paper is to examine further the degree to which Japanese share price behaviour has become uncoupled from fundamentals since Quantitative Easing was adopted by monetary policy makers globally after the GFC, and more particularly, whether the adoption of the QQE policy by Japanese monetary authorities has had a major impact on Japanese share prices.

We use a monthly data series featuring Japanese and US stock price indices, money supply, long-term bond rates, industrial production, exchange rates, consumer confidence, and P/E ratios, largely taken from the Federal Bank of St. Louis (FRED) database in the USA. A variety of statistical and econometric techniques are used including Auto-Regressive distributed lag (ARDL) analysis, cointegration analysis, simulations, as well as OLS regression analysis.

The sample and the econometric methods adopted are described in section 2, the results are presented in section 3, and section 4 concludes.

2. Data and Econometric Methods

The authors decided to use a sample of monthly data taken from the Federal Bank of St. Louis (FRED) database in the USA, (see:https://fred.stlouisfed.org/) commencing in January 1980. We used the University of Michigan Monthly Comsumer Sentiment Series to track consumer sentiment in the USA [UMCSENT], and an Organization for Economic Co-operation and Development (OECD), Consumer Opinion Surveys of Confidence Indicators and their Composite Indicators of the OECD Indicator for Japan, [CSCICP03JPM665S], a monthly series, which was also drawn from FRED. In addition we used OECD measures of monthly share prices for the USA, [PASTT01USM661N] and for Japan [SPASTT01JPM661N], both of which were downloaded from FRED. We required monthly measures of the money supply in both countries. We used total [BOGMBASE] for the USA, which equals total monthly balances maintained plus currency in circulation, drawn from FRED, and a monthly measure of the Japanese money supply [MABMM301], taken from the OECD, plus an M3 OECD measure for Japan, [JPNMABMM301GYSAM] retrieved from FRED. We required a monthly industrial production series for both countries and sourced [INDPRO] from FRED for the USA. This is an economic indicator that measures real output for all facilities located in the United States manufacturing, mining, and electric, and gas utilities (excluding those in U.S. territories). For monthly industrial production in Japan we used [JPNPROINDMISMEI] which is an OECD measure that is available via FRED. We used a monthly series of the Japanese Yen/US dollar exchange rate [CCUSMA02JPM618N], which is also am OECD series available via FRED.

Finally, we required a series of monthly price/earnings (P/E) ratios for the two aggregate markets.We initially examined a monthly series of price/earnings (P/E) ratios for the USA from Robert Shiller's database at Yale University, but then realised we could get this series and series for Japan from Barclay's Bank website, https://indices.barclays/IM/21/en/indices/static/historic-cape.app, which draws on Shiller's measures. Campbell and Shiller (1998) used Dividend/Price ratios and smoothed Price/Earnings ratios to forecast a bearish outlook for the US capital market at the time.

We chose these particular series for our anlysis because there is a long history of research on the relationship between macro-economic variables, expectations and stock market movements. Chen, Roll and Ross (1986) explored the relationship between economic forces and the stock market and reported that the spread between long and short rates, unexpected and expected inflation, industrial production, and the spread between high and low grade bonds captured sources of risk that were priced in the market.

Fama (1981) explored the relationship between real stock returns, capital expenditures and output. Fama and French, K (1989) suggested that expected returns on common stocks and long-term bonds contain a term or maturity premium that contains a clear business-cycle pattern (low near peaks, high near troughs). Fama and Schwert (1977). examined the extent that various assets were hedges against the expected and unexpected components of the inflation rate during the period 1953–1971.

Bernanke and Gertler (2001) in an exploration of the policy implications of inflation targetting, suggested that, conditional on a strong policy response to expected inflation, they could see little evidence in their simulations of any additional gains from allowing an independent response of central bank policy to the level of asset prices. More recently Brunnmeir et al. (2021) in a US study use a structural VAR model of 10 monthly frequency variables, identified by heteroskedasticity. Negative reduced-form responses of output to credit growth are caused by endogenous monetary policy response to credit expansion shocks. They suggest that, on average, credit and output growth remain positively associated. For portions of the analysis in this paper we also adopt a VAR approach.

One of the difficulties encountered with the series used in this paper was that some of them were not available until the beginning of 1982, so the total sample, whilst initially comprising 495 monthly observations, ending in March 2021 was reduced by 24 observations to 471, and the Japanese monthly Industrial Production series had 494 observations.

2.1. Ordinary Least Squares Analyis

We initially analysed the relationship between all the series using Ordinary Least Squares (OLS) regression analysis. The basic model was constructed to examine the degree to which logarithmic differences or changes in the various series explained changes in Japanese share prices. The model estimated was:

$$ldTSJAP_t = \begin{array}{l} \alpha + \beta_1 ldTSUS_t + \beta_2 ldJAPMON_t + \beta_3 ldUSMON_t + \beta_4 ldUSSENT_t + \beta_5 ldJAPSENT_t + \\ \beta_6 ldUSPROD_t + \beta_7 ldJAPPROD_t + \beta_8 ldUSPE_t + \beta_9 ldJAPPE_t + \beta_{10} ldEXCHR_t + \varepsilon_t. \end{array} \quad (1)$$

We used logarithmic first differences to undertake this portion of the analysis, because we believed, as later confirmed by our empirical analysis, as presented in the next section, that these base series were likely to be non-stationary. This avoided the issue of spurious regression results, as first outlined by Granger and Newbold (1974). However, the fact that the base series are I(1) meant that we can utilise cointegration analysis.

2.2. Cointegration Analysis

It became apparent following the pioneering work by Engle and Granger (1987), subsequently cited in their Nobel Prize in Economics Award in 2003, that the levels of most macro-economic series are non-stationary. This implies that their variances and auto-covariances are a function of time. This feature also applies to the time series properties of most financial prices, including stock prices, in spot and futures formats. Non-stationary time series that need to be differenced once to become stationary are described as being integrated of order 1; I(1). By contrast stationary series do not need to be differenced to become stationary and are said to be integrated of order 0; I(0).

The crucial insight of Engle and Granger (1987) was that linear combinations of non-stationary series might become stationary, if they are viewed as possessing an equilibrium relationship which causes them to move in step through time. When we combine different series with different orders of integration we might expect the following relationships to hold:

$$x_t \sim I(0) \Rightarrow a + bx_t \sim I(0). \tag{2}$$

$$x_t \sim I(1) \Rightarrow a + bx_t \sim I(1). \tag{3}$$

$$x_t \sim I(0),\, y_t \sim I(1) \Rightarrow ax_t + by_t \sim I(1). \tag{4}$$

However, if cointegration exists, then:

$$x_t \sim I(1),\ y_t \sim I(1) \Rightarrow ax_t + by_t \sim I(0). \tag{5}$$

The Granger representation theorem suggests that if a set of variables are cointegrated, then there exists a valid error correction representation of the data, and vice-versa.

The Engle-Granger (1987) two step procedure for testing for the existence of cointegration suggests that we take two I(1) series and run a regression of one on the other:

$$y_t = \delta_0 + \delta_1 x_t + u_t. \tag{6}$$

This captures their long-run relationship, as it is a long-run equilibrium equation. The residuals from equation (5) are a measure of disequilibrium.

$$\hat{u}_t = y_t - \hat{\delta}_0 + \hat{\delta}_1 x_t.$$

A test of cointegration, is whether $\hat{u}_t$ in the equation above, is stationary. In the case where this holds our estimate of equation (5) is said to be super-consistent.

The Error Correction Model can be written as:

$$\triangle y_t = \phi_0 + \sum_{j=1} \phi_j \triangle y_{t-j} + \sum_{h=0} \phi_h \triangle x_{t-h} + \alpha \hat{u}_{t-1} \tag{7}$$

The Johansen (1991) test of cointegration is a more general procedure for testing cointegration of several, say k, I(1) time series which permits more than one cointegrating relationship. It utilises tests based either on the trace or eigenvalue. The null hypothesis for the trace test is that the number of cointegration vectors is $r = r^* < k$ versus the alternative that $r = k$. Testing proceeds sequentially for $r^* = 1, 2$, etc. and the first non-rejection of the null is taken as an estimate of r. A constant, a trend term, or both may be included. The model can be written as a general $VAR(\rho)$ model:

$$X_t = \mu + \Phi D_t + \Pi_p X_{t-p} + ... + \Pi_1 X_{t-1} + \varepsilon_t, \quad t = 1, ..., T. \tag{8}$$

If the model is written as a long-run vector error correction model (VECM), it can be written as:

$$\Delta X_t = \mu + \Phi D_t + \Pi X_{t-p} + \Gamma_{p-1} \Delta X_{t-p+1} + ... + \Gamma_1 \Delta X_{t-1} + \varepsilon_t, \quad t = 1, ..., T \tag{9}$$

where

$$\Gamma_i = \Pi_1 + ... + \Pi_i - I, \quad i = 1, ..., p-1.$$

We apply the Johansen test to the levels of some of our basic series to keep the analysis relatively straightforward.

2.3. ARDL analysis

We undertake the analysis using autoregressive distributed lag models (ARDL). We use a R package by Jordan and Philips (2020) called dynamac. They suggest that, in a typical ARDL model, the number of lags of the dependent variable in levels is given by p, the number of lags of the dependent variable in differences is given by m, the number of lags of the independent variables in levels is given by l, and the number of lags of the independent variables in differences is given by q. If we restricted all but the contemporaneous and first lag of each series to be zero, a simple ARDL model could be written as:

$$y_t = \alpha_0 + \phi_1 y_{t-1} + \theta_{1,0} x_{1,t-1} + \theta_{1,1} x_{1,t-1} + ...\theta_{k,0} x_{k,t-1} + \beta * T + \epsilon_t, \quad (10)$$

where $\alpha_0$is a constant and $\beta * T$ is a trend term. The usual convention is to add sufficient lags to the system to whiten the residuals.

There are a number of R library packages which undertake cointegration analysis using generalised testing approaches including, Natsiopoulos and Tzeremes (2021) ARDL, ECM and Bounds-Test for Cointegration (ARDL) package, plus Sun's asymmetric price transmission R package (apt, 2020), which facilitates the assessment of asymmetric price transmissions between two time series, and includes several functions for linear and nonlinear threshold cointegration analysis

The R package dynamac provides a means to use the coefficients from an estimated model to simulate meaningful responses in the dependent variable to counterfactual changes in an independent variable, x, allowing the change, y, to filter through the various forms of the x variable in the model, as well as different forms of the y variable (like differences and lagged levels) that might be included. We fit an ARDL model in ECM form, and then simulate the impact of one standard deviation shocks to the variable in question.

Pesaran et al. (2001) deloped a novel and even more general approach to the problem of testing the existence of a level relationship between a dependent variable and a set of regressors, when it is not known with certainty whether regressors are trend- or first-difference stationary. Two sets of asymptotic critical values are provided for the two polar cases which assume the regressors are, on the one hand, purely I(1) and, on the other, purely I(0). Since the two sets of critical values provide critical value bounds for all classifications of the regressors in I(1), purely I(0) or mutually cointegrated, they proposed a bounds testing procedure. If the Wald or F-statistic falls outside the critical value bounds, a conclusive inference can be drawn without needing to know the integration/cointegration status of the underlying regressors.

