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Oil and US dollar exchange rate dependence: A detrended cross-correlation approach

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ABSTRACT

This paper examines the relationship between oil prices and the US dollar exchange rate using detrended cross-correlation analysis. For a wide set of currencies in the periods before and since the onset of the recent global financial crisis, we characterized the oil price–exchange rate relationship at different time scales and documented two main findings. First, the cross-correlation analysis indicated that oil price–exchange rate correlations were negative and low, having in general lower values for longer time scales. Second, negative dependence between oil and the US dollar increased after the onset of the global financial crisis for all time scales, thereby providing evidence of both contagion and interdependence. This empirical evidence has important implications for monetary and fiscal policies, asset management and risk assessment.

1. Introduction

In recent years, the joint swing in crude oil prices and the US dollar (USD), even after the onset of the financial crisis, has revitalized interest in the oil price–exchange rate relationship, given that this is paramount for many financial and economic applications. Since the beginning of 2000 (Fig. 1) crude oil spot prices – measured using West Texas Intermediate (WTI) as the benchmark – rose from about 25 USD per barrel to a historic maximum of about 145 USD per barrel in July 2008, whereas the value of the USD relative to widely traded currencies fell, mainly against the euro. However, after the onset of the financial crisis, oil prices fell to a low of about 30 USD in December 2008 while the dollar appreciated over the same period. While crude oil prices steadily increased from the beginning of 2009, the value of the dollar fell.

In the literature, the oil price and exchange rate nexus is well established. Firstly, the role of oil prices in explaining exchange rate movements was noted early on by Golub (1983) and Krugman (1983): an oil-exporting (oil-importing) country may experience exchange rate appreciation (depreciation) when oil prices rise (fall). Empirical research by Golub (1983), Amano and Norden (1998), Akram (2004), Huang and Guo (2007), Chen and Chen (2007) and Lizardo and Mollick (2010) provides evidence for the role of oil prices in determining exchange rates. On the other hand, the potential importance of exchange rates for oil price movements, highlighted by Bloomberg and Harris (1995), is based on the law of one price for tradable goods: since oil is a homogeneous and internationally traded commodity priced in USD, a depreciation in the USD reduces the oil price for foreigners relative to commodity prices, pushing up the crude oil price in USD. Empirical evidence on the effect of a weak dollar on the rise in oil prices has been reported by Pindyck and Rotemberg (1990), Bloomberg and Harris (1995), Sadorsky (2000), Yousefi and Wirjanto (2004), Zhang et al. (2008) and Akram (2009).

Although previous empirical research has examined the role of the oil–exchange rate nexus for one or, at the most, two time scales (the short and the long run) and using different econometric techniques (e.g., cointegration theory or the vector autoregressive model), little is known about how oil prices and exchange rates co-move in different time scales. This paper fills this gap by re-examining oil–exchange rate interdependence at different time scales using the detrended cross-

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correlation coefficient as developed by Zebende (2011) for non-stationary time series analysis. This approach is motivated by the fact that the transmission of an oil or USD exchange rate shock may be observed for different time scales, since investors in those markets could be heterogeneous with respect to their investment horizons; in addition, the calculation of some measures of risk, like value-at-risk or expected shortfall, demands measures of dependence at different time scales for which risk should be measured according to investor horizons.

Based on detrended cross-correlation values at different time scales, we propose a test to identify contagion and interdependence between oil and the USD that consists of non-overlapping confidence intervals for the level of correlation coefficients obtained through detrended cross-correlation at different time scales for the periods before and after the onset of the financial crisis. This test shares the same spirit as the test proposed in Gallegati (2012): Shock transmission due to contagion is rapid and quickly fades; so changes in cross-correlations between time series at shorter time scales are associated with contagion, whereas changes at longer time scales are associated with interdependence or co-movement.

Our empirical analysis has endeavored to answer three questions: are the USD and oil prices negatively correlated? Does oil and USD exchange rate dependence change depending on the time scale? And has the oil and USD relationship changed since the advent of the financial crisis? Using data for the USD exchange rate against a large set of currencies for the period January 2000 to May 2012, empirical evidence revealed two new findings. First, oil prices and USD values moved in

