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Afees A. Salisu

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Afees A. Salisu

Centre for Econometric & Allied Research

University of Ibadan, Nigeria.

Email: aa.salisu@cear.org.ng

Phone: +2348034711769

Abstract

This study offers a new evidence for the nonstationary behavior of OECD stock prices using the PANICCA test of Reese and Westerlund (2016) which is a combined approach of the Principal Components-based Panel analysis of Nonstationarity in Idiosyncratic and Common components (PANIC) of Bai and Ng (2004, 2010) and the Cross-section Average (CA) of Pesaran (2007) and Pesaran et al. (2013). The results suggest that the nonstationarity evident in OECD stock prices is largely driven by idiosyncratic components while the common factors are stationary. More importantly, it is found that ignoring relevant covariates in the common factor model may lead to wrong conclusions.

Key words: Panel unit root, PANICCA, Stock exchanges, OECD
JEL Classification: C12, C23, C33, G12, G23

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1.0 Motivation

Most of the panel unit root tests of different generations do not offer any information as regard the sources of nonstationarity.[1] The few exceptions however, are Bai and Ng [BN hereafter] (2004, 2010) and Reese and Westerlund [RW hereafter] (2016). Technically, information about the sources of nonstationary help distinguish between common factors and idiosyncratic components of a variable and to also establish whether nonstationarity is pervasive, unit specific or both. Meanwhile, such information are useful both from policy and research perspectives. From the policy perspective, cross-sections that are driven by common factors are more likely to suffer contagion effect in the presence of shocks than those influenced by unit-specific factors. Thus, the sources of nonstationarity can help in effective planning both at the national and international levels. Also from the empirical perspective, such information can be used to determine the appropriate assumption to make on the parameters in a panel data model. For instance, if the long run equilibrium in a panel data model is largely driven by common factors, the assumption of homogeneity may not be too restrictive in that instance. However, if the cointegration is due to idiosyncratic component which is specific to individual units, a typical nonstationary heterogeneous panel data model will be more appropriate.

To the best of the knowledge of the author, this is the first paper to investigate the underlying sources of nonstationarity of stock prices. It is also the first to subject to empirical scrutiny the PANICCA – the Principal Components-based Panel analysis of Nonstationarity in Idiosyncratic and Common components (PANIC) with Cross-section Average (CA) test developed by RW (2016). The PANICCA test is a combined approach of the PANIC test by BN (2004, 2010) and the CA augmentation approach of Pesaran

[1] A review of the prominently used panel unit root tests in the empirical literature is rendered in Hlouskova and Wagner (2006) and Salisu and Isah (2017).

(2007) and Pesaran et al. (2013) that exploits the strengths of both tests and therefore overcomes their inherent weaknesses.

The remainder of this study is organized as follows: Section 2 describes the methodology for the PANICCA test; Section 3 discusses the data and results while Section 4 concludes the paper.

2.0 The PANICCA test set up

The data generating process (DGP) for the variable of interest say $Y_{i,t}$, is assumed to follow a common factor model given as:[2]

$$Y_{i,t} = \alpha_i' \mathrm{D}_{t,p} + \lambda_i' \mathrm{F}_t + e_{i,t} \tag{1}$$

where $e_{i,t}$ is a scalar idiosyncratic error; F_t is an $r \times 1$ vector of common factors; λ_i is the corresponding vector of factor loadings; $\mathrm{D}_{t,p}$ is a polynomial trend function given as $\mathrm{D}_{t,p} = \left(1, \ldots, t^p\right)'$ with $\left(p+1\right) \times 1$ vector of trends. Thus, the series $Y_{i,t}$ is the sum of deterministic component $\left(\mathrm{D}_{t,p}\right)$, a common component- $\lambda_i' \mathrm{F}_t$ [which can be considered as a global or international trend common to all the units] and an error - ε_{it} that is largely idiosyncratic [which is unit specific]. The $\mathrm{D}_{t,p}$ has two options: (i) a constant where $p = 0$ and (ii) a constant and trend where $p = 1$. With the increasing evidence of co-movements between stock price and other financial variables such as exchange rate, bond price and commodity prices (see for example, Diebold and Yilmaz, 2012), it seems very plausible then to allow for additional variables as suggested by RW (2016). Thus, a vector of additional variables denoted as $\mathrm{X}_{i,t}$ is formulated with the following DGP:

$$\mathrm{X}_{i,t} = \beta_i' \mathrm{D}_{t,p} + \Lambda_i' \mathrm{F}_t + \mathrm{u}_{i,t} \tag{2}$$