In the empirical analysis that follows we use the R library package Dynamac developed by Jordan and Philips (2020). They stress that autoregressive distributed lag (ARDL) models are a useful tool for estimating scientific processes over time. However, as the models become more complex by adding richness in dynamic specifications (through multiple lags of variables, either in levels or differences, or lags of the dependent variable), it becomes more difficult to draw meaningful inferences from coefficients alone. The dynamac program uses the estimated model coefficients to simulate the impact of a shock to one of the variables in the regression. This "shock" means that, at a time specified, the value of an x variable will move to some level. If the variable is in levels or lagged levels, this means that its new value becomes the pre-shock average plus whatever the shock value is. If the variable is in differences or lagged differences, the shock lasts for one period (as a permanent change in a differenced variable would imply that it is changing every period!).

3. Results

Table 1 presents a set of summary statistics for these monthly series and graphs of the series are presented in Figure 3. The graphs reveal the various shocks to the share price indices in the two countries following the 1987 financial crash, the 2007 Global Financial crisis and the more recent impact of COVID-19. The standard deviations of the two share market index series presented in Table 1 reveal that both markets have similar volatility, as captured by their standard deviations and positive skewness. It is apparent from the graphs in Figure 1 that consumer sentiment is much less volatile in Japan than in the

USA.

Unit root tests in the form of KPSS tests for all the series are presented in Table 1. All series reject the null-hypothesis of stationarity at the 1 per cent level with the exception of the Japanese consumer sentiment series which still rejects it at the 2 per cent level. These results suggest that the series are suitable candidates for cointegration analysis. The basic ordinary least squares (OLS) regression analysis of the series is therefore undertaken with first differences to ensure the stationarity of the variables. Further analysis, using levels of the series, can be undertaken with cointegration techniques.

The plots of industrial production and the descriptive statistics for the two countries reveal that industrial production is more volatile in the USA than in Japan, while P/E ratios are more volatile in Japan. The money supply in both countries has shown a strong upward trend and low volatility, while the Yen/US dollar exchange rate has shown a continuous downward trend.

Figure 3 shows plots of the various base series. Most show evidence of trending behaviour apart from the Japanese sentiment series which appears to show little variation which is confirmed by the summary statistics in Table 1 which suggest its standard deviation is roughly 8 times lower than that for US sentiment.

The basic OLS regression analysis for the pre-GFC period, 1982-2007, produced the results shown in Table 2. The variables showing a significant relationship with Japanese Index returns are US share price index returns, which are significant at the 1 percent level, changes in US sentiment, which are significant at a 10 percent level. The lagged change in the US money supply is significant at the 1 percent level, whilst the change in Japanese Industrial Production is significant at a 5 percent level. The Japanese P/E ratio and one lag of it are significant at the 1 percent level. Similarly the US P/E ratio and 1 lag of it are significant at the 1 percent level but have negative coefficients.

Table 1. Summary Statistics Base Series

Variable	Mean	Median	Minimum	Maximum	St.Dev	Skewness	Ex Kurtosis	No. Obs	KPSS Test with trend
US Share Index	53.643	55.526	5.7901	144.96	36.293	0.36309	−0.99087	495	0.402383***
JAP Share Index	85.386	85.709	29.385	184.33	30.546	0.37090	0.13132	495	0.605059***
US Money	6.3925e+012	4.8041e+012	1.4827e+012	1.9670e+013	4.2491e+012	0.99856	0.11180	494	1.81548***
Jap Money	8.9452e+014	9.6835e+014	2.9520e+014	1.4948e+015	3.0092e+014	−0.34825	−0.69380	494	1.36332***
US Sentiment	86.822	90.400	51.700	112.00	12.398	−0.52154	−0.36997	471	0.508438***
JAP Sentiment	100.00	100.01	94.863	102.51	1.4943	−0.58824	0.30425	468	0.197504**
US Ind Prod	83.071	90.505	47.829	112.05	19.663	−0.34051	−1.4238	495	1.21736***
JAP Ind Prod	97.542	100.51	69.070	119.47	11.394	−0.91403	0.28057	494	1.26567***
US P/E Ratio	23.944	23.580	8.0600	47.130	7.8151	0.61451	0.51448	471	0.989497***
JAP P/E Ratio	42.921	38.410	16.600	90.920	19.987	0.58971	−0.95396	471	0.904327***
US/Jap Exch. Rate	131.93	116.67	76.643	271.6	46.325	1.5460	1.2410	495	1.25347***

Note: *** Indicates Significance at the 1% level, ** Indicates Significance at the 5% level

Figure 3. Plots of the Basic Series

Table 2. OLS Regression Analysis (Period 1 1982:05--2007:12)

Model 4: OLS, using observations 1982:05–2007:12 ($T = 308$)
Dependent variable: ld_TSJAP

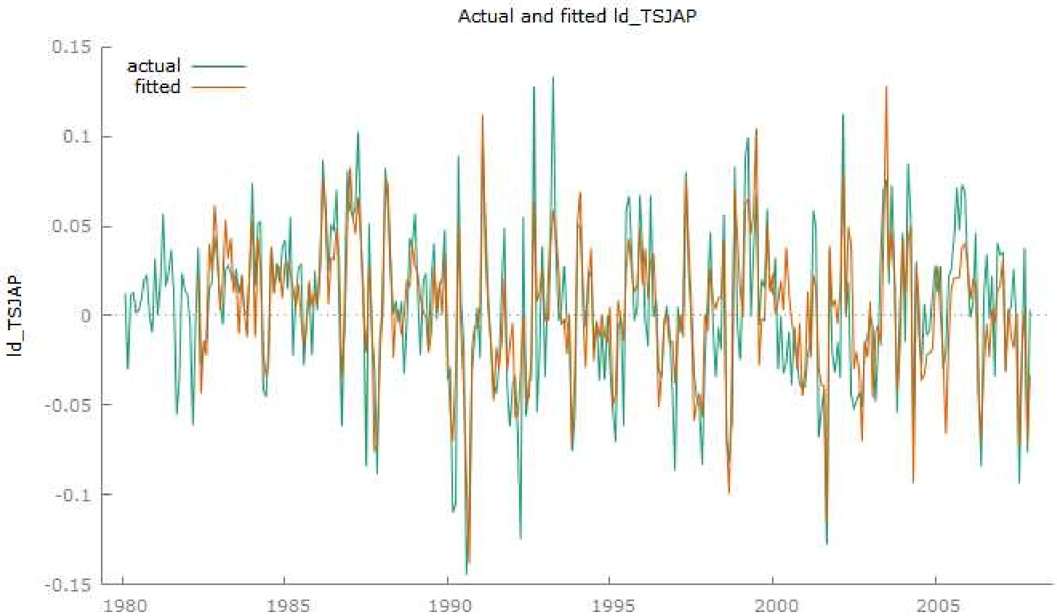
	Coefficient	Std. Error	t-ratio	p-value
const	0.00204593	0.00444241	0.4605	0.6455
ld_TSUS	0.587581	0.0869209	6.760	0.0000***
ld_IUMVCSENT	0.0686455	0.0411820	1.667	0.0967*
ld_JAPMON	−0.103248	1.01861	−0.1014	0.9193
ld_USMON	−1.03264	0.894225	−1.155	0.2492
ld_USMON_1	1.43171	0.544321	2.630	0.0090***
ld_CSCICP03JPM665S	2.43516	0.993910	2.450	0.0149**
ld_JAPINDPRO	0.275055	0.125525	2.191	0.0293**
ld_JAPPEBARC	0.374137	0.0268857	13.92	0.0000***
ld_JAPPEBARC_1	0.274552	0.0262879	10.44	0.0000***
ld_JAPPEBARC_2	0.0175146	0.0259033	0.6762	0.4995
ld_JAPPEBARC_3	−0.0244024	0.0257568	−0.9474	0.3443
ld_USAPRBARC	−0.236697	0.0583651	−4.055	0.0001***
ld_USAPRBARC_1	−0.107323	0.0534082	−2.009	0.0455**
ld_USAPRBARC_2	−0.0272265	0.0398975	−0.6824	0.4956
ld_USAPRBARC_3	0.0494754	0.0393399	1.258	0.2096
ld_USJAPEXCH	−0.133212	0.0662374	−2.011	0.0453**
ld_USINDPR	−0.113881	0.0968898	−1.175	0.2409
ld_USINDPR_1	−0.203967	0.115462	−1.767	0.0784*
ld_USINDPR_2	−0.132021	0.117291	−1.126	0.2613
ld_USINDPR_3	−0.179617	0.0962782	−1.866	0.0632*
sq_ld_IUMVCSENT	−0.366994	0.393624	−0.9323	0.3520
sq_ld_TSUS	−1.19985	0.905104	−1.326	0.1861
sq_ld_TSJAP	1.51661	0.567331	2.673	0.0080**
sq_ld_JAPMON	31.0169	82.8927	0.3742	0.7086
sq_ld_USMON	−6.30580	49.4634	−0.1275	0.8987
sq_ld_CSCICP03JPM665S	−432.100	389.861	−1.108	0.2687
sq_ld_USINDPR	−8.21026	2.69435	−3.047	0.0025***
sq_ld_JAPINDPRO	4.91415	6.16148	0.7976	0.4258
sq_ld_JAPPEBARC	−0.597203	0.149663	−3.990	0.0001***
sq_ld_USAPRBARC	0.194096	0.453127	0.4283	0.6687
sq_ld_USJAPEXCH	−0.398694	1.31102	−0.3041	0.7613

Mean dependent var	0.003362	S.D. dependent var	0.044976
Sum squared resid	0.198404	S.E. of regression	0.026811
R^2	0.680517	Adjusted R^2	0.644633
$F(31, 276)$	18.96440	P-value(F)	1.14e–51
Log-likelihood	694.4897	Akaike criterion	−1324.979
Schwarz criterion	−1205.616	Hannan–Quinn	−1277.253
$\hat{\rho}$	0.008556	Durbin–Watson	1.975111

RESET test for specification –

Null hypothesis: specification is adequate
Test statistic: $F(2, 274) = 2.76289$
with p-value = $P(F(2, 274) > 2.76289) = 0.0648681$

Figure 4. Plot of Actual versus Fitted Period 1 Pre-GFC



The US/Japanese Exchange rate change is significant at the 5 percent level and has a negative sign. 1 and 3 lags of the change in US Industrial Production are significant at the 10 percent level and have negative signs.

The square of 3 lags of the changes in Japanese share prices was significant at a 5 per cent level, as was the square of US Industrial production at the 1 percent level with a negative sign. Finally, the square of the Japanese P/E ratio was significant at the 1 percent level with a negative sign. The table shows the OLS regression results of running an augmented version of model. We included up to 3 lags of certain variables. Ramsey Reset Tests of the regression specification suggested that we should add squares of variables. The regression proved to be quite effective and explained over 64 percent, in terms of its Adjusted R-square, of the dependent variable, the logarithmic difference in Japanese share price index, in effect the continuously compounded monthly share returns, for the pre-global financial crisis period, terminating at the end of 2007. The figures display plots of the fitted and actual series over this time interval.