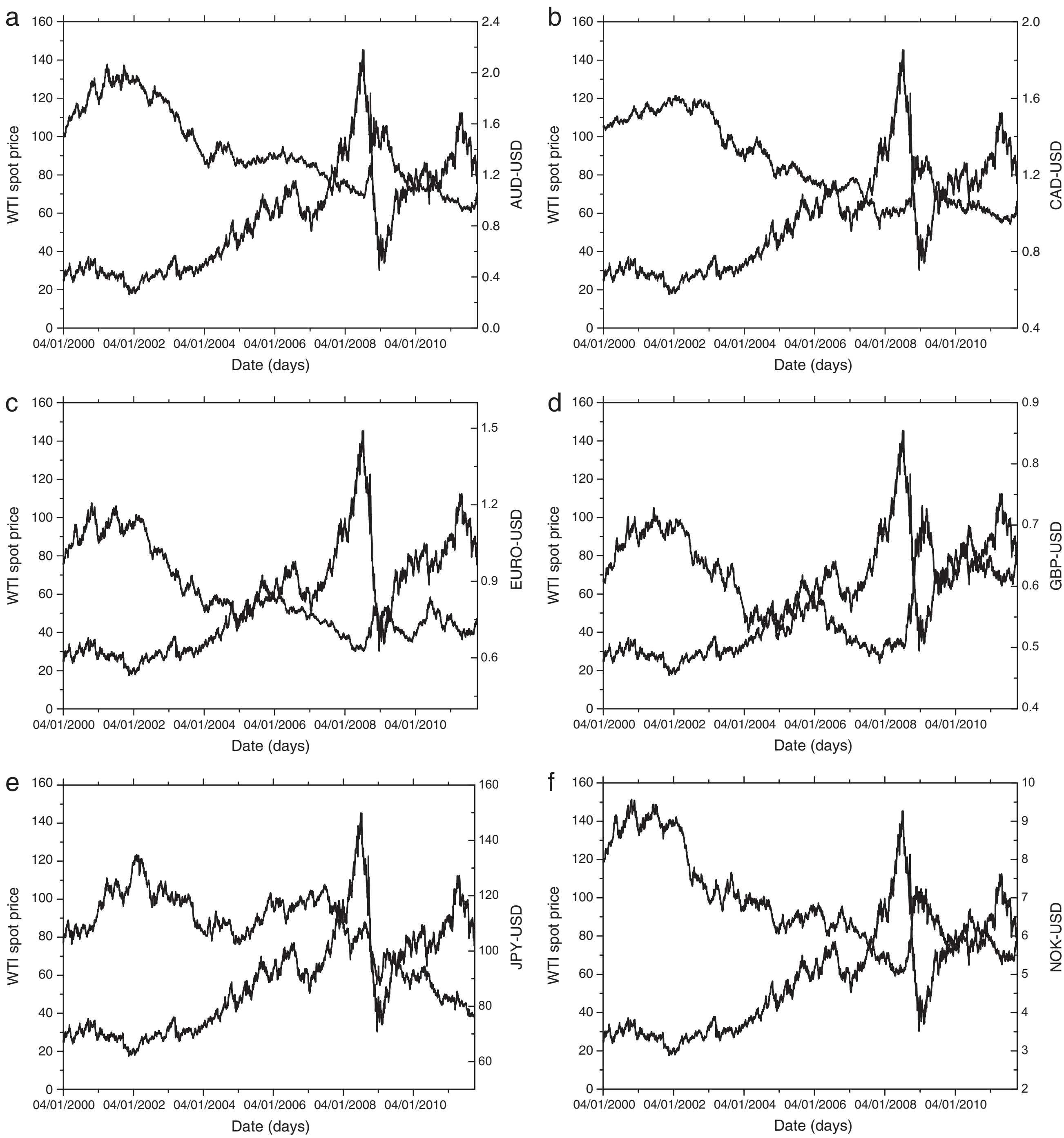

Fig. 1. WTI crude oil spot prices and major exchange rates for the period 4 January 2000 to 5 May 2012.

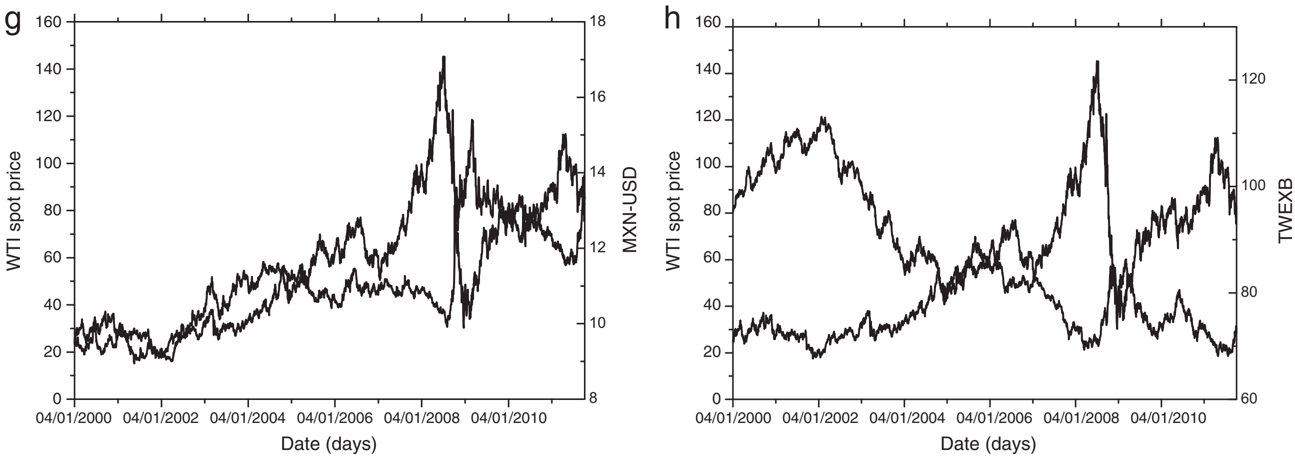

Fig. 1 (*continued*).

opposite directions in the period before the financial crisis, with negative and low correlations for shorter time scales, and, in general, lower values for longer time scales. Second, negative cross-correlations decreased significatively for all time scales, but especially for longer time scales, with the onset of the financial crisis, providing evidence, therefore, of both contagion and increased interdependence. The fact that oil and exchange rate markets became more (negatively) dependent in the period after the onset of the financial crisis meant that the diversification benefits of investors operating in those markets were considerably increased.

