

Oil Price-Macroeconomic Relationship in Australia and New Zealand: Application of a Hidden Cointegration Technique

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Abstract: *This study examines the relationships between oil prices and macroeconomic variables such as industrial/manufacturing production index, consumer price index, real effective exchange rates, lending rates and stock price index in Australia and New Zealand within the framework of hidden cointegration technique and crouching error correction model (CECM) of Granger and Yoon (2002) using updated data; the study hopes to contribute to the literature on oil price-macroeconomic relationship in the Asia Pacific region. The results suggest a weak or no evidence of long-run relationships between crude oil prices and macroeconomic variables in these countries with few exceptions. Positive changes in crude oil prices are found to influence the increase in consumer price indices in Australia and negative changes in crude oil prices found to be responsible for the long-run relationships with decrease in stock price indices and interest rates. The study fails to find any convincing evidence of the long-run relationship between oil price and New Zealand macroeconomic variables.*

Keywords: Australia, Cointegration, Macroeconomic, New Zealand, Oil price

JEL classifications: C13, Q43

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1. Introduction

Skyrocketing commodity prices, particularly crude oil (CP), create tensions in most countries (Blein and Longo, 2009), regardless of their development status. Oil prices are watched carefully worldwide its status as a vital commodity having relatively inelastic demand. The CP shocks that began in the 1970s attracted the attention of many researchers and it has been regarded as one of the reasons for global economic slowdowns, especially for oil importing countries (Hamilton, 1983; 1996; 2003). Recent increases in CP have renewed

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the interests of all concerned and it is now generally agreed that increases in CP result in declining economic activities in the oil importing countries. Oil is an engine of growth and hence, increases in its price have direct impact on many economic activities.

A body of literature deals with oil price-macroeconomic relationships. Broadly speaking, there are two categories of studies on the impacts of CP shocks on economic activities such as economic growth and inflation in the case of the USA or Western Europe: studies that document evidence of negative impacts of CP shocks and those which report little or no evidence of impacts of the shocks. The first category deals with the pioneering work of Hamilton (1983). Using Sims' (1980) VAR approach to the USA data for the period 1948-1980, the author shows that CP and the USA's Gross National Product (GNP) growth exhibit a strong correlation. The author also reports that oil price increased sharply prior to every recession in the USA after World War II. Following Hamilton, a number of studies document the adverse impacts CP had on the Gross Domestic Product (GDP) of the USA (Mork, 1989; Lee *et al.*, 1995; Gisser and Goodwin, 1986; Hamilton, 1996; Hamilton, 2003; Bjornland, 2000; Cuñado and Gracia, 2003). Negative impacts of CP shocks are reported under different market structures as well (Rotemberg and Woodford, 1996; Finn, 2000). Some studies focus on the factor market and industry levels, recording adverse impacts of CP on employment, real wages and industry outputs (Keane and Prasad, 1996; Davis and Haltiwanger, 2001; Davis *et al.*, 1997; Lee and Ni, 2002; Lippi and Nobili, 2009; Francesco, 2009). A number of studies deal with the magnitude and strength of the impacts of CP shocks and reach a consensus that the impacts of earlier shocks, in the 1970s are more severe than the later shocks of the 1980s or 1990s (Burbidge and Harrison, 1984; Blanchard and Gali, 2007; Raymond and Rich, 1997; Bohi, 1991). Studies outside the USA and Western Europe also report negative impacts of CP shocks (Lescaroux and Mignon, 2009; Tang *et al.*, 2010; Zhang and Reed, 2008; Cologni and Manera, 2009; Huang *et al.*, 2005).

Other studies focus on the relationship between CP and exchange rates, some report evidence of Granger causality from CP to exchange rates (Akram, 2004; Amano and van Norden, 1998; Lizardo and Mollick, 2010; Benassy-Quere *et al.*, 2005). Yet, others report that exchange rates influence CP (Cooper, 1994; Brown and Phillips, 1986; Yousefi and Wirjanto, 2004; Zhang *et al.*, 2008), while a few studies show that CP does not have any relationship with exchange rates (Aleisa and Dibooglu, 2002; Breitenfeller and Cuaresma, 2008).

There are also discussions on the association between CP and stock prices. Jones and Kaul (1996) for the USA and Canada; Papapetrou (2001) for Greece; Sadorsky, (1999);(2003) for the USA; Basher and Sadorsky (2006) for some emerging markets; and Park and Ratti (2008) for the USA and 13

European countries, reporting that CP negatively affect stock prices. However, a few studies find little or no relationship between oil and stock prices (Chen *et al.*, 2007; Huang *et al.*, 1996; Cong *et al.*, 2008; Apergis and Miller, 2009). The second category of studies that find no or weak evidence of the impacts of CP shocks on economic activities include Hooker (1996) and Segal (2007).