We then ran the same regression with an identical specification post the GFC using data from 2008 onwards but without adding the squares of variables, as the Reset Test suggested that the specification was correct. The results of this more simple OLS regression are shown in Table 3. This regression was even more effective with an Adjusted R-square of almost 86 per cent. US share returns are significant at a 1 percent level as are changes in the US money supply which are also significant at a 1 percent level but have a negative sign. Changes in Japanese sentiment are significant at the 10 percent level. Changes in the Japanese P/E ratio and one lag of it have positive coefficients significant at the 1 percent level. The reverse applies to one and two lags of the coefficients on US P/E ratio which are significant at the 5 percent level and have negative signs. There is a positive coefficient on changes in the US/Japanese exchange rate which is significant at the 1 percent level. The Durbin Watson statistic is close to 2 and the regression itself is highly significant.

The results of the regressions in the two periods are not strongly supportive of the basic hypothesis adopted in the paper, namely that changes in Japanese monetary policy post-GFC have an impact on Japanese share prices. In these two regressions, the coefficients on changes in the Japanese money supply are not significant. However, whilst insignificant in the first period, in the second, post GFC period, changes in the US money supply become significant with a negative coefficient. The model was even more successful in this period with an increase in the Adjusted R-Square to over 85 percent. A plot of the actual versus fitted is shown in Figure 5.

Table 3. OLS Regression Period 2 Post GFC (2008:01--2020:12)

OLS, using observations 2008:01–2020:12 ($T = 156$)
Dependent variable: ld_TSJAP

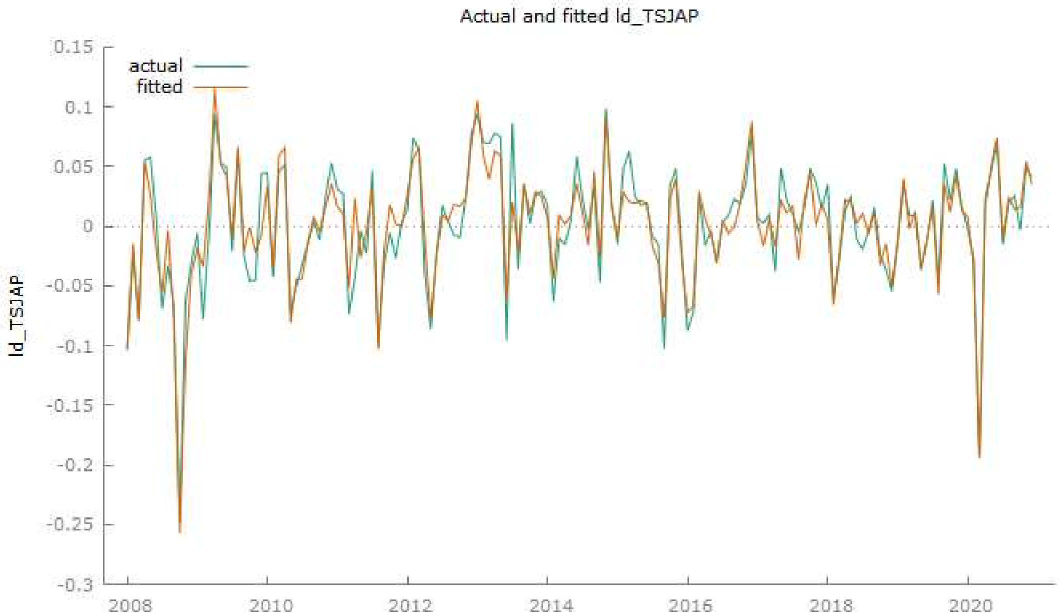
	Coefficient	Std. Error	t-ratio	p-value
const	−0.00133932	0.00286912	−0.4668	0.6414
ld_TSUS	0.744117	0.0655719	11.35	0.0000***
ld_IUMVCSENT	−0.0191461	0.0351700	−0.5444	0.5871
ld_JAPMON	−0.608933	1.29681	−0.4696	0.6394
ld_USMON	1.06373	0.442232	2.405	0.0175**
ld_USMON_1	−0.277193	0.428576	−0.6468	0.5189
ld_CSCICP03JPM665S	1.32666	0.693355	1.913	0.0578*
ld_JAPINDPRO	0.113371	0.0716648	1.582	0.1160
ld_JAPPEBARC	0.193760	0.0371523	5.215	0.0000***
ld_JAPPEBARC_1	0.126076	0.0378932	3.327	0.0011***
ld_JAPPEBARC_2	−0.00800894	0.0350957	−0.2282	0.8198
ld_JAPPEBARC_3	−0.0105754	0.0321474	−0.3290	0.7427
ld_USAPRBARC	−0.152926	0.0603501	−2.534	0.0124**
ld_USAPRBARC_1	−0.123472	0.0587203	−2.103	0.0373**
ld_USAPRBARC_2	−0.0615524	0.0506538	−1.215	0.2264
ld_USAPRBARC_3	−0.00165506	0.0478060	−0.03462	0.9724
ld_USJAPEXCH	0.791894	0.0939528	8.429	0.0000***
ld_USINDPR	0.144711	0.111049	1.303	0.1947
ld_USINDPR_1	−0.00564396	0.105205	−0.05365	0.9573
ld_USINDPR_2	−0.111344	0.0950932	−1.171	0.2437
ld_USINDPR_3	0.0435562	0.0794375	0.5483	0.5844

Mean dependent var	0.001075	S.D. dependent var	0.051040
Sum squared resid	0.049775	S.E. of regression	0.019202
R^2	0.876729	Adjusted R^2	0.858467
$F(20, 135)$	48.00745	P-value(F)	2.03e–51
Log-likelihood	406.5529	Akaike criterion	−771.1058
Schwarz criterion	−707.0588	Hannan–Quinn	−745.0927
$\hat{\rho}$	0.068806	Durbin–Watson	1.861588

RESET test for specification –

Null hypothesis: specification is adequate
Test statistic: $F(2, 133) = 0.758578$
with p-value $= P(F(2, 133) > 0.758578) = 0.470347$

Figure 5. OLS actual versus fitted post GFC



3.1. Cointegration Analysis

The simple OLS regression analysis did not pick up any of the information contained in the levels of the basic series whereas cointegration analysis does. Given a central focus of the paper is the linkage between changes in monetary policy and changes in Japanese share prices the most simple analysis was to use simple Engle-Granger cointegration analysis across the two variables in the two sub periods of interest. However, various specifications for this analysis, with and without a constant and a trend failed to pick up any evidence of cointegration, in that ADF tests of the residuals failed to reject the null hypothesis of a unit root. However, these tests have low power.

We estimated a VECM involving the variables representing the levels of the Japanese and US share price indices, the Japanese and US money supplies and included 6 lags. The results are presented in Table 4 for period 1 which runs from 1982-2007.

The results of the estimation suggested that there is at least 1 cointegrating vector which was estimated using an unrestricted trend and a constant. The first portion of Table 4 reports the cointegrating and adjustment vectors. Equation 1 in Table 4 reports the coefficients estimated for the variables driving the adjustments to Japanese share prices. It suggests that 1 lag and 4 lags of the change in Japanese share index returns are significant at the 1 and 5 percent levels respectively. None of the lagged changes in US share index returns is significant, whilst the 4th lag of the change in Japanese money supply is significant at a 10 percent level. None of the lagged changes in US money supply are significant and neither is the trend term captured by 'time', or the error correction term named 'ECI'. This suggests that these are short-term effects.

Table 4: VECM system, lag order 6
Maximum likelihood estimates, observations 1980:07–2007:12 ($T = 330$)
Cointegration rank = 1
Case 5: Unrestricted trend and constant

Cointegrating vectors (standard errors in parentheses)

$TSJAP_{t-1}$	1.00000
	(0.000000)
$TSUS_{t-1}$	−2.86422
	(0.864851)
$JAPMON_{t-1}$	0.000000
	(1.70527e–013)
$USMON_{t-1}$	−3.54698e–011
	(1.96739e–011)

Adjustment vectors

$TSJAP_{t-1}$	1.00000
$TSUS_{t-1}$	−0.532467
$JAPMON_{t-1}$	−1.20335e+012
$USMON_{t-1}$	2.20770e+010

Log-likelihood = −19251.9

Determinant of covariance matrix = 5.53223e+045
AIC = 117.3087
BIC = 118.5060
HQC = 117.7863

Equation 1: ΔTSJAP

	Coefficient	Std. Error	t-ratio	p-value
const	0.812826	0.766785	1.060	0.2900
ΔTSJAP$_{t-1}$	0.371794	0.0620732	5.990	0.0000
ΔTSJAP$_{t-2}$	−0.0623204	0.0657240	−0.9482	0.3438
ΔTSJAP$_{t-3}$	−0.0970528	0.0663355	−1.463	0.1445
ΔTSJAP$_{t-4}$	0.135609	0.0664186	2.042	0.0420
ΔTSJAP$_{t-5}$	−0.00172814	0.0625759	−0.02762	0.9780
ΔTSUS$_{t-1}$	−0.109892	0.192646	−0.5704	0.5688
ΔTSUS$_{t-2}$	0.0648963	0.198544	0.3269	0.7440
ΔTSUS$_{t-3}$	0.294179	0.200592	1.467	0.1435
ΔTSUS$_{t-4}$	−0.119645	0.201483	−0.5938	0.5531
ΔTSUS$_{t-5}$	0.0855082	0.202151	0.4230	0.6726
ΔJAPMON$_{t-1}$	1.75950e–013	1.65590e–013	1.063	0.2888
ΔJAPMON$_{t-2}$	−1.11017e–013	1.65080e–013	−0.6725	0.5018
ΔJAPMON$_{t-3}$	0.000000	1.69892e–013	−0.06979	0.9444
ΔJAPMON$_{t-4}$	−2.72671e–013	1.62748e–013	−1.675	0.0949
ΔJAPMON$_{t-5}$	1.61319e–013	1.65620e–013	0.9740	0.3308
ΔUSMON$_{t-1}$	2.74162e–011	1.89272e–011	1.449	0.1485
ΔUSMON$_{t-2}$	8.98375e–012	1.92616e–011	0.4664	0.6413
ΔUSMON$_{t-3}$	−9.96928e–012	1.88692e–011	−0.5283	0.5976
ΔUSMON$_{t-4}$	7.55055e–012	1.92219e–011	0.3928	0.6947
ΔUSMON$_{t-5}$	−2.63838e–011	1.93699e–011	−1.362	0.1742
time	−0.0100370	0.00772924	−1.299	0.1951
EC1	−0.00515244	0.00742450	−0.6940	0.4882