The rest of the paper is laid out as follows: Section 2 provides a literature overview regarding the relationship between oil prices and exchange rates. Section 3 introduces the detrended cross-correlation coefficient based on the detrended fluctuation analysis (DFA) (Peng et al., 1994) and detrended cross-correlation analysis (DCCA) (Podobnik and Stanley, 2008) methods and hypothesis testing. Sections 4 and 5 describe the data used in this research and our results. Section 6 discusses some implications of oil and exchange rate dependency and, finally, Section 7 concludes the paper.

2. Literature review

Consistent with theoretical explanations regarding the oil price and exchange rate relationship mentioned above, the empirical literature has investigated reciprocal influences between the USD exchange rate and the price of oil, generally finding a negative link between them.

Evidence of the role of oil prices in explaining the real exchange rate was reported by Amano and Norden (1998), who used cointegration theory, and by Camarero and Tamarit (2002), who used panel cointegration techniques. Similarly, Akram (2004) provided evidence of a non-negative relationship between oil prices and the Norwegian exchange rate that varied with oil price level and trend. Using a four-dimensional structural vector autoregression model, Huang and Guo (2007) found that real oil price shocks had a minor appreciation effect on China's real exchange rate and government energy regulation. In contrast, using monthly panel data for the G7 countries, (Chen and Chen (2007) demonstrated the dominant nature of real oil prices in real exchange rate movements and their significant forecasting power. Evidence of a negative relationship between oil price shifts and exchange rate changes was provided by Cifarelli and Paladino (2010), who used a multivariate generalized autoregressive conditional heteroskedasticity-in-mean (GARCH-M) model. Using cointegration analysis for a monetary approach to exchange rate determination, Lizardo and Mollick (2010) showed the significant contribution of oil prices to explaining long-term USD movements, supporting a negative relationship between oil prices and the USD. Finally, Basher et al. (2012) investigated the dynamic relationship between oil, exchange rates and stock prices in emerging stock markets using a structural vector autoregression model, finding that positive shocks to oil prices tended to depress stock prices and USD exchange rates in the short run.

Other empirical studies have highlighted the role played by a weak USD in oil prices. Sadorsky (2000) investigated the relationship between oil futures prices and various USD exchange rates, finding evidence of Granger causality from exchange rates to energy futures prices. Indjehagopian et al. (2000) have also noted that variations in exchange rates have an impact on oil prices. The impact of USD fluctuations on the formation of OPEC oil prices has been examined, using the general method of moments, by Yousefi and Wirjanto (2004), who reported evidence of a negative correlation between USD exchange rate fluctuations and the formation of OPEC oil prices. Using a vector error correction model, Krichene (2005) provided evidence of the different impacts of a fall in the nominal effective exchange rate on oil prices in the short and long term. Despite USD exchange rate influence on oil prices in the long run, Zhang et al. (2008) provided evidence of a limited effect in the short term and of a slight risk of a spillover effect from the currency market to the oil market. For quarterly data, Akram (2009) reported evidence suggesting that a weaker USD leads to higher oil prices and that USD shocks account for oil price fluctuations. Using two measures of dependence, namely, correlations and copulas, Reboredo (2012) examined how oil prices and exchange rates co-move and documented two main findings for a wide range of currencies: oil price–exchange rate dependence was in general weak, although it rose substantially in the period after the onset of the global financial crisis, and there was no extreme market dependence between oil prices and exchange rates. Using a wavelet decomposition approach for oil and exchange rate, Reboredo and Rivera-Castro, (2013) also found evidence of a change in oil–exchange rate dependence around the financial crisis. Using copulas, Wu et al. (2012) studied the dependence structure between the oil price and the USD exchange rate, assessing economic value through an asset-allocation strategy and finding economic value in dynamic trading strategies that exploit oil and exchange rate co-movement.

Different explanations for the negative relationship between crude oil prices and the USD value have been provided in most of the empirical studies. To begin with, if the USD depreciates, the price of oil drops for non-US consumers and their crude oil demand is affected, which eventually pushes up the price. Second, some oil-exporting countries choose to use currencies linked to the USD as a means of stabilizing the purchasing power of their exports in USD in terms of imports in non-USD currencies. Finally, when the USD is weaker, oil becomes more attractive as an investment, because a weak USD leads to reduced returns on USD-denominated financial assets. Despite the fact that the negative relationship between oil and USD has been confirmed by most of the above-mentioned empirical studies, no empirical research has examined whether (1) the link between oil prices and the USD exchange rate is the same for different time scales, or (2) whether this link at different time scales changes in response to a global financial crisis. Below we consider these two dimensions of the oil–USD relationship and discuss implications for policy design and market trading.