[2] A detailed exposition of the PANICCA test is provided in Reese and Westerlund (2016).

where $\mathrm{X}_{i,t}$ is an $m\times 1$ vector of additional variables; $\mathrm{u}_{i,t}$ is the corresponding $m\times 1$ vector of idiosyncratic errors. Since $\mathrm{X}_{i,t}$ is assumed to share the common factors of $Y_{i,t}$ (the variable of interest), then the DGP for the combined variables becomes:

$$\mathrm{Z}_{i,t}=\mathrm{B}_i'\mathrm{D}_{t,p}+\mathrm{C}_i'\mathrm{F}_t+\mathrm{V}_{i,t} \tag{3}$$

where $\mathrm{B}_i=(\alpha_i,\beta_i)$; $\mathrm{C}_i=(\lambda_i,\Lambda_i)$ with $r\times(m+1)$ matrix dimension and $\mathrm{V}_{i,t}=(e_{i,t},\mathrm{u}_{i,t}')'$. RW (2016) note that since the first differenced $\mathrm{Z}_{i,t}$, which eliminates any uncertainty regarding its order of integration, is used in the estimation process, then any existing method for common factor models can be used to estimate equation (3). Unlike the BN (2010) that employ the PC approach to estimate F_t and $e_{i,t}$, RW (2016) employ the CA approach. After estimation, the $\hat{\mathrm{F}}_t$ and $\hat{e}_{i,t}$ are then tested for unit root using the respective test equations: $\hat{e}_{i,t}=\rho\hat{e}_{i,t-1}+\varepsilon_{i.t}$ and $\hat{\mathrm{F}}_t=\rho\hat{\mathrm{F}}_{t-1}+\eta_t$ with the null hypothesis that $\rho_1=\rho_2=\ldots=\rho_N=1$. The test statistics of BN (2004, 2010) are used in RW (2016) to test for unit root in both $\hat{e}_{i,t}$ and $\hat{\mathrm{F}}_t$. There are three test statistics proposed for the unit root test of $\hat{e}_{i,t}$ each for $p=0$ and $p=1$ and are denoted as $P_{a,p}$, $P_{b,p}$ and PMSB_p [Panel Modified Sargan–Bhargava] tests. Their respective computations are given as:

For $p=0$:

$$P_{a,p=0}=\frac{\sqrt{NT}\left(\hat{\rho}_0^{+}-1\right)}{\sqrt{2\hat{\phi}_\varepsilon^4/\hat{\omega}_\varepsilon^4}};\ P_{b,p=0}=\frac{\sqrt{NT}\left(\hat{\rho}_0^{+}-1\right)}{\sqrt{\hat{\phi}_\varepsilon^4\Big/\left[\hat{\omega}_\varepsilon N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^0\right)'\hat{e}_{i,-1}^0\right]}};$$

$$\mathrm{PMSB}_{p=0}=\frac{\sqrt{N}\left(N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^0\right)'\hat{e}_{i,-1}^0-\hat{\omega}_\varepsilon^2/2\right)}{\sqrt{\hat{\phi}_\varepsilon^4/3}}$$

For $p=1$:

$$P_{a,p=1}=\frac{\sqrt{NT}\left(\hat{\rho}_1^{+}-1\right)}{\sqrt{36\hat{\sigma}_\varepsilon^4\hat{\phi}_\varepsilon^4/5\hat{\omega}_\varepsilon^8}};P_{b,p=1}=\frac{\sqrt{NT}\left(\hat{\rho}_1^{+}-1\right)}{\sqrt{6\hat{\sigma}_\varepsilon^4\hat{\phi}_\varepsilon^4\Big/\left[5\hat{\omega}_\varepsilon^6 N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^0\right)'\hat{e}_{i,-1}^0\right]}};$$

$$\text{PMSB}_{p=1} = \frac{\sqrt{N}\left(N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^{0}\right)'\hat{e}_{i,-1}^{0} - \hat{\omega}_{\varepsilon}^{2}/6\right)}{\sqrt{\hat{\phi}_{\varepsilon}^{4}/45}}$$