Mean dependent var	0.202907	S.D. dependent var	4.340804
Sum squared resid	5157.725	S.E. of regression	4.098830
R^2	0.168003	Adjusted R^2	0.108381
$\hat{\rho}$	0.011243	Durbin–Watson	1.976839

Table 4 (contd): Equation 2: ΔTSUS

	Coefficient	Std. Error	t-ratio	p-value
const	0.0591114	0.248105	0.2383	0.8118
ΔTSJAP$_{t-1}$	−0.0121039	0.0200848	−0.6026	0.5472
ΔTSJAP$_{t-2}$	−0.00303895	0.0212660	−0.1429	0.8865
ΔTSJAP$_{t-3}$	−0.0148137	0.0214639	−0.6902	0.4906
ΔTSJAP$_{t-4}$	0.0287194	0.0214908	1.336	0.1824
ΔTSJAP$_{t-5}$	−0.0230262	0.0202474	−1.137	0.2563
ΔTSUS$_{t-1}$	0.177856	0.0623336	2.853	0.0046
ΔTSUS$_{t-2}$	−0.0876069	0.0642419	−1.364	0.1737
ΔTSUS$_{t-3}$	0.0556196	0.0649047	0.8569	0.3921
ΔTSUS$_{t-4}$	−0.114564	0.0651930	−1.757	0.0799
ΔTSUS$_{t-5}$	0.186149	0.0654092	2.846	0.0047
ΔJAPMON$_{t-1}$	0.000000	0.000000	−0.6839	0.4945
ΔJAPMON$_{t-2}$	0.000000	0.000000	−0.1064	0.9154
ΔJAPMON$_{t-3}$	0.000000	0.000000	0.5617	0.5747
ΔJAPMON$_{t-4}$	0.000000	0.000000	0.2485	0.8039
ΔJAPMON$_{t-5}$	0.000000	0.000000	−1.221	0.2229
ΔUSMON$_{t-1}$	1.31248e–011	6.12421e–012	2.143	0.0329
ΔUSMON$_{t-2}$	−1.78814e–013	6.23239e–012	−0.02869	0.9771
ΔUSMON$_{t-3}$	−2.99185e–012	6.10542e–012	−0.4900	0.6245
ΔUSMON$_{t-4}$	2.70689e–012	6.21954e–012	0.4352	0.6637
ΔUSMON$_{t-5}$	5.96796e–013	6.26744e–012	0.09522	0.9242
time	0.00330299	0.00250092	1.321	0.1876
EC1	0.00274351	0.00240232	1.142	0.2543

Mean dependent var	0.258798	S.D. dependent var	1.339597
Sum squared resid	539.9872	S.E. of regression	1.326241
R^2	0.085383	Adjusted R^2	0.019840
$\hat{\rho}$	0.002683	Durbin–Watson	1.993528

Equation 3: ΔJAPMON

	Coefficient	Std. Error	t-ratio	p-value
const	7.26951e+011	2.64545e+011	2.748	0.0064
ΔTSJAP$_{t-1}$	−1.03629e+010	2.14156e+010	−0.4839	0.6288
ΔTSJAP$_{t-2}$	5.45616e+010	2.26752e+010	2.406	0.0167
ΔTSJAP$_{t-3}$	6.26224e+009	2.28862e+010	0.2736	0.7846
ΔTSJAP$_{t-4}$	2.59663e+010	2.29148e+010	1.133	0.2580
ΔTSJAP$_{t-5}$	−6.70142e+009	2.15891e+010	−0.3104	0.7565
ΔTSUS$_{t-1}$	9.01713e+010	6.64640e+010	1.357	0.1759
ΔTSUS$_{t-2}$	−3.89386e+010	6.84987e+010	−0.5685	0.5701
ΔTSUS$_{t-3}$	−8.95596e+010	6.92055e+010	−1.294	0.1966
ΔTSUS$_{t-4}$	−3.61406e+010	6.95129e+010	−0.5199	0.6035
ΔTSUS$_{t-5}$	1.50275e+011	6.97434e+010	2.155	0.0320
ΔJAPMON$_{t-1}$	0.101474	0.0571295	1.776	0.0767
ΔJAPMON$_{t-2}$	0.289244	0.0569535	5.079	0.0000
ΔJAPMON$_{t-3}$	0.119031	0.0586140	2.031	0.0431
ΔJAPMON$_{t-4}$	0.132442	0.0561492	2.359	0.0190
ΔJAPMON$_{t-5}$	0.0600128	0.0571400	1.050	0.2944
ΔUSMON$_{t-1}$	5.80755	6.53002	0.8894	0.3745
ΔUSMON$_{t-2}$	6.88861	6.64536	1.037	0.3007
ΔUSMON$_{t-3}$	8.35922	6.50998	1.284	0.2001
ΔUSMON$_{t-4}$	0.365349	6.63166	0.05509	0.9561
ΔUSMON$_{t-5}$	2.46398	6.68274	0.3687	0.7126
time	3.66081e+009	2.66664e+009	1.373	0.1708
EC1	6.20021e+009	2.56150e+009	2.421	0.0161

Mean dependent var	2.20e+12	S.D. dependent var	2.08e+12
Sum squared resid	6.14e+26	S.E. of regression	1.41e+12
R^2	0.567757	Adjusted R^2	0.536782
$\hat{\rho}$	−0.012935	Durbin–Watson	2.021603

Table 4 (contd) Equation 4: ΔUSMON

	Coefficient	Std. Error	t-ratio	p-value
const	2.59335e+009	2.35138e+009	1.103	0.2709
$\Delta TSJAP_{t-1}$	2.42520e+008	1.90350e+008	1.274	0.2036
$\Delta TSJAP_{t-2}$	2.53526e+008	2.01545e+008	1.258	0.2094
$\Delta TSJAP_{t-3}$	−1.68357e+008	2.03420e+008	−0.8276	0.4085
$\Delta TSJAP_{t-4}$	5.63022e+007	2.03675e+008	0.2764	0.7824
$\Delta TSJAP_{t-5}$	−1.12879e+008	1.91891e+008	−0.5882	0.5568
$\Delta TSUS_{t-1}$	−6.97243e+008	5.90756e+008	−1.180	0.2388
$\Delta TSUS_{t-2}$	−7.01261e+008	6.08842e+008	−1.152	0.2503
$\Delta TSUS_{t-3}$	−4.54418e+008	6.15123e+008	−0.7387	0.4606
$\Delta TSUS_{t-4}$	−2.89679e+008	6.17856e+008	−0.4688	0.6395
$\Delta TSUS_{t-5}$	−1.56586e+009	6.19904e+008	−2.526	0.0120
$\Delta JAPMON_{t-1}$	0.000125040	0.000507788	0.2462	0.8057
$\Delta JAPMON_{t-2}$	0.000239600	0.000506223	0.4733	0.6363
$\Delta JAPMON_{t-3}$	0.000157822	0.000520982	0.3029	0.7621
$\Delta JAPMON_{t-4}$	0.00115054	0.000499074	2.305	0.0218
$\Delta JAPMON_{t-5}$	0.000220250	0.000507881	0.4337	0.6648
$\Delta USMON_{t-1}$	0.171360	0.0580411	2.952	0.0034
$\Delta USMON_{t-2}$	0.0215784	0.0590664	0.3653	0.7151
$\Delta USMON_{t-3}$	0.158870	0.0578630	2.746	0.0064
$\Delta USMON_{t-4}$	−0.184032	0.0589446	−3.122	0.0020
$\Delta USMON_{t-5}$	−0.00868482	0.0593986	−0.1462	0.8838
time	−7.03287e+007	2.37020e+007	−2.967	0.0032
EC1	−1.13750e+008	2.27675e+007	−4.996	0.0000

Mean dependent var	1.80e+10	S.D. dependent var	1.54e+10
Sum squared resid	4.85e+22	S.E. of regression	1.26e+10
R^2	0.379539	Adjusted R^2	0.335076
$\hat{\rho}$	−0.018278	Durbin–Watson	2.035612

Cross-equation covariance matrix

	$\Delta TSJAP$	$\Delta TSUS$	$\Delta JAPMON$	$\Delta USMON$
$\Delta TSJAP$	15.6295	2.03087	2.46803e+011	−5.21830e+009
$\Delta TSUS$	2.03087	1.63632	−4.51763e+010	−2.68984e+009
$\Delta JAPMON$	2.46803e+011	−4.51763e+010	1.86036e+024	2.40101e+021
$\Delta USMON$	−5.21830e+009	−2.68984e+009	2.40101e+021	1.46974e+020

determinant = 5.53223e+045

The adjusted R-square for this equation is close to 11 percent and the DW statistic is close to 2, suggesting that autocorrelation of the residuals is not an issue.

Equation 2 in Table 4 shows factors driving changes in the US share price index. All the lagged values of the change in the Japanese share price index have no significant effect, whilst 1, 4, and 5 lags of changes in the US share price index are significant at 1, 10, and 1 percent levels respectively. Lagged changes in the Japanese money supply have no effect, while 1 lag of the change in the US money supply is significant at the 5 percent level. The time trend and the error correction term are insignificant, and the adjusted R-square is a low 1.9 percent.

Equation 3 in Table 4 shows factors driving changes in the Japanese money supply. The constant is significant at a 1 percent level, while 2 lags of the changes in Japanese share prices are significant at a 5 percent level. The lagged changes in US share prices have no significant effect, while the first 4 lags of changes in the Japanese money supply are significant at 10, 1, 5, and 5 percent levels respectively. The trend term in the equation is insignificant while the error correction term is significant at a 5 percent level. The adjusted R-square for this equation is nearly 54 percent and the Durbin-Watson statistic is 2.02.

Finally, equation 4 in Table 4 shows the factors driving changes in the US money supply in the first period prior to 2008. Neither the constant, nor any lags of changes in Japanese share prices are significant. The fifth lag of changes in US share prices is negatively significant at a 5 percent level. The fourth lag of changes in the Japanese Money supply has a positive coefficient and is significant at a 5 percent level. The first and third lags of changes in the US money supply have positive coefficients and are significant at a 1 percent level, whilst the fourth lag of changes in the US money supply is also significant at a 1 perecnet level but has a negative coefficient. Both the time trend and the error correction term have negative coefficients and are significant at a 1 percent level. The adjusted R-squared of this equation is 33.5 percent and the Durbin-Watson statistic is 2.03.

The overall impression, given by this set of equations in the VECM analysis for period 1, is that changes in monthly share prices are subject to short term effects but changes to the Japanese and US money supplies are subject to error-correction effects and are cointegrated. This is apparent in the fact that that their error correction terms are significant and their equations have more explanatory power reflected in higher adjusted R-squares, particularly in the case of the terms driving chnages in the Japanese Money supply which explain about 54 percent of its variation in this period.