3. Methodology

To quantify dependence between oil and the USD exchange rate, we adopted the recent proposition implemented by Zebende (2011) based on the detrended cross-correlation analysis (DCCA) method (Podobnik and Stanley, 2008). DCCA is a generalization of detrended fluctuation analysis (DFA), a method developed by Peng et al. (1994) that signals a relationship between $F_{DFA}(n)$ (root mean square fluctuation) and the scale n, characterized for a power law $F_{DFA}(n) \propto n^{\alpha}$. In this way, α is the long-range auto-correlation scaling exponent, such that if $\alpha = 0.5$ the signal is uncorrelated, if $\alpha < 0.5$ the signal is anti-persistent, and if $\alpha > 0.5$ the signal is persistent.

The DCCA method is designed to investigate power-law cross-correlations between two simultaneously recorded time series, $\{y_i\}$ and $\{y'_i\}$, of equal length N, in the presence of non-stationarity, by means of the detrended covariance function $F^2_{DCCA}(n)$. If long-range cross-correlation appears between these two time series, then $F_{DCCA} \sim n^{\lambda}$. The λ exponent quantifies long-range power-law correlations and also identifies seasonality (Zebende and Machado-Filho, 2009), but λ does not quantify the level of cross-correlations.

To quantify the level of cross-correlation, we can apply the DCCA cross-correlation coefficient as developed by Zebende (2011), defined as the ratio between the detrended covariance function F^2_{DCCA} and the detrended variance function F_{DFA}, i.e.,

$$\rho_{DCCA}(n) \equiv \frac{F^2_{DCCA}(n)}{F_{DFA\{y_i\}(n)}\ F_{DFA\{y'_i\}(n)}}. \quad (1)$$

Eq. (1) leads us to a new scale of cross-correlation in non-stationary time series.[1] The value of ρ_{DCCA} ranges between $-1 \le \rho_{DCCA} \le 1$. A value of $\rho_{DCCA} = 0$ means that there is no cross-correlation and the level of cross-correlation is split between the positive and the negative case. Exponent ρ_{DCCA} has been tested on selected time series, both simulated and real cases, and has proved to be quite robust (Podobnik et al., 2011).

As in Gallegati (2012), we consider the existence of contagion and interdependence as a change in the correlation level for small and large scales between two different periods, respectively. Thus, if we denote the estimation of the detrended cross-correlation coefficients for the periods after and before the onset of the global financial crisis as ρ^A_{DCCA} and ρ^B_{DCCA}, respectively, we can test the null hypothesis of no contagion and no interdependence defined by:

$$H_0 : \rho^A_{DCCA} = \rho^B_{DCCA}. \quad (2)$$

This hypothesis of no contagion and no interdependence can be rejected with 95% confidence when the confidence intervals of the correlation coefficients do not overlap (see Gençay et al., 2002).

4. Data

We empirically investigated dependency between exchange rates and crude oil prices using daily observations from 4 January 2000 to 5 May 2012. We took oil prices in USD per barrel for West Texas Intermediate (WTI), given that WTI is used as a benchmark for determining the price of other light crudes in the USA and is closely related to other crude oil markets, like those of Brent, Maya, Dubai, etc. (see Reboredo, 2011). We took the USD exchange rate (foreign currency per unit of USD, i.e., an increase in an exchange rate leads to an appreciation in the USD) against euro currency countries (EUR) and the currencies for Australia (AUD), Canada (CAD), Japan (JPY), Mexico (MXN), Norway (NOK) and the United Kingdom (GBP). Additionally, to examine dependency between oil and the aggregate exchange rate, we considered the Broad Trade Weighted Exchange Index (TWEXB) of the US Federal Reserve. Data for oil prices were downloaded from the Energy Information Administration (EIA) website (http://www.eia.doe.gov) and exchange rate series were downloaded from the websites of the Bank of England (http://www.bankofengland.co.uk) and the Federal Reserve Bank of Saint Louis (http://www.frbstlouis.com).

Fig. 1 illustrates oil price and exchange rate dynamics for the different countries considered throughout the sample period. Oil prices and USD rates apparently tended to move in opposite directions, mainly after the onset of the financial crisis when oil prices experienced a drastic drop (from July 2008) and the USD temporarily recovered value. In fact, co-movement between oil prices and the USD was apparently more intense in the period after 15 July 2008, the point at which oil prices started to decline markedly after a significant rising track. Using the likelihood ratio F-statistic developed by Andrews (1993), Andrews and Ploberger (1994) and Hansen (1997) for the null of no change point in linear dependence between oil and exchange rate data, we endogenously identified a single structural breakpoint in linear dependence: between July 2008 and September 2008. We thus examined data for two periods: one before and the other after 15 July 2008. For each period we computed crude oil price and exchange rate returns on a continuous compounding basis as the difference between the log of the current price and that of the one-period lagged price.

Table 1
Descriptive statistics for daily oil price and exchange rate returns for the period 4 January 2000 to 5 May 2012.