Different dimensions of CP shocks have been discussed in literature written in the period 1983 to 2010. Literature reviews show the causes of CP shocks along with consequences to economic activities. Research is ongoing to find even more compact conclusions about the CP shocks and the question as to whether the latter still matter for economic activities is also being addressed in recent studies by for example Lescaroux (2011).

To sum up, most studies focus on developed countries with only a few available outside G-7 countries. Although many studies document the impacts of CP on economic activities in developed countries and some in countries outside the USA and Western Europe, there is a dearth of studies in the context of Asia and Pacific countries, particularly focusing on Australia and New Zealand. The aim of the current study is to examine the relationships between CP and industrial production (IP), consumer price index (CPI), real effective exchange rates (REER), interest (lending) rates (IR), and stock price index (SPI) in Australia and New Zealand. The available studies on CP-macroeconomic relationship in these areas are as follows: Faff and Brailsford (1999) find a relationship between CP and stock market returns in Australia reporting positive sensitivity of oil and gas related stock prices to CP while negative sensitivity is reported for paper, packaging, transport and banking industries. Valadkhani and Mitchell (2002), using an input-output model, report that CP helps increase CPI in Australia and the shock was stronger during the 1970s than in recent times. Gil-Alana (2003), applying fractionally cointegrated methods, reports that real CP and unemployment maintain a cointegrated relationship. Gounder and Bartlett (2007), using vector autoregressive (VAR) models, document adverse impacts of CP on the economic variables of New Zealand in the short-run. Alom *et al.* (2013) using structural VAR models examine the short-run relationships between CP and macroeconomic variables in Australia and New Zealand and a few other Asian countries. Their results identify weak evidence of the impacts of oil prices on macroeconomic variables. They report that only REER is affected by CP shocks. The paucity of studies in the context of these countries is one of the main inspirations for the completion of the current study, distinct from the existing studies in several aspects. First, data until 2010 is used which includes the two major oil shocks of 2007-08 and 2010. Inclusion of these recent shocks will enhance understanding of the impacts of CP shocks on economic activities. Second, the study is implemented within the framework of a hidden cointegrated and CECM models, which were rarely used in previous studies.

The remainder of the paper is organised as follows: Section 2 introduces data and their sources; section 3 discusses the method used in the analyses of data, while section 4 reports and discusses empirical results; and section 5 draws relevant conclusions from the study.

2. Data description

CP is used along with selected macroeconomic and financial variables, namely IP or manufacturing production indices (MP), CPI, IR, REER, and SPI for Australia and New Zealand as specified previously. As a proxy for CP, Dubai spot prices measured in US\$ per barrel are used because the Dubai price is more relevant to these countries (Liu *et al.*, 2010). The main objective is to investigate the relationships between CP and IP/MP, CPI, REER, IR and SPI. Data are sourced mainly from the International Financial Statistics (IFS) database of IMF. Seasonally adjusted series are collected for IP/MP directly from the IFS database; the other series are seasonally adjusted using USA census-X12. The use of seasonally adjusted data overcomes the inappropriateness of seasonal pattern although seasonally unadjusted data may produce different results which are beyond the scope of this study.

It has been argued that after the 1980s, the effects of CP shocks on macroeconomic variables are mild. Quarterly data was therefore collected over the period 1980 to 2010 to examine this proposition in the context of Asia Pacific countries, but, because of unavailability of data, the start date varies. For Australia, data for all series are available from 1980Q1 to 2010Q2 making a total of 122 observations. In the New Zealand case, data are available for the period 1987Q1 to 2010Q3 making a total of 93 observations. The availability of data, in other words, restricts its collection to after major economic reforms in New Zealand's economy.

Real CP in domestic currencies is used for each country. In order to transform nominal C to real price, nominal exchange rates and CPI are used. The real series are computed in the following way for C:

$$RCP_t = CP_t * \frac{E_t}{CPI_t}$$

Where RCP_t stands for real CP at time t; CP_t represents nominal CP at time t, E_t stands for nominal exchange rate while CPI_t represents consumer price indices at time t.