Figure 6 presents the results of impulse response analysis of shocks to variables in the system in the first period. The grey areas in the lines in the graphs in Figure 6 represent estimates of 95 percent error bands. The first variable in each graph heading is the variable shocked and the second variable is the one subject to the tracing out of the impact within the estimated VECM. The first graph on the top line of Figure 6, shows the impact of a shock to Japanese share prices on Japanese share prices, so this, though significant, can be ignored for our current purposes, as we are interested in the inter-actions between variables in the system. Of more interest is the impact of a shock to US share prices but the second graph on the top row of Figure 6 shows that the error bands span zero. This is the case for all graphs on the first two rows in Figure 6.

The second two rows in Figure 6 are of more interest. A shock to total shares in Japan has an impact on the Japanese money supply but not a shock to US share returns. If we ignore the effect of a shock to Japanese money on

Japanese money, then the next graph in the third row of Figure 6 shows that a shock to US money also has an effect on Japanese money. In the final row of Figure 6 it is clear in the third diagram that a shock to Japanese money has an effect on US money.

Figure 6 Graphs of shocks to variables in Cointegration Analysis pre GFC period (1982-2007)

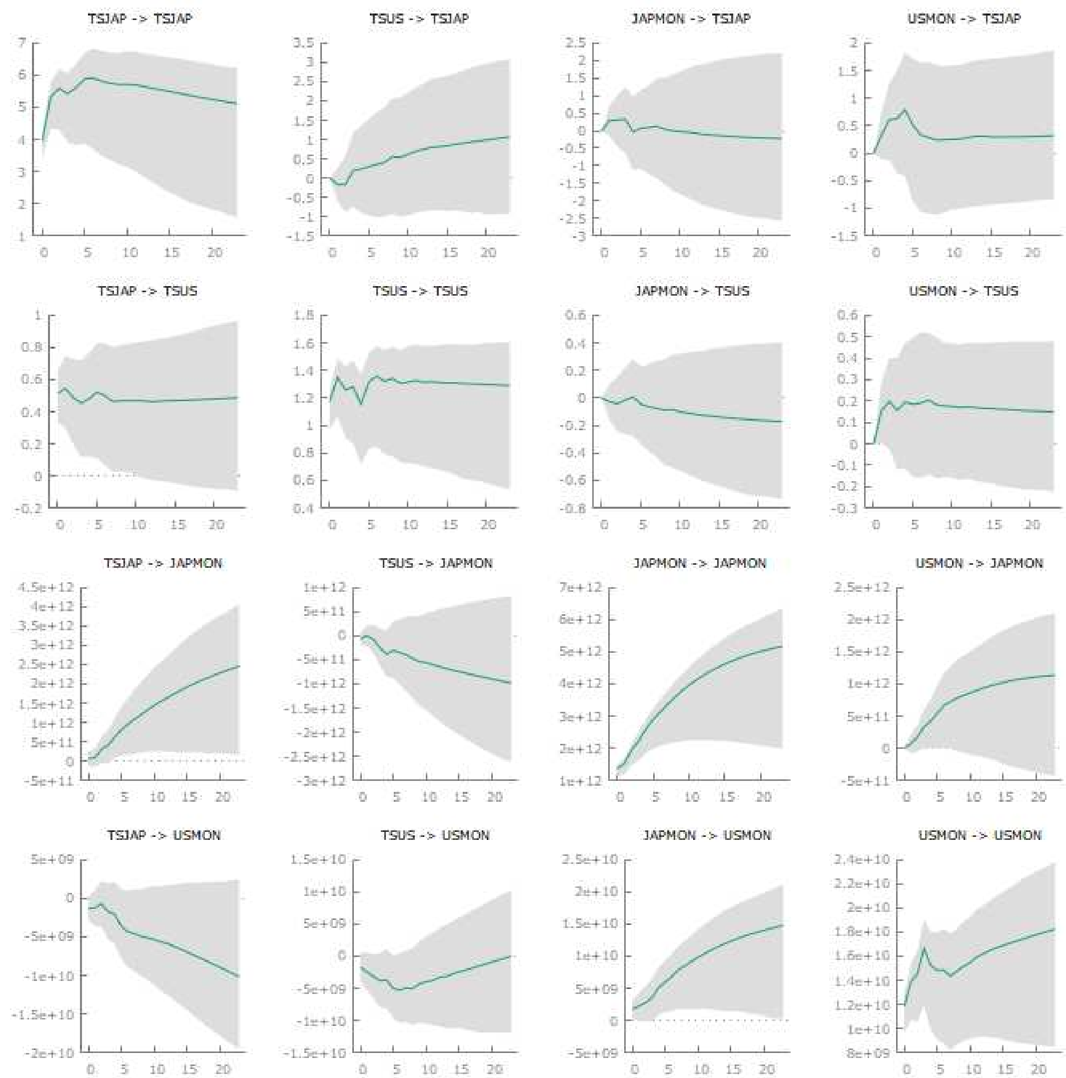


Table 5 presents the results of the VECM analysis in Period 2 which runs from 2008-2021. Equation 1 shows the variables that have an impact on the change in total share returns in Japan. The constant is significant at the 5 percent level. The first lagged change of share prices in Japan is significant at the 10 percent level but none of the other lagged changes in this variable are significant. None of the lagged changes in the Japanese money supply are significant. Similarly, none of the lagged changes in either US share prices or US money supply are significant. The time trend is insignificant but the error correction term (ECI) is significant at the 1 percent level. The adjusted R-squared is slightly lower than in the first period with a value of just under 9 percent, whilst the Durbin Watson statistic is 1.96.

The second equation in Table 5 shows factors driving the change in the Japanese money supply. The constant is insignificant but 1 and 5 lags of the change in Japanese share prices are significant at the 5 and 1 percent levels respectively. The 4th lag of changes in US share prices is significant at the 10 percent level, whilst the first 2 lags of changes in the US money supply are significant at the 1 percent level. The time trend is insignificant but the error correction term is significant at the 10 percent level. The adjusted R-squared is 81 percent and the Durbin Watson statistic is 2.

The third equation in Table 5 shows the factors driving changes in US share prices. In this equation the constant is significant at the 1 percent level, but none of the lagged changes in Japanese share prices have an impact. The second lag of changes in the Japanese money supply is significant at the 10 percent level, while 1 lag of changes in US share prices is significant at the 10 percent level. None of the lagged changes in the US money supply are significant and this also applies to the time trend. However, the error correction term is significant at the 1 percent level. The adjusted R-squared is

12 percent and the Durbin Watson statistic is 1.97.

Equation 4 in Table 5 shows factors driving changes in the US money supply. The constant and all lagged changes in Japanese share prices are insignificant. The first two lags of changes in the Japanese money supply are significant at the 10 and 5 percent levels respectively. One and three lags of changes in US share prices are significant at the 1 percent level. The first two lags of changes in the US money supply are significant at a 1 percent level, yet both the time trend and error correction term are insignificant. The adjusted R-squared is almost 69 percent and the Durbin Watson statistic is 2.01.

The difference in the explanatory power of the VECM system pre, and post-GFC, is quite apparent. Prior to 2008, the Adjusted R-squares of changes in Japanese and US Share prices, and changes in Japanese and US money supplies, are 11 percent, 2 percent, 54 percent and 34 percent respectively. After the GFC, from 2008 onwards, these values decrease to 8.8 percent, in the case of changes in Japanese share prices, but increase to 12.3 percent in the case of changes to US share prices, and to a remarkable 81 percent in the case of changes to the Japanese money supply, and to almost 69 percent in the case of changes to the US money supply. The implication is that in both countries, following the GFC, changes in money supply become much more predictable, as do changes in US share prices.

The analysis of shocks to the variables in the post-GFC period from 2008 onwards, shows that apart from self-shocks to individual variables, the most notable effects are in the third and fourth graphs in row 2 of Figure 7, which reveal that both shocks to US share prices and to US money supply have an impact on the Japanese money supply. In the third row of the figure, in the first graph, shocks to Japanese share prices have an impact on US share prices, and in the fourth graph in this row, shocks to US money have an impact on

US share prices. In the final row of the figure, it can be seen in the first graph, that shocks to Japanese share prices have an impact on the US money supply, and similarly, in the third graph, that shocks to share prices in the US, also have an impact on the the US money supply.

Table 5: VECM system, lag order 6
Maximum likelihood estimates, observations 2008:01–2021:02 ($T = 158$)
Cointegration rank = 1
Case 5: Unrestricted trend and constant

Cointegrating vectors (standard errors in parentheses)	$TSJAP_{t-1}$	1.00000
		(0.000000)
	$JAPMON_{t-1}$	7.86020e–012
		(9.84481e–012)
	$TSUS_{t-1}$	31.6653
		(8.61524)
	$USMON_{t-1}$	−7.05052e–010
		(3.60177e–010)

Adjustment vectors	$TSJAP_{t-1}$	1.00000	Log-likelihood = −9494.29
	$JAPMON_{t-1}$	2.01344e+011	
	$TSUS_{t-1}$	1.18862	
	$USMON_{t-1}$	5.50553e+009	

Determinant of covariance matrix = 1.83651e+047

AIC = 121.4973

BIC = 123.5132

HQC = 122.3160

Equation 1: ΔTSJAP

	Coefficient	Std. Error	t-ratio	p-value
const	17.2713	7.00191	2.467	0.0149
ΔTSJAP$_{t-1}$	0.253612	0.143843	1.763	0.0801
ΔTSJAP$_{t-2}$	0.206554	0.149585	1.381	0.1696
ΔTSJAP$_{t-3}$	−0.168740	0.146639	−1.151	0.2519
ΔTSJAP$_{t-4}$	−0.0140543	0.146186	−0.09614	0.9236
ΔTSJAP$_{t-5}$	−0.0122541	0.138271	−0.08862	0.9295
ΔJAPMON$_{t-1}$	−3.90864e–013	2.64772e–013	−1.476	0.1422
ΔJAPMON$_{t-2}$	0.000000	2.60811e–013	0.2900	0.7723
ΔJAPMON$_{t-3}$	3.93020e–013	2.58525e–013	1.520	0.1308
ΔJAPMON$_{t-4}$	−1.30621e–013	2.59889e–013	−0.5026	0.6161
ΔJAPMON$_{t-5}$	0.000000	1.96267e–013	−0.03253	0.9741
ΔTSUS$_{t-1}$	−0.0172345	0.150884	−0.1142	0.9092
ΔTSUS$_{t-2}$	−0.112839	0.159968	−0.7054	0.4818
ΔTSUS$_{t-3}$	0.0564449	0.159933	0.3529	0.7247
ΔTSUS$_{t-4}$	0.100537	0.163261	0.6158	0.5391
ΔTSUS$_{t-5}$	0.0888666	0.156310	0.5685	0.5706
ΔUSMON$_{t-1}$	0.000000	5.68898e–012	−0.002832	0.9977
ΔUSMON$_{t-2}$	2.99515e–012	7.73096e–012	0.3874	0.6991
ΔUSMON$_{t-3}$	−4.30066e–012	7.96131e–012	−0.5402	0.5900
ΔUSMON$_{t-4}$	3.86311e–012	7.47426e–012	0.5169	0.6061
ΔUSMON$_{t-5}$	−9.92656e–012	6.69087e–012	−1.484	0.1402
time	−0.00824113	0.00925309	−0.8906	0.3747
EC1	−0.00306600	0.00103143	−2.973	0.0035