	Mean (%)	Std.dev. (%)	Skew.	Kurt.	JB[1]	ARCH-LM[1]	LB[1]	Corr. with oil
Panel A: 4 January 2000 to 15 July 2008								
WTI	0.081	2.42	−0.52	6.82	0.00	0.01	0.15	–
AUD	−0.019	0.71	0.59	6.91	0.00	0.00	0.18	−0.11
CAD	−0.017	0.51	0.05	4.20	0.00	0.00	0.16	−0.12
EUR	−0.021	0.60	−0.04	4.04	0.00	0.01	0.19	−0.08
GBP	−0.009	0.52	0.06	3.63	0.00	0.00	0.21	−0.07
JPY	−0.000	0.61	−0.32	4.64	0.00	0.01	0.19	−0.06
NOK	−0.021	0.65	0.13	3.79	0.00	0.00	0.22	−0.12
MXN	0.004	0.46	0.11	5.49	0.00	0.00	0.18	−0.03
TWEXB	−0.014	0.42	0.12	3.57	0.00	0.00	0.19	−0.12
Panel B: July 16, 2008 to May 5, 2012								
WTI	−0.066	3.23	0.24	7.60	0.00	0.00	0.00	–
AUD	−0.000	1.29	0.79	11.34	0.00	0.00	0.00	−0.45
CAD	0.005	0.91	−0.13	6.34	0.00	0.00	0.00	−0.45
EUR	0.023	0.85	−0.14	5.56	0.00	0.00	0.00	−0.32
GBP	0.029	0.83	0.35	8.45	0.00	0.00	0.00	−0.30
JPY	−0.035	0.88	−0.36	7.06	0.00	0.00	0.00	0.22
NOK	0.019	1.17	−0.13	6.06	0.00	0.00	0.00	−0.44
MXN	0.029	0.96	0.66	13.33	0.00	0.00	0.00	−0.37
TWEXB	0.003	0.65	−0.54	6.60	0.00	0.00	0.00	−0.39

Notes: Daily data for the period 4 January 2000 to 5 May 2012. Data are split into two samples: (a) Panel A: 4 January 2000 to 15 July 2008 (before the crisis) and (b) Panel B: 16 July 2008 to 5 May 2012 (after the onset of the crisis). The table reports the basic statistics for return series, including mean (Mean), standard deviation (Std.dev.), skewness (Skew.) and kurtosis (Kurt.). ARCH-LM (Lagrange multiplier test for autoregressive conditional heteroskedasticity) refers to the empirical statistics of the statistical test for conditional of order ten. LB are the empirical statistics of the Ljung–Box tests for autocorrelations of order ten applied to raw return series. JB are the empirical statistics of the Jarque–Bera test for normality based on skewness and excess kurtosis. Corr. refers to the correlation coefficients.

[1] A p-value of <0.05, indicates rejection of the null hypothesis for the associated statistical tests at the 5% level.

[1] It is to be noted that in Zebende (2011) Eq. (1) was typed incorrectly.

Table 1 shows descriptive statistics for oil and exchange rate returns for the samples representing the periods before and after 15 July 2008 (hereafter, the pre-crisis and crisis periods, respectively). Average returns were similar across markets and the corresponding standard deviations were larger in an order of several magnitudes. Since the means of the return series were very small relative to the standard deviations, it could be concluded that there was no significant trend in the data. Average returns increased significantly, except in Japan and for oil, in the crisis period, whereas volatility increased in all cases, showing relatively high risks in the crisis period. Negative values for skewness were not common to all the exchange rates, even though the value decreased during the financial crisis for most of the exchange rates considered. All returns show excessive kurtosis that was generally greater in the crisis period, implying fatter tails for returns. The Jarque–Bera test strongly rejected the normality of the unconditional distribution for all the series in both periods. Moreover, Ljung–Box statistic values for uncorrelation up to 36th order in the returns suggest the non-existence of serial correlation for most exchange rate returns in the pre-crisis period; correlation became broadly common, however, in the crisis period. Finally, the Lagrange multiplier test for autoregressive conditional heteroskedasticity (ARCH-LM) for serially correlated squared returns indicated that ARCH effects were likely to be found in all the return series for both periods.

Tables 2 and 3 provide a Granger causality analysis between oil and exchange rates for both sample periods. Using a vector autoregressive model with one or two lags, the evidence on causality shows an absence of causality in the period before the crisis (except in CAD and NOK), whereas causality changed in the crisis period as oil prices became an important factor in explaining some exchange rates. Taken together with the evidence provided by the correlation coefficient reported in Table 1, a clear difference in dependency is evident in both sample periods.

Table 2
Oil prices versus exchange rates: Granger causality test, 4 January 2000 to 15 July 2008.