where $\varepsilon_{i,t}$, $\mu_{i,t}$ and η_t are the respective innovations for the stationary AR(1) processes for $e_{i,t}$, $\text{u}_{i,t}$ and $\text{F}_{i,t}$ and are independently and identically distributed across relevant data index(es) and $\hat{e}'_{i,-1} = \left(\hat{e}_{i,2},\ldots,\hat{e}_{i,T-1}\right)'$. The AR(1) coeffcients - $\hat{\rho}_0^+$ and $\hat{\rho}_1^+$ are respectively computed as $\hat{\rho}_0^+ = \hat{\rho}_0 + \frac{\hat{\tau}_\varepsilon}{\left(NT\right)^{-1}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^{0}\right)'\hat{e}_{i,-1}^{0}}$ and $\hat{\rho}_1^+ = \hat{\rho}_1 + \frac{3\hat{\sigma}_\varepsilon^2}{T\hat{\omega}_\varepsilon^2}$ with $\hat{\rho}_p$ obtained from the pooled AR(1) regression of $e_{i.t}^{p}$ while $\hat{\sigma}_\varepsilon^2$, $\hat{\omega}_\varepsilon^2$, $\hat{\phi}_\varepsilon^4$ and $\hat{\tau}_\varepsilon$ are given by the cross-sectional averages of $\hat{\sigma}_{\varepsilon,i}^2$, $\hat{\omega}_{\varepsilon,i}^2$, $\hat{\phi}_{\varepsilon,i}^4$ and $\hat{\tau}_{\varepsilon,i}$ respectively. The asymptotic null distributions of $P_{a,p}$, $P_{b,p}$ and PMSB_p are detailed in RW (2016). The null hypothesis of a unit root in the idiosyncratic components of all panels is therefore tested via the $P_{a,p}$, $P_{b,p}$ and PMSB_p test statistics.

In testing for unit root in $\hat{\text{F}}_{i,t}$, the test to apply is determined by the number of common factors. If only one common factor is to be estimated, then, testing can be carried out using any existing unit root test such as the augmented Dickey-Fuller which is suggested in BN (2004). However, if at least two factors are estimated, the iterative procedure of Bai and Ng (2004) is applied and it produces both the modified "filtered" Q_f $\left[MQ_f\right]$ and the "corrected" Q_c $\left[MQ_c\right]$ test developed in Stock and Watson (1988).

3.0 Data and Results

3.1 Data

The data set utilized are monthly stock prices of 32 OECD countries, spanning from 31st May 2004 to 30th June 2017 yielding exactly 158 observations for each cross-section unit. The choice of scope is underscored by the availability of balanced panel data for all the units considered. For robustness, the panel OECD is divided into Euro Area (countries that belong to the Euro Zone) and Non-Euro Area and the data sets are obtained from same source (Bloomberg Terminal) for easy comparability.

3.2 Results and Discussion

The analysis begins with the non-PANIC panel unit root tests in order to first establish the behavior of the stock price indices. The following panel unit root tests are considered: Harris and Tzavalis (1999), Breitung (2000) and Levin et al. (2002) tests (with the null hypothesis of unit root with common process) and the Im et al. (2003) and Pesaran (2007) tests (with the null hypothesis of individual unit root). The results reveal that the stock price indices of OECD countries are non-stationary regardless of the choice of panel unit root test. Although, the LLC test seems to suggest that stock price indices of Non-Euro are stationary but this is only evident at 10% level of significance. Otherwise, both the Euro and Non-Euro stock prices are also non-stationary like the full panel OECD.