Mean dependent var	0.166014	S.D. dependent var	4.021597
Sum squared resid	1990.282	S.E. of regression	3.839639
R^2	0.216177	Adjusted R^2	0.088443
$\hat{\rho}$	0.013329	Durbin–Watson	1.961878

Equation 2: ΔJAPMON

	Coefficient	Std. Error	t-ratio	p-value
const	2.41035e+012	2.18862e+012	1.101	0.2727
ΔTSJAP$_{t-1}$	1.01310e+011	4.49616e+010	2.253	0.0259
ΔTSJAP$_{t-2}$	6.64710e+010	4.67562e+010	1.422	0.1574
ΔTSJAP$_{t-3}$	−3.17009e+009	4.58356e+010	−0.06916	0.9450
ΔTSJAP$_{t-4}$	−2.10754e+010	4.56940e+010	−0.4612	0.6454
ΔTSJAP$_{t-5}$	1.27231e+011	4.32198e+010	2.944	0.0038
ΔJAPMON$_{t-1}$	0.102585	0.0827609	1.240	0.2173
ΔJAPMON$_{t-2}$	−0.0397403	0.0815227	−0.4875	0.6267
ΔJAPMON$_{t-3}$	0.229068	0.0808081	2.835	0.0053
ΔJAPMON$_{t-4}$	−0.229289	0.0812346	−2.823	0.0055
ΔJAPMON$_{t-5}$	−0.0701741	0.0613478	−1.144	0.2547
ΔTSUS$_{t-1}$	−8.90580e+009	4.71624e+010	−0.1888	0.8505
ΔTSUS$_{t-2}$	−1.33640e+010	5.00018e+010	−0.2673	0.7897
ΔTSUS$_{t-3}$	−5.05342e+010	4.99908e+010	−1.011	0.3139
ΔTSUS$_{t-4}$	8.81058e+010	5.10311e+010	1.727	0.0865
ΔTSUS$_{t-5}$	−6.83048e+010	4.88585e+010	−1.398	0.1644
ΔUSMON$_{t-1}$	9.26837	1.77823	5.212	0.0000
ΔUSMON$_{t-2}$	8.38139	2.41650	3.468	0.0007
ΔUSMON$_{t-3}$	0.849737	2.48850	0.3415	0.7333
ΔUSMON$_{t-4}$	−2.52410	2.33626	−1.080	0.2819
ΔUSMON$_{t-5}$	3.04401	2.09139	1.455	0.1479
time	4.15665e+009	2.89227e+009	1.437	0.1530
EC1	−6.17321e+008	3.22399e+008	−1.915	0.0576

Mean dependent var	2.93e+12	S.D. dependent var	2.78e+12
Sum squared resid	1.94e+26	S.E. of regression	1.20e+12
R^2	0.840140	Adjusted R^2	0.814088
$\hat{\rho}$	−0.010346	Durbin–Watson	2.009101

Equation 3: ΔTSUS

	Coefficient	Std. Error	t-ratio	p-value
const	21.6460	6.69322	3.234	0.0015
ΔTSJAP$_{t-1}$	−0.0540161	0.137501	−0.3928	0.6951
ΔTSJAP$_{t-2}$	0.126838	0.142990	0.8870	0.3766
ΔTSJAP$_{t-3}$	−0.0447504	0.140174	−0.3192	0.7500
ΔTSJAP$_{t-4}$	−0.00704785	0.139741	−0.05043	0.9599
ΔTSJAP$_{t-5}$	−0.144545	0.132175	−1.094	0.2761
ΔJAPMON$_{t-1}$	−3.56312e–013	2.53099e–013	−1.408	0.1615
ΔJAPMON$_{t-2}$	4.18880e–013	2.49312e–013	1.680	0.0952
ΔJAPMON$_{t-3}$	1.13373e–013	2.47127e–013	0.4588	0.6471
ΔJAPMON$_{t-4}$	−2.54389e–013	2.48432e–013	−1.024	0.3077
ΔJAPMON$_{t-5}$	0.000000	1.87614e–013	0.3556	0.7227
ΔTSUS$_{t-1}$	0.273386	0.144232	1.895	0.0602
ΔTSUS$_{t-2}$	−0.108230	0.152915	−0.7078	0.4803
ΔTSUS$_{t-3}$	−0.0290774	0.152882	−0.1902	0.8494
ΔTSUS$_{t-4}$	0.0444663	0.156063	0.2849	0.7761
ΔTSUS$_{t-5}$	0.241264	0.149419	1.615	0.1087
ΔUSMON$_{t-1}$	−6.23576e–013	5.43817e–012	−0.1147	0.9089
ΔUSMON$_{t-2}$	−1.62493e–012	7.39012e–012	−0.2199	0.8263
ΔUSMON$_{t-3}$	3.23873e–013	7.61031e–012	0.04256	0.9661
ΔUSMON$_{t-4}$	−4.09955e–012	7.14474e–012	−0.5738	0.5671
ΔUSMON$_{t-5}$	−3.76817e–012	6.39589e–012	−0.5892	0.5567
time	−0.0125028	0.00884515	−1.414	0.1598
EC1	−0.00364432	0.000985959	−3.696	0.0003

Table 4 (Contd):

Mean dependent var	0.319369	S.D. dependent var	3.920526
Sum squared resid	1818.658	S.E. of regression	3.670360
R^2	0.246362	Adjusted R^2	0.123547
$\hat{\rho}$	0.013490	Durbin–Watson	1.971889

Equation 4: ΔUSMON

	Coefficient	Std. Error	t-ratio	p-value
const	4.04548e+009	1.19172e+011	0.03395	0.9730
ΔTSJAP$_{t-1}$	3.27836e+009	2.44820e+009	1.339	0.1828
ΔTSJAP$_{t-2}$	−3.73562e+009	2.54592e+009	−1.467	0.1446
ΔTSJAP$_{t-3}$	−3.27437e+009	2.49579e+009	−1.312	0.1918
ΔTSJAP$_{t-4}$	8.25567e+007	2.48808e+009	0.03318	0.9736
ΔTSJAP$_{t-5}$	2.71988e+009	2.35336e+009	1.156	0.2498
ΔJAPMON$_{t-1}$	0.00815490	0.00450641	1.810	0.0726
ΔJAPMON$_{t-2}$	−0.00885351	0.00443899	−1.994	0.0481
ΔJAPMON$_{t-3}$	0.00625913	0.00440008	1.423	0.1572
ΔJAPMON$_{t-4}$	−0.00672454	0.00442330	−1.520	0.1308
ΔJAPMON$_{t-5}$	0.000797913	0.00334045	0.2389	0.8116
ΔTSUS$_{t-1}$	−9.06591e+009	2.56804e+009	−3.530	0.0006
ΔTSUS$_{t-2}$	5.14808e+008	2.72265e+009	0.1891	0.8503
ΔTSUS$_{t-3}$	7.59696e+009	2.72205e+009	2.791	0.0060
ΔTSUS$_{t-4}$	−1.90540e+008	2.77869e+009	−0.06857	0.9454
ΔTSUS$_{t-5}$	3.84205e+008	2.66039e+009	0.1444	0.8854
ΔUSMON$_{t-1}$	0.863546	0.0968261	8.919	0.0000
ΔUSMON$_{t-2}$	−0.393155	0.131580	−2.988	0.0033
ΔUSMON$_{t-3}$	0.0831471	0.135501	0.6136	0.5405
ΔUSMON$_{t-4}$	0.0588038	0.127212	0.4623	0.6446
ΔUSMON$_{t-5}$	0.0362436	0.113878	0.3183	0.7508
time	2.34411e+008	1.57487e+008	1.488	0.1390
EC1	−1.68800e+007	1.75549e+007	−0.9616	0.3380

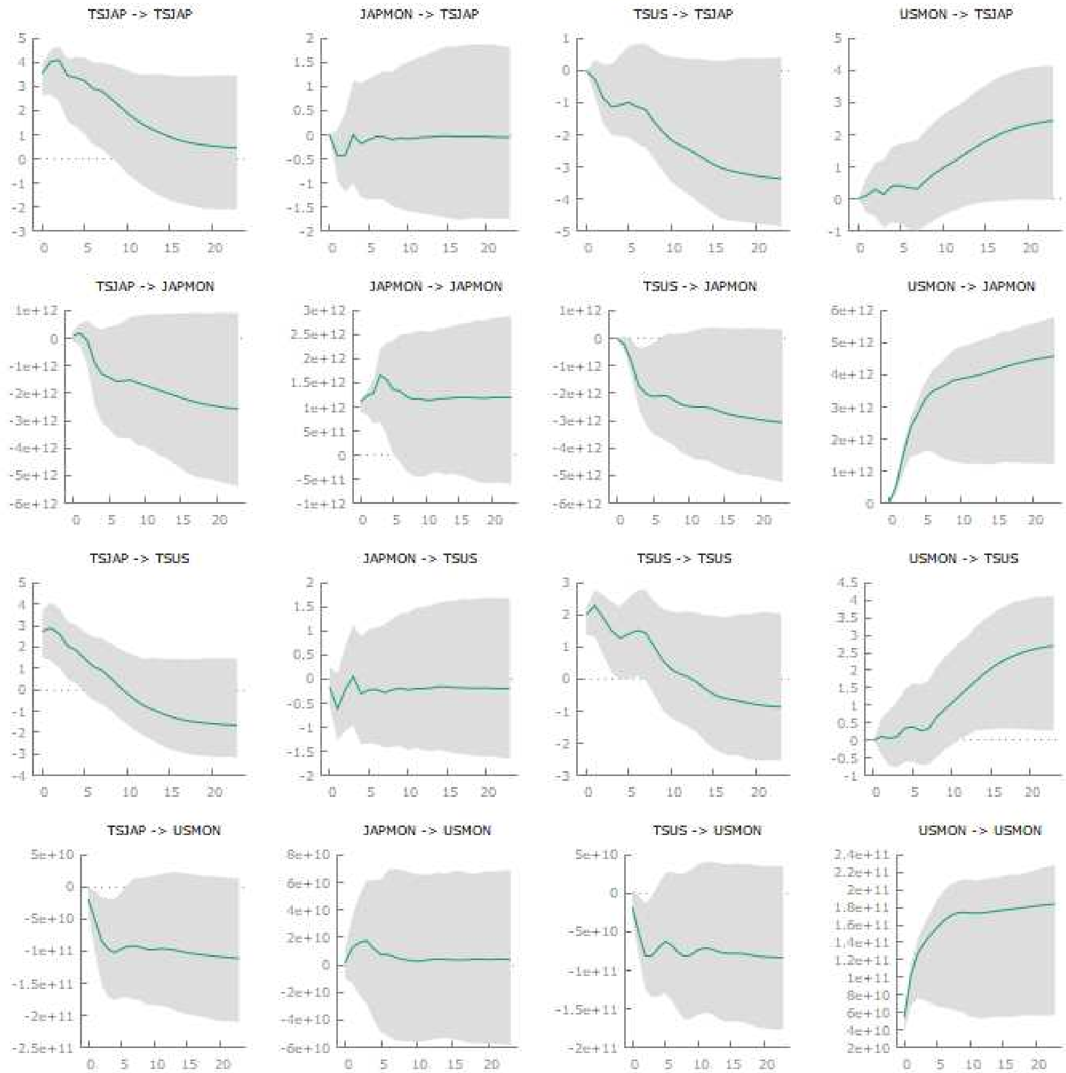
Mean dependent var	7.72e+10	S.D. dependent var	1.16e+11
Sum squared resid	5.77e+23	S.E. of regression	6.54e+10
R^2	0.729230	Adjusted R^2	0.685104
$\hat{\rho}$	−0.004993	Durbin–Watson	2.009486

Cross-equation covariance matrix

	ΔTSJAP	ΔJAPMON	ΔTSUS	ΔUSMON
ΔTSJAP	12.5967	3.22537e+011	9.68853	−6.92280e+010
ΔJAPMON	3.22537e+011	1.23073e+024	6.00999e+010	−5.66025e+020
ΔTSUS	9.68853	6.00999e+010	11.5105	−8.86571e+010
ΔUSMON	−6.92280e+010	−5.66025e+020	−8.86571e+010	3.64900e+021

determinant = 1.83651e+047

Figure 7: Graphs of shocks to variables in post-GFC Period 2 (2008-2021)



However, this analysis is quite restricted, in that we have only used four variables and some of their lagged values in the estimation of the VECM system. We shall expand upon this in the next section of results.