H_0: Oil prices do not Granger-cause exchange rates	Lags	Statistics[1]	Hypothesis
WTI–AUD	1	0.585 (0.444)	Non-rejection
	2	0.513 (0.598)	Non-rejection
WTI–CAD	1	7.210 (0.007)	Rejection
	2	3.979 (0.018)	Rejection
WTI–EUR	1	0.184 (0.667)	Non-rejection
	2	1.158 (0.314)	Non-rejection
WTI–GBP	1	0.406 (0.523)	Non-rejection
	2	0.230 (0.794)	Non-rejection
WTI–JPY	1	2.848 (0.091)	Non-rejection
	2	2.963 (0.051)	Non-rejection
WTI–NOK	1	6.079 (0.013)	Rejection
	2	3.607 (0.027)	Rejection
WTI–MXN	1	0.167 (0.682)	Non-rejection
	2	0.536 (0.585)	Non-rejection
WTI–TWEXB	1	3.607 (0.060)	Non-rejection
	2	1.764 (0.190)	Non-rejection
H_0: Exchange rates do not Granger-cause oil prices	**Lags**	**Statistics[1]**	**Hypothesis**
AUD–WTI	1	0.512 (0.474)	Non-rejection
	2	0.275 (0.759)	Non-rejection
CAD–WTI	1	1.209 (0.271)	Non-rejection
	2	0.518 (0.595)	Non-rejection
EUR–WTI	1	0.013 (0.907)	Non-rejection
	2	0.022 (0.978)	Non-rejection
GBP–WTI	1	0.025 (0.872)	Non-rejection
	2	0.961 (0.382)	Non-rejection
JPY–WTI	1	1.273 (0.259)	Non-rejection
	2	1.367 (0.254)	Non-rejection
NOK–WTI	1	0.553 (0.457)	Non-rejection
	2	0.487 (0.614)	Non-rejection
MXN–WTI	1	0.871 (0.350)	Non-rejection
	2	0.492 (0.611)	Non-rejection
WTI–TWEXB	1	0.134 (0.714)	Non-rejection
	2	0.230 (0.794)	Non-rejection

[1] In parentheses, p-values <0.05 indicates rejection of the null hypothesis for the associated statistical tests at the 5% level.

Table 3
Oil prices versus exchange rates: Granger causality test, 16 July 2008 to 5 May 2012.

H_0: Oil prices do not Granger-cause exchange rates	Lags	Statistics[1]	Hypothesis
WTI–AUD	1	11.439 (0.000)	Rejection
	2	5.971 (0.002)	Rejection
WTI–CAD	1	4.816 (0.028)	Rejection
	2	5.017 (0.006)	Rejection
WTI–EUR	1	1.919 (0.166)	Non-rejection
	2	0.961 (0.382)	Non-rejection
WTI–GBP	1	2.579 (0.108)	Non-rejection
	2	4.485 (0.011)	Rejection
WTI–JPY	1	0.149 (0.698)	Non-rejection
	2	1.311 (0.269)	Non-rejection
WTI–NOK	1	22.411 (0.000)	Rejection
	2	11.194 (0.000)	Rejection
WTI–MXN	1	0.320 (0.571)	Non-rejection
	2	0.473 (0.622)	Non-rejection
WTI–TWEXB	1	3.034 (0.081)	Non-rejection
	2	1.548 (0.212)	Non-rejection
H_0: Exchange rates do not Granger-cause oil prices	**Lags**	**Statistics[1]**	**Hypothesis**
AUD–WTI	1	5.673 (0.017)	Rejection
	2	2.974 (0.481)	Non-rejection
CAD–WTI	1	0.087 (0.766)	Non-rejection
	2	0.571 (0.564)	Non-rejection
EUR–WTI	1	3.301 (0.069)	Non-rejection
	2	2.077 (0.125)	Non-rejection
GBP–WTI	1	3.175 (0.074)	Non-rejection
	2	1.723 (0.178)	Non-rejection
JPY–WTI	1	0.925 (0.336)	Non-rejection
	2	0.926 (0.396)	Non-rejection
NOK–WTI	1	3.920 (0.043)	Rejection
	2	3.452 (0.031)	Rejection
MXN–WTI	1	0.682 (0.408)	Non-rejection
	2	0.473 (0.623)	Non-rejection
WTI–TWEXB	1	2.561 (0.109)	Non-rejection
	2	1.406 (0.245)	Non-rejection

[1] In parentheses, p-values <0.05 indicates rejection of the null hypothesis for the associated statistical tests at the 5% level.

However this analysis, mainly from the point of view of the Pearson correlation coefficient, is not robust (Wilcox, 2005) and can be misleading if outliers are present, as tends to happen in real-world data characterized by a high degree of non-stationarity (Devlin et al., 1975). In view of this issue, the next section discusses the detrended cross-correlation coefficient.

5. Results

We applied the detrended cross-correlation coefficient to oil and exchange rate return series. We estimated the ρ_{DCCA} for each pair of composite variables (oil price and exchange rates for different countries) for each of the two sampling periods considered (pre-crisis and crisis). The results for the correlation for WTI prices and exchange rates for different time scales are shown in Fig. 2. The red squares correspond to the correlation coefficient for the pre-crisis period, while the blue circles indicate the correlation coefficient for the crisis period. The vertical lines indicate the upper and lower limits for the 95% confidence interval.

The ρ_{DCCA} evidence points to two different patterns of oil price–exchange rate dependence for the two periods studied. First, in general there is negative weak dependence between oil prices and exchange rates in the pre-crisis period, with correlations close to -0.1 in the different time scales, with the exception of the relationship between the WTI price and the Mexican peso (MXN): for small scales the correlations were negative and near zero, while there was positive although weak correlation for the longer time scales. Second, in the crisis period in general there is negative and significant dependence between oil prices and exchange rates in shorter time scales, which increased from 100 days on, approximately. Different behavior was observed in the relationship between the Japanese yen (JPY) and WTI prices, which was positive and increased with the different time scales.