Table 1: Conventional panel unit root tests

Panel A: Full Sample						
Test Method	**Full OECD**		**Euro Area**		**Non-Euro Area**	
	Level	**1st Diff.**	**Level**	**1st Diff.**	**Level**	**1st Diff.**
Null Hypothesis: Unit root with common process						
Levin, Li and Chu t*	-0.381	-37.887***	1.183	-27.273***	-1.568*	-26.299***
Breitung lambda	1.647	-39.841***	-1.048	-28.162***	2.486	-28.181***
Harris Tzavalis rho	0.982	0.161***	0.984	0.183***	0.981	0.136***
Null Hypothesis: Unit root with individual unit root process						
Im, Pesaran & Shin W Stat	0.206	-44.851***	0.984	-30.872***	0.244	-32.556***
Pesaran Cd test[2]	2.867	-18.923***	2.839	2.839***	1.106	-13.06***
No. of Cross-sections	32	32	16	16	16	16
No of Periods	158	158	158	158	158	158
Total observations	5056	5056	2528	2528	2528	2528

Note: ***, **, * indicate statistical significance at 1%, 5% and 10% respectively. The stock price indices are expressed in natural logs.

The next objective is to ascertain whether the observed nonstationarity for the three panel data samples is pervasive, unit specific or both. As noted previously, the RW (2016) PANICCA test is employed with and without additional variables in the common factor model. On the basis of the Arbitrage Pricing Theory for stock price valuation which assumes that asset returns are driven by macroeconomic risks, the single-variable based common factor model in equation 1 is extended to include variables that have been empirically validated to influence stock prices. Two variables are considered in this regard: oil price changes, a source of external shock to stock market (Kilian and Park, 2009; Salisu and Oloko, 2015; Salisu and Isah, 2017) and movements in exchange rate, a measure of macroeconomic resilience to external shocks with implications on stock market (Tsai, 2012; Tsagkanos and Siriopoulos, 2013). These variables are included in a stepwise manner with the following sequence: (i) no additional variables; (ii) one additional variable at a time; and (iii) two additional variables at a time.

Table 2: PANICCA test results (without additional variables)

Cross-sections	Common Factors		Idiosyncratic Components					
	$p=0$	$p=1$	$p=0$			$p=1$		
			$P_{a,p}$	$P_{b,p}$	PMSB_p	$P_{a,p}$	$P_{b,p}$	PMSB_p
Full OECD panel	2.833	2.916	1.239	1.751	3.290	.852	.956	1.077
	(.999)	(.999)	(.892)	(.960)	(1.000)	(.803)	(.830)	(.859)
Euro area	3.513	9.355	1.351	1.547	.922	.168	.173	.186
	(1.000)	(1.000)	(.912)	(.939)	(.822)	(.567)	(.569)	(.574)
Non-Euro area	2.358	2.458	.603	.953	3.377	.981	1.216	1.506
	(.997)	(.998)	(.727)	(.830)	(1.000)	(.837)	(.888)	(.934)

Note: The Full OECD panel here involves 32 countries in which 16 belong to the Euro area and the other half belong to the Non-Euro area. The stock price indices are expressed in natural logs. Since there are no additional variables other than the variable of interest, the ADF-type test is used for the common factors while the three test statistics namely $P_{a,p}$, $P_{b,p}$ and PMSB_p are used for the idiosyncratic errors regardless of whether additional variables are included or not in the test equation for the variable of interest. The option $p=0$ implies constant only in the model while $p=1$ implies constant and trend. Values in parentheses denote probability values.

The results of the PANICCA test are presented in Tables 3, 4 and 5 for (i), (ii) and (iii) respectively as previously highlighted. There are four discernible findings from the test. First, , where there are no additional variables, the results indicate that nonstationarity in stock prices of OECD including Euro and Non-Euro areas is due to both the common factors and idiosyncratic errors as all the statistics are not statistically significant (see

Table 2). Secondly, the inclusion of covariates improves the outcome of the test for all the data samples (see Tables 3-5). This evidence is robust to alternative statistics for evaluating the PANICCA test. The new evidence from the inclusion of covariates suggests that the nonstationarity of stock prices of OECD countries including those of the sub-samples of Euro or Non Euro areas is attributable to the idiosyncratic errors only whereas the common factors are found to be stationary. Thirdly, as a consequence of this new evidence, ignoring the covariates in the panel unit root analysis of OECD stock prices may lead to wrong inferences. Fourth, from practical and policy perspectives, domestic trends seem to have greater potential to cause permanent shock on OECD stock exchanges as a whole than international trends.