3.2. ARDL Model results using 'dynamac'

We estimated an ARDL model that incorporated all the variables in our dataset for period 1, namely, 1982 through to the end of 2007. The results are shown in Table 6. The coefficients on the difference of one lag of US share returns, the difference of one lag of share returns in Japan and one lag of the difference in the US money supply are significant. Once we have a model estimated we can use the coefficients in the model to simulate how a change to a variable in the system model produces a corresponding change in the dependent variable. The results of simulated responses to shocks to the Japanese money supply, Japanese share levels and to the US money supply are shown in Figure 8. In the system estimated Japanese share levels are the dependent variable.

We used the program 'dynamac' because this permits the simulation of the impact of a shock. If the variable is in levels or lagged levels, the program is constructed so that its new value becomes the pre-shock average plus whatever the shock value is. If the variable is in differences or lagged differences, the shock lasts for one period (as a permanent change in a differenced variable would imply that it was changing every period).

The program produced the diagrams in Figures 8 and 9 for the pre and post-GFC periods respectively. The estimates of the coefficients in Table 7 suggest, that in the post GFC period, the coefficient on lagged differences in the Japanese money supply, differences in the lagged US share return, lagged differences in the Japanese share return, and lagged differences of US money supply, are significant at the 1 percent level, whilst lagged levels of US Share prices and lagged differences in Japanese industrial production, are significant at the 5 percent level.

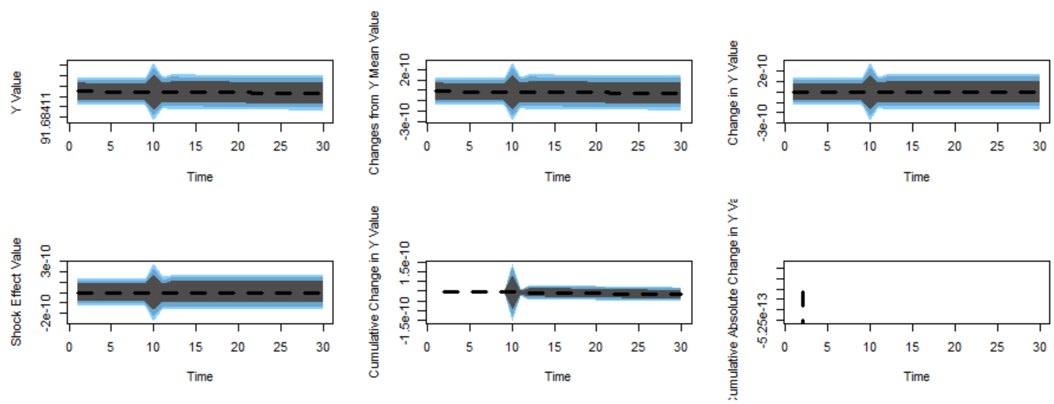
Table 6. ARDL analysis period 1: 1982-2007

Coefficients	Estimates	Standard Error	T. Value
Intercept	-4.023e-15	2.524e-15	-1.594e+00
l.1.TSJAP	2.152e-18	6.159e-18	3.490e-01
d.1.JAPMON	-1.632e-29	6.507e-29	-2.510e-01
l.1.JAPMON	-2.483e-30	2.236e-30	-1.110e+00
ld.1.JAPMON	-1.572e-30	6.422e-29	-2.400e-02
d.1.TSUS	-2.856e-16	7.971e-17	-3.583e+00***
d.1.USMON	2.541e-27	7.620e-27	3.330e-01
d.1.USINDPR	2.974e-17	7.240e-17	4.110e-01
d.1.JAPINDPRO	-8.096e-17	8.862e-17	-9.130e-01
d.1.TSJAP	1.000e+00	2.375e-17	4.210e+16***
l.1.TSUS	-2.786e-17	2.279e-17	-1.222e+00
l.1.USMON	1.780e-29	2.328e-28	7.600e-02
l.1.USINDPR	6.730e-17	4.889e-17	1.377e+00
l.1.JAPINDPRO	1.932e-17	2.881e-17	6.700e-01
ld.1.TSUS	-1.982e-17	7.455e-17	-2.660e-01
ld.1.USMON	-1.587e-26	7.824e-27	-2.029e+00**
ld.1.USINDPR	-3.702e-17	7.217e-17	-5.130e-01
ld.1.JAPINDPRO	-3.737e-17	8.696e-17	-4.300e-01

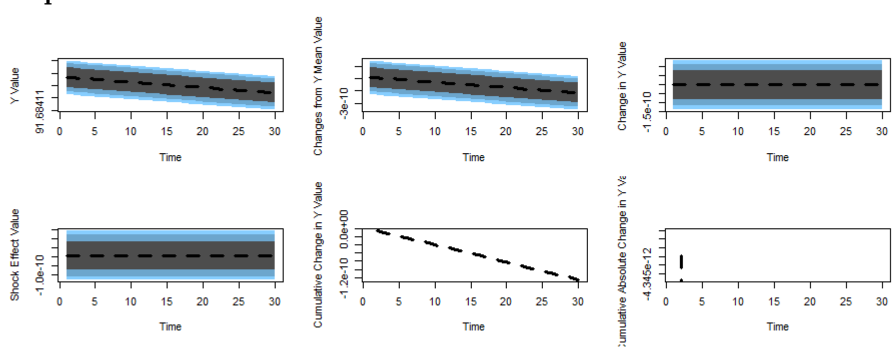
NOTE: *,**, *, indicates significance at the 1%, 5% and 10% levels respectively**

Figure 8: Impact of a shock to Japanese Money, US shares, and Japanse Money on Total Shares in Japan in Period 1

Shock to Japanese Money in Period 1



Impact of a shock to US Shares in Period 1



Impact of a shock to US Money in Period 1

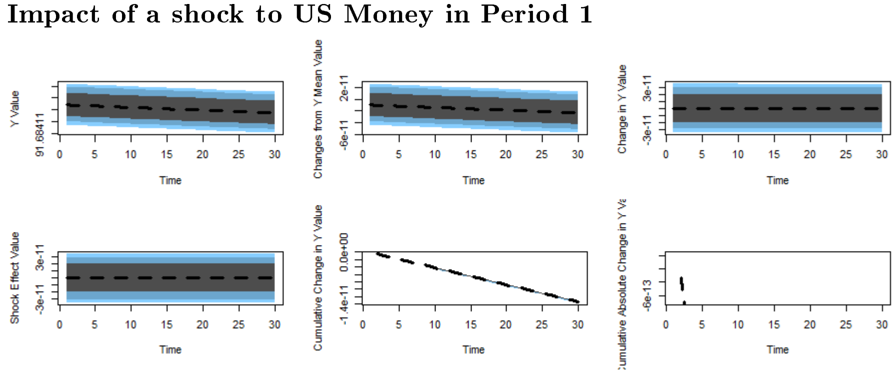


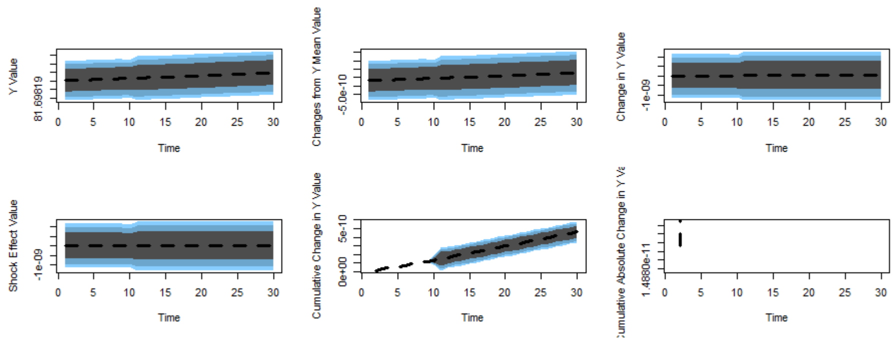
Table 7. ARDL analysis period 2: 2008-2021

Coefficients	Estimates	Standard Error	T. Value
Intercept	2.342e-14	1.800e-14	1.301e+00
l.1.TSJAP	-3.770e-17	2.921e-17	-1.291e+00
d.1.JAPMON	-5.483e-28	1.689e-28	-3.245e+00***
l.1.JAPMON	-1.204e-29	2.172e-29	-5.550e-01
ld.1.JAPMON	1.914e-28	1.382e-28	1.385e+00
d.1.TSUS	-1.141e-15	1.052e-16	-1.084e+01***
d.1.USMON	-8.115e-27	4.468e-27	-1.816e+00*
d.1.USINDPR	-8.400e-17	1.644e-16	-5.110e-01
d.1.JAPINDPRO	-9.185e-17	9.947e-17	-9.230e-01
d.1.TSJAP	1.000e+00	9.786e-17	1.022e+16***
l.1.TSUS	1.446e-16	6.399e-17	2.259e+00 **
l.1.USMON	-2.701e-29	9.045e-28	-3.000e-02
l.1.USINDPR	-1.400e-16	16 1.177e-16	-1.190e+00
l.1.JAPINDPRO	-3.984e-17	6.198e-17	-6.430e-01
ld.1.TSUS	-6.306e-17	8.024e-17	-7.860e-01
ld.1.USMON	1.499e-26	4.576e-27	3.277e+00 ***
ld.1.USINDPR	6.965e-17	1.462e-16	4.760e-01
ld.1.JAPINDPRO	2.274e-16	9.811e-17	2.318e+00**