The significant decrease (or increase for the Japanese yen) in the correlation value for the crisis period for all time scales allowed us to reject the null hypothesis in Eq. (2), thus supporting the argument of financial contagion and interdependence between oil prices and USD exchange rates with the advent of the financial crisis. This result is consistent with the descriptive and causality analyses provided in Section 4 for a single scale and with the empirical evidence of co-movement between

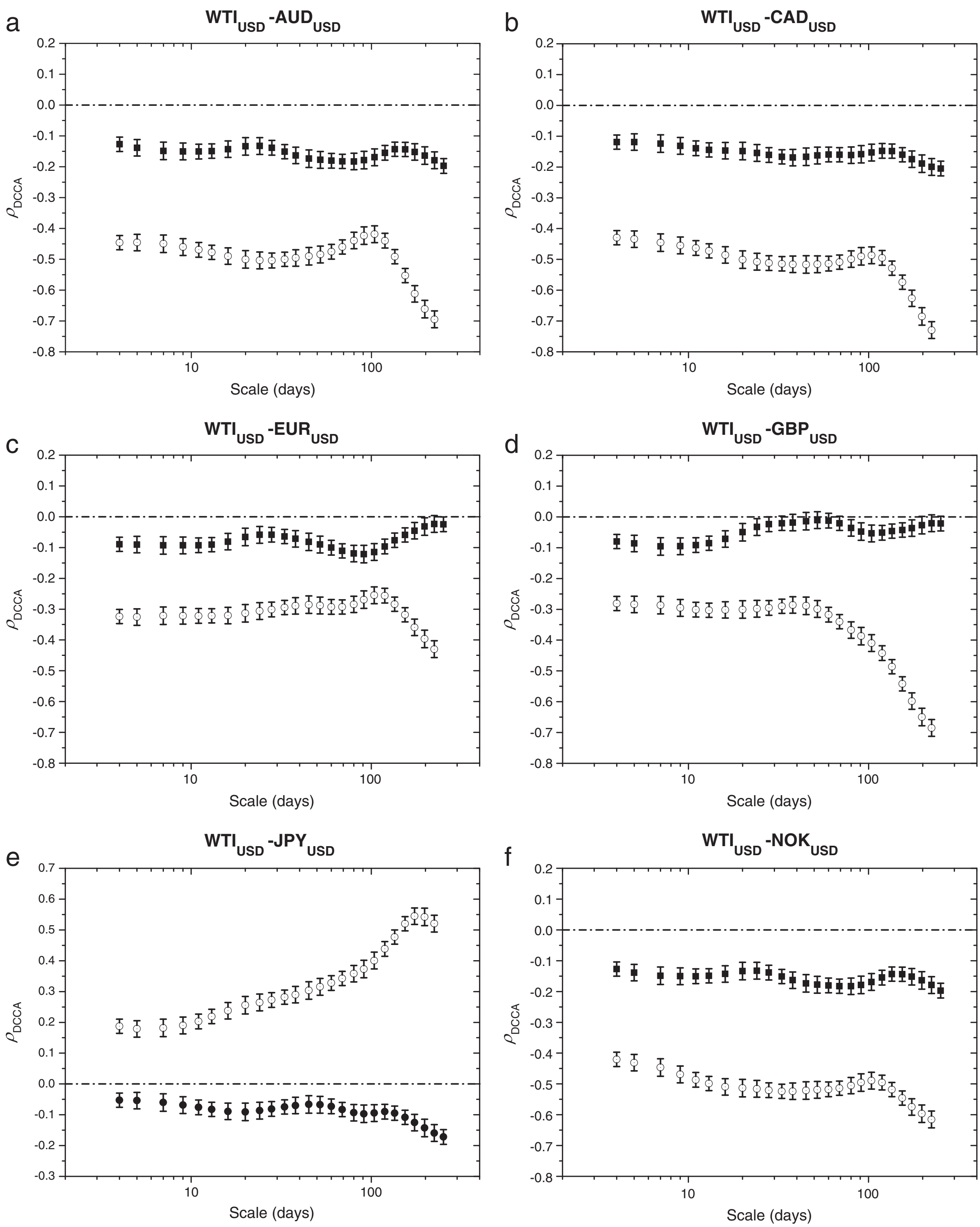

Fig. 2. Detrended cross-correlation coefficient for WTI and exchange rates.