Table 3: PANICCA test results with one additional variable (oil price)

Cross-sections	Common Factors				Idiosyncratic Components					
	$p=0$		$p=1$		$p=0$			$p=1$		
	MQ_f	MQ_c	MQ_f	MQ_c	$P_{a,p}$	$P_{b,p}$	PMSB_p	$P_{a,p}$	$P_{b,p}$	PMSB_p
Full OECD panel	-12.008 (0.000)	-17.094 (0.000)	-11.755 (0.000)	-16.826 (0.000)	1.212 (.887)	1.745 (.960)	3.564 (1.000)	1.083 (.861)	1.257 (.896)	1.462 (.928)
Euro area	-10.014 (0.000)	-14.690 (0.000)	-11.494 (0.000)	-16.372 (0.000)	1.334 (.9089)	1.555 (.940)	1.047 (.852)	.215 (.585)	.222 (.588)	.238 (.594)
Non-Euro area	-11.339 (0.000)	-16.000 (0.000)	-11.895 (0.000)	-17.390 (0.000)	.546 (.708)	.878 (.810)	3.595 (1.000)	1.151 (.875)	1.494 (.932)	1.936 (.974)

Note: The Full OECD panel here involves 32 countries in which 16 belong to the Euro area and the other half belong to the Non-Euro area. The stock price indices are expressed in natural logs. With the consideration of covariates in the test equation, the MQ statistics of Bai and Ng (2004, 2010) are produced and reported for the common factors. However, the three test statistics namely $P_{a,p}$, $P_{b,p}$ and PMSB_p are still valid for the idiosyncratic errors regardless of whether additional variables are included or not in the test equation for the variable of interest. The option $p=0$ implies only constant in the model while $p=1$ implies constant and trend. Values in parentheses denote probability values.

Table 4: PANICCA test results with one additional variable (exchange rate)

Cross-sections	Common Factors				Idiosyncratic Components					
	$p=0$		$p=1$		$p=0$			$p=1$		
	MQ_f	MQ_c	MQ_f	MQ_c	$P_{a,p}$	$P_{b,p}$	PMSB_p	$P_{a,p}$	$P_{b,p}$	PMSB_p
Full OECD	-11.787	-15.977	-14.13	-19.109	1.269	1.809	3.372	.575	.621	.676
panel	(0.000)	(0.000)	(0.000)	(0.000)	(.898)	(.965)	(1.000)	(.718)	(.733)	(.751)
Euro area	-8.469	-11.727	-13.712	-18.319	1.253	1.436	.920	-.163	-.160	-.144
	(0.000)	(0.000)	(0.000)	(0.000)	(.895)	(.925)	(.821)	(.435)	(.437)	(.443)
Non-Euro	-11.471	-19.326	-13.151	-18.854	.796	1.314	3.862	.887	1.065	1.278
area	(0.000)	(0.000)	(0.000)	(0.000)	(.787)	(.906)	(1.000)	(.813)	(.857)	(.900)

Note: The Full OECD panel here involves 32 countries in which 16 belong to the Euro area and the other half belong to the Non-Euro area. The stock price indices are expressed in natural logs. With the consideration of covariates in the test equation, the MQ statistics of Bai and Ng (2004, 2010) are produced and reported for the common factors. However, the three test statistics namely $P_{a,p}$, $P_{b,p}$ and PMSB_p are still valid for the idiosyncratic errors regardless of whether additional variables are included or not in the test equation for the variable of interest. The option $p=0$ implies only constant in the model while $p=1$ implies constant and trend. Values in parentheses denote probability values.

Table 5: PANICCA test results with two additional variables (oil price & exchange rate)

Crosse-sections	Common Factors				Idiosyncratic Components					
	$p=0$		$p=1$		$p=0$			$p=1$		
	MQ_f	MQ_c	MQ_f	MQ_c	$P_{a,p}$	$P_{b,p}$	PMSB_p	$P_{a,p}$	$P_{b,p}$	PMSB_p
Full OECD	-13.785	-24.480	-14.423	-16.864	1.265	1.846	3.751	.913	1.033	1.173
panel	(0.000)	(0.000)	(0.000)	(0.000)	(.897)	(.968)	(1.000)	(.819)	(.849)	(.880)
Euro area	-12.946	-28.314	-12.658	-33.192	1.252	1.454	1.015	-.045	-.045	-.033
	(0.000)	(0.000)	(0.000)	(0.000)	(.895)	(.927)	(.845)	(.482)	(.482)	(.487)
Non-Euro	-11.15	-20.628	-23.377	-17.433	.764	1.298	4.285	1.024	1.281	1.601
area	(0.000)	(0.000)	(0.000)	(0.000)	(.778)	(.903)	(1.000)	(.847)	(0.900)	(.945)