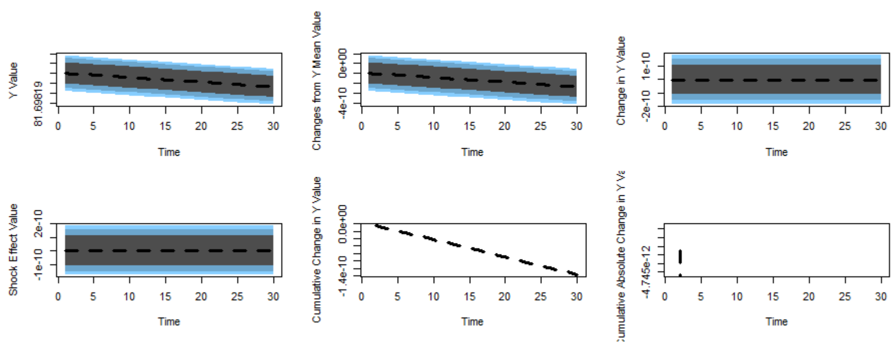
NOTE: *,**, *, indicates significance at the 1%, 5% and 10% levels respectively**

Figure 9: Impact of a shock to Japanese Money, US Money, and Japanese Money on Total Shares in Japan in Period 2

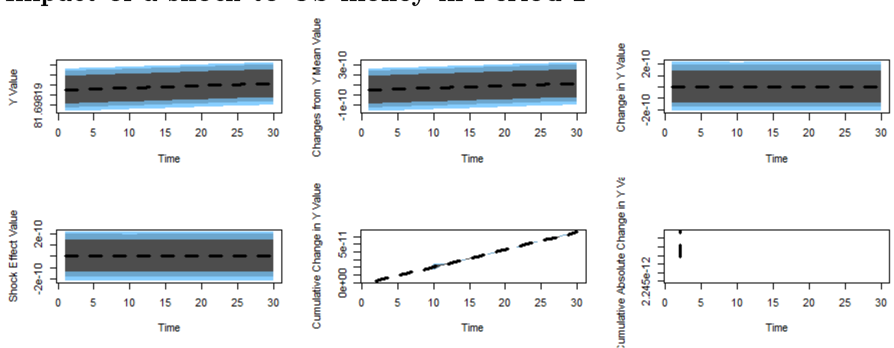
Impact of a Shock to Japanese Money in Period 2



Impact of a shock to US shares in Period 2



Impact of a shock to US money in Period 2



The panels in the plots in Figures 8 and 9, moving across the top row in the figures, show the simulated impact of the shock in levels, in differences from the mean, in differences, and in the bottom set of three images, the shock effect value, the cumulative differences, plus the cumulative absolute differences. In Figure 8 it can be seen that the effect of a shock to Japanese money on the level of total share prices in Period 1 is short-lived and relatively minor. The impact of a shock to US shares is negative on balance. This suggests a relatively stronger response to a downward movement than an upward movement in the level of share prices. Finally, a shock to US money in period 1 has a negative effect on Japanese share price, as suggested by the third portion of Figure 8.

In the post-GFC period the responses to the same series of shocks to Japanese money, US shares and US money, on the level of share prices in Japan, are shown in Figure 9. The first set of diagrams in Figure 9 are of significance to the central theme in this paper, and they reflect the fact that the the impact of a shock to Japanese money, as shown in Figure 9, has become positive. This can be seen in the effect of cumulative differences in the central diagram in the bottom row of the first panel. The impact of a shock to US shares, as shown in the middle panel, is negative and unchanged. Finally, the impact of a shock to US money, has also changed sign, and become positive in this second, post-GFC period. These analyses are consistent with Mizuno (2021), who examined the influence of QQE on the behaviour of Japanese stock price trends, and suggested that purchases under the QQE policy have lead to an upswing in Japanese share prices.

Since 2008, central banks around the world have continued to pursue unprecedented monetary easing. As a result, Japan and the United States were able to recover stock prices comparatively quickly. What was revealed in this paper is that the Bank of Japan's QQE policy from the purchase of ETFs has created an uptrend in stock prices, while the United States has not created an uptrend in stock pricesto the same degree, although it has a monetary easing policy. The Bank of Japan's holdings amounted to 50 trillion yen in 2021 because the bank's ETF purchases would support stock prices from falling to a certain level in the stock market, and the ETFs they once purchased did not sell even if stock prices rose. On the other hand, since the Federal Reserve did not purchase stocks in U.S. monetary easing, it is thought that monetary easing did not create an uptrend in stock prices in the United States to quited the same degree. Though it is apparent in the graphs in Figures 6 and 7, that shocks to US money post the GFC also had a larger impact on US stocks than in the pre-GFC period. However, the focus of the paper, particularly in the simulations in Figures 8 and 9, has been on the situation in Japan.

4. Conclusion

This paper uses monthly data sets, mainly drawn from Federal Bank of St. Louis (FRED) database in the USA, to empirically assess the impact of the GFC in Japan via the responses it evoked from monetary authorities and assesses the impact of these policies, in combination with the impact of related changes in key economic variables, both in the USA and in Japan, with reference also to the recent economic shock produced by the global COVID-19 pandemic. We apply a variety of techniques which include ordinary least squares regression, cointegration analysis and VECM applications, plus ARDL analysis and related simulations. The results are consistent, once the levels of variables are included in the analysis, and suggest that the adoption of QQE policy by the Japanese monetary authorities has led to an upswing in Japanese share prices in the post-GFC period, whereas no such effect was apparent in the pre-GFC period. Since 2008, the Bank of Japan's QQE has had a strong impact on stock prices which has been very apparent.

References

[1] Bernanke, B., and M. Gertler (2001), Should Central Banks Respond to Movements in Asset Prices? *American Economic Review Papers and Proceedings* 91, 253-257.

[2] Brunnermeier, M., D. Palia, K.A. Sastry, and C.A. Sims (2021) Feedbacks: Financial Markets and Economic Activity, *American Economic Review,* 111 (6): 1845-79.

[3] Campbell, J. Y. and Y. Hamao (1992), Predictable Stock Returns in the United States and Japan: A Study of Long-Term Capital Market Integration, *Journal of Finance,* 47(1):43-69.

[4] Campbell, J.Y. and R. Shiller (1998), Valuation Ratios and the Long-Run Stock Market Outlook, *Journal of Portfolio Management*, 24(2):11–26.

[5] Chen, N., Roll, R., and S. Ross (1986) Economic Forces and the Stock Market, *Journal of Business,* 59, 383-403.

[6] Engle, R.F. and C.W.J. Granger, (1987), Cointegration and Error Correction: Representation, Estimation and Testing, *Econometrica*, 55 251-276.

[7] Fama E.F. (1981), Stock Returns, Real Activity, Inflation and Money, *American Economic Review,* 71, 545-65.

[8] Fama, E. and K. French (1989), Business Conditions and Expected Returns on Stocks and Bonds, *Journal of Financial Economics,* 25, 23-49.

[9] Fama, E.F. and G. Schwert (1977) Asset Returns and Inflation, *Journal of Financial Economics*, 5, 115- 146.

[10] Granger, C.W.J. and P. Newbold (1974), Spurious regressions in econometrics, *Journal of Econometrics*, 2(2):111-120.

[11] Jordan, S. and A.Q. Philips, (2020), dynamac: Dynamic Simulation and Testing for Single-Equation ARDL Models, R package version 0.1.11. https://CRAN.R-project.org/package=dynamac

[12] Johansen, S. (1991), Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, 59 (6): 1551–1580.

[13] Karolyi, A. and R. Stulz (1996), Why do markets move together? An investigation of US-Japan stock return comovements, *Journal of Finance*, 51(3): 951-986.

[14] Kawamoto, T., T. Nakazawa, Y. Kishaba, K. Matsumura, and J. Nakajima, (2021), Estimating effects of expansionary monetary policy since the introduction of Quantitative and Qualitative Monetary Easing (QQE) using the Macroeconomic Model (Q-JEM), supplementary paper series, Bank of Japan Working Paper Series, No.21-E-4.

[15] Mizuno, H., (2021), Analysis and Forecasting of Stock Price Trends, Working Paper, Fukuoka University, Japan.

[16] Surveys of Consumers, University of Michigan, University of Michigan: Consumer Sentiment © [UMCSENT], retrieved from FRED, Federal Reserve Bank of St. Louis, (Accessed on 23 April 2021)", https://fred.stlouisfed.org/

[17] Organization for Economic Co-operation and Development, Consumer Opinion Surveys: Confidence Indicators: Composite Indicators: OECD Indicator for Japan [CSCICP03JPM665S], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CSCICP03JPM665S, accessed April 22, 2021.

[18] Organization for Economic Co-operation and Development, Total Share Prices for All Shares for the United States [SPASTT01USM661N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/SPASTT01USM661N, accessed April 22, 2021.

[19] Organization for Economic Co-operation and Development, Total Share Prices for All Shares for Japan [SPASTT01JPM661N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/SPASTT01JPM661N, April 22, 2021.

[20] Board of Governors of the Federal Reserve System (US), Monetary Base; Total [BOGMBASE], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/BOGMBASE, April 22, 2021.

[21] Organization for Economic Co-operation and Development, Monetary aggregates and their components: Broad money and components: M3: M3 for Japan [JPNMABMM301GYSAM], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/JPNMABMM301GYSAM, April 22, 2021.

[22] Board of Governors of the Federal Reserve System (US), Industrial Production: Total Index [INDPRO], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/INDPRO, April 22, 2021.

[23] Board of Governors of the Federal Reserve System (US), Industrial Production: Total Index [INDPRO], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/INDPRO, April 22, 2021.

[24] Organization for Economic Co-operation and Development, Production of Total Industry in Japan [JPNPROINDMISMEI], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/JPNPROINDMISMEI, April 22, 2021.

[25] Organization for Economic Co-operation and Development, National Currency to US Dollar Exchange Rate: Average of Daily Rates for Japan [CCUSMA02JPM618N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CCUSMA02JPM618N, April 22, 2021.

[26] Jordan, S. and A.Q. Philips, (2020), dynamac: Dynamic Simulation and Testing for Single-Equation ARDL Models, R package version 0.1.11. https://CRAN.R-project.org/package=dynamac.

[27] Natsiopoulos, K., and N. Tzeremes (2021), ARDL: ARDL, ECM and Bounds-Test for Cointegration. R package version 0.1.1. https://CRAN.R-project.org/package=ARDL.

[28] Pesaran, M.H., Y. Shin, and R.J. Smith (2001), Bounds testing approaches to the analysis of level relationships, *Journal of Applied Econometrics*, 16: 289-326.

[29] Shin, Y., B. Yu, and M. Greenwood-Nimmo (2014), Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework, *The Festschrift in Honor of Peter Schmidt.: Econometric Methods and Applications.* Horrace, W. & Sickles, R. (eds.), New York: Springer, 281-314.

[30] Sun, C. (2020), apt: Asymmetric Price Transmission, R package version 3.0. https://CRAN.R-project.org/package=apt.