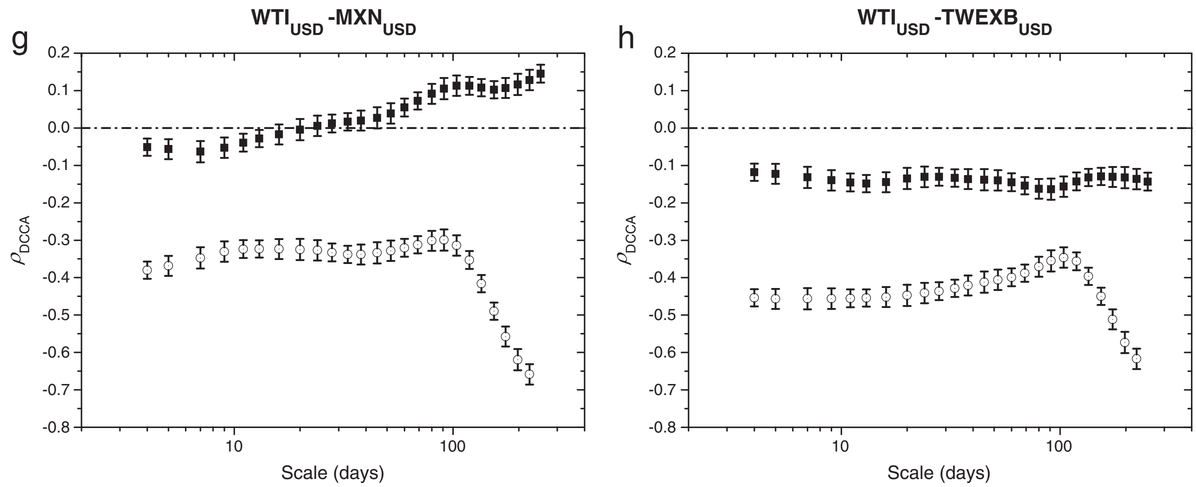

Fig. 2 (*continued*).

oil and exchange rates supplied by copula functions and reported in Reboredo (2012).

6. Discussion

Our results on oil price and USD exchange rate dependence using ρ_{DCCA} have a number of relevant policy and financial implications for policy makers, researches and traders that merit discussion.

First, the weak evidence of negative dependence between oil and the USD to the middle of 2008 indicates that it is not possible to explain the rise in oil prices on the basis of USD depreciation; the primordial role was played by forces pushing up oil prices in intrinsic demand and supply behavior in international oil markets. It also implies that the forecasting power of exchange rates regarding oil prices was weak. In contrast, with the onset of the financial crisis, the USD and oil prices co-moved more intensively, so the USD not only played a more active role in moving oil prices but also increased its forecasting ability. Our results indicate that those effects were different at different time scales: for time scales greater than 100 days the effects were more intensive, so over the long run, oil and USD values were more closely linked.

Second, our results indicate that, in the period between 2000 and the middle of 2008, non-US oil-importing countries that experienced inflationary pressures arising from oil prices could actively have used monetary policy to control those pressures, since they could not be partially offset by USD depreciation. However, in the financial crisis period, the evidence of oil price–exchange rate dependence for different time scales suggests that monetary policy could be used more passively to control oil inflationary pressures, given that the inflationary effects would be partially offset by foreign currency depreciation, although mainly for long-range time scales.

Third, our results also have implications for the fiscal and monetary policies of oil-exporting countries. For governments concerned with isolating government spending from oil price volatility, our results indicate that before the mid-2008 government spending would have been exposed to oil revenue changes since price volatility could not be diversified by USD movements; however, the increase in dependence between oil prices and exchange rates with the onset of the crisis meant that a positive oil price shock could be partially offset by USD depreciation and vice versa. On the other hand, interdependence between oil and exchange rate markets has implications for oil-exporting countries that peg their currencies to the USD. The purchasing power of such countries with respect to oil-importing countries increases (decreases) when oil prices go up (down), if oil prices – in USD – do not co-move with exchange rates. On the contrary, the effectiveness of the currency pegging policy is more constrained, since some of the gains from a rise in oil prices will be absorbed by USD depreciation, although the impact of oil price volatility on oil purchasing power fluctuations will be dampened.

Finally, our results also have important implications for risk management and asset pricing in spot and derivative crude oil and exchange rate markets. Evidence of changes in dependence at different time scales, mainly with the onset of the financial crisis, indicate that some measures of financial risk, like value-at-risk or expected shortfall, would have different values depending on the investor's horizon, as the degree of dependence between oil and the USD changes significantly: value-at-risk decreases as the time scale enlarges. Likewise, the portfolio risk varies at different time scales since the forecasting ability of exchange rates is greater for longer than for shorter time scales. The implications of our findings of time-varying dependence are also important for the market risk faced by oil-importing (exporting) countries from a positive (negative) oil price shock that was different in both sample periods: the USD has a much stronger diversification effect, which increased with the time scales in the post-July 2008 compared to the pre-July 2008 period.

7. Conclusions

We analyzed oil price–exchange rate dependence using detrended cross-correlation analysis in order to identify differences and shifts in the oil price–exchange rate relationship for several time scales. We showed that the time scale decomposition property of ρ_{DCCA} is useful in revealing the existence of contagion and interdependence between oil prices and exchange rates during a financial crisis, since the correlation analysis applied on a scale-by-scale basis provided reliable confidence intervals of the estimated time scale correlations in the pre-crisis and crisis periods.

Our main findings for a large set of currencies and the WTI benchmark crude oil prices for the period 4 January 2000 to 5 May 2012 can be summarized as follows. First, in the pre-crisis period oil price changes had a weak and negative effect on exchange rates and vice versa. Second, after the onset of the global financial crisis there was evidence of contagion and (negative) interdependence between oil prices and exchange rates.

The implications of our findings regarding oil price–exchange rate interdependence are important for the management of fiscal policy in oil-exporting countries, for monetary policies aimed at controlling oil inflationary pressures, for purchasing power gains by oil-exporting emerging economies with USD-pegged currencies, and, finally, for risk management and the pricing of currencies and oil-related assets.

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