Note: The Full OECD panel here involves 32 countries in which 16 belong to the Euro area and the other half belong to the Non-Euro area. The stock price indices are expressed in natural logs. With the consideration of covariates in the test equation, the MQ statistics of Bai and Ng (2004, 2010) are produced and reported for the common factors. However, the three test statistics namely $P_{a,p}$, $P_{b,p}$ and PMSB_p are still valid for the idiosyncratic errors regardless of whether additional variables are included or not in the test equation for the variable of interest. The option $p=0$ implies only constant in the model while $p=1$ implies constant and trend. Values in parentheses denote probability values.

4.0 Conclusion

This study offers a new evidence as regard the panel unit root of OECD stock price indices using the PANICCA test developed by Reese and Westerlund (2016) which combines the attributes of both the PANIC test of Bai and Ng (2004, 2010) and the Cross-section Average (CA) test of Pesaran (2007) and Pesaran et al. (2013). The outcome of the various analyses suggests that ignoring covariates in the common factor model of stock prices of OECD may give misleading inferences.

References

Bai, J. and Ng, S. (2004). A PANIC attack on unit roots and cointegration. Econometrica, 72 (4), 1127-1177.

Bai, J. and S. Ng (2010). Panel unit root tests with cross-section dependence: a further investigation. Econometric Theory 26(4), 1088-1114.

Breitung, J. (2000). The local power of some unit root tests for panel data. In: Baltagi BH, editor. Nonstationary panels, panel cointegration and dynamic panels. Amsterdam (: Elsevier; 161-77).

Diebold, F.X. and Yilmaz, K. (2012). Better to give than to receive: predictive directional measurement of volatility spillovers. International Journal of Forecasting 28, 57–66.

Harris, R.D. and Tzavalis, E. (1999). Inference for unit roots in dynamic panels where the time dimension is fixed. Journal of Economics, 91(2), 201-26.

Hlouskova, J. and Wagner, M. (2006). The performance of panel unit root and stationarity tests: Results from a large scale simulation study. Econometric Reviews, 25(1), 85-116.

Im. K.S., Pesaran, M.H. and Shin. Y (1997). Testing for unit roots in heterogeneous panels. mimeo: Department of Applied Economics, University of Cambridge.

Kilian, L. and Park, C. (2009). The impact of oil price shocks on the US stock market. International Economic Review 50(4), 1267–1287.

Levin, A., Lin. C.F. and Chu, C.S.J. (2002). Unit root tests in panel data: asymptotic and finite sample properties. Journal of Economics, 108(1), 1-24.

Maddala, G.S. and Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. Oxford Bulletin of Economics and Statistics, 61(S1), 631-52.

Narayan, P. K., Gupta, R. (2015). Has oil price predicted stock returns for over century? Energy Economics 48, 18-23.

Pesaran, H.M. (2007). A simple panel unit root test in presence of cross-section dependence. Journal of Applied Econometrics 22: 265–312.

Pesaran HM, Smith LV, Yamagata T. (2013). Panel unit root test in the presence of a multifactor error structure. Journal of Econometrics 175: 94–115.

Reese, S. and J. Westerlund (2016). PANICCA - PANIC on cross-section averages Journal of Applied Econometrics, 31(6), 961-981.

Salisu, A.A. and Isah, K.O. (2017). Revisiting the oil price and stock market nexus: A nonlinear Panel ARDL approach. Economic Modelling, 66: 258-271.

Salisu A.A., Oloko, T.F.(2015). Modelling oil price-US stock nexus: A VARMA-BEKK-AGARCH approach. Energy Economics *50,* 1-12.

Tsagkanos, A. and Siriopoulos, C. (2013). A long-run relationship between stock price index and exchange rate: A structural nonparametric cointegrating regression approach. Journal of International Financial Markets, Institutions and Money, 25, 106-118.

Tsai, C. (2012). The relationship between stock price index and exchange rate in Asian markets: A quantile regression approach. Journal of International Financial Markets, Institutions and Money, 22(3), 609-621.