In order to test the hidden cointegration, the series are decomposed into its positive and negative components and accumulate them at each time, t. The positive and negative components are defined as follows¹:

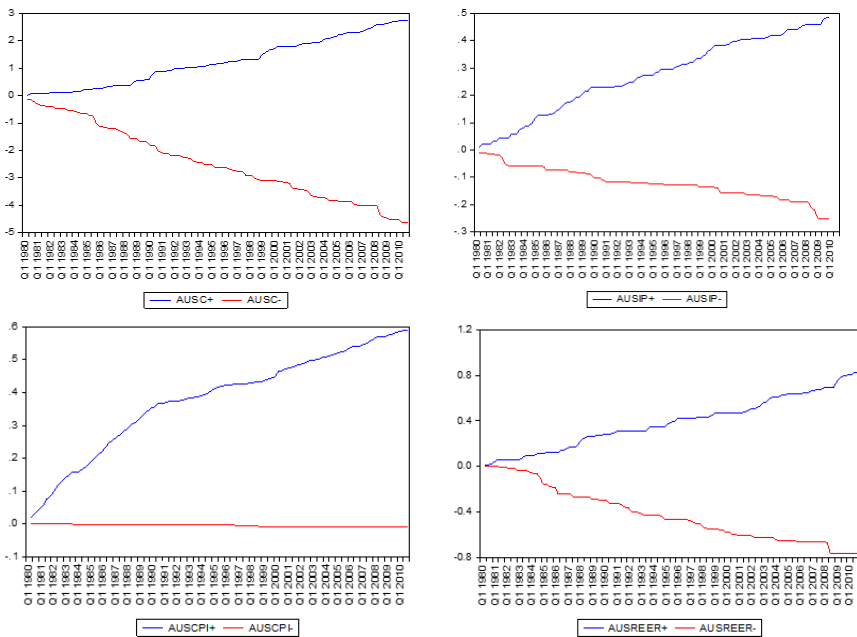
CPI+ = Cumulative sum of the positive components of consumer price index

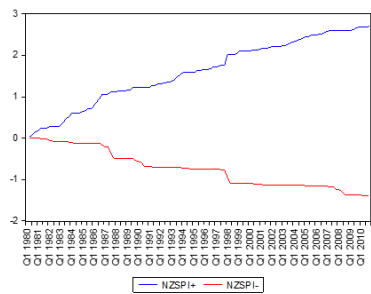
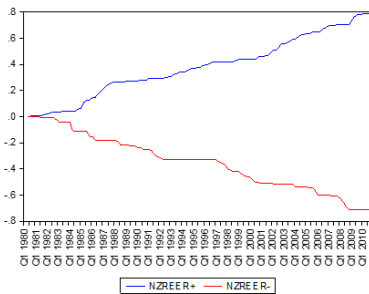
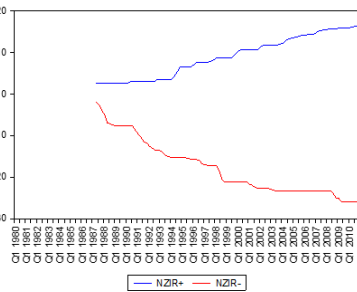
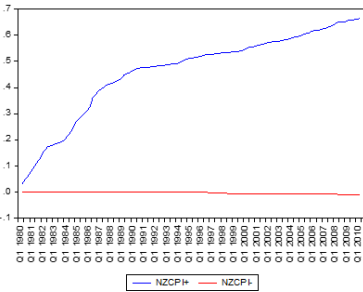
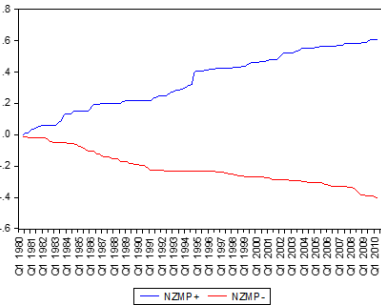
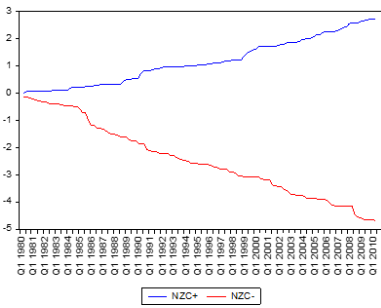
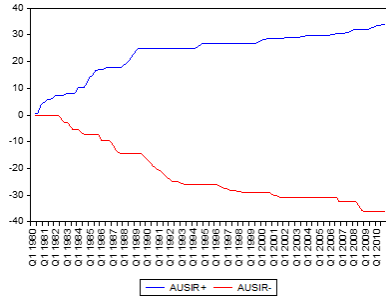
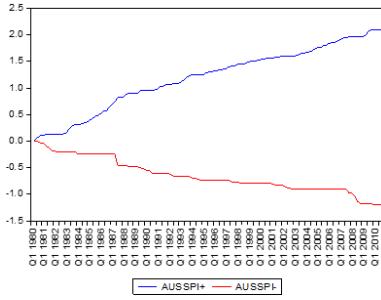
CPI- = Cumulative sum of the negative components of consumer price index

- IP/MP+ = Cumulative sum of the positive components of industrial/manufacturing production index
- IP/MP- = Cumulative sum of the negative components of industrial/manufacturing production index
- REER+ = Cumulative sum of the positive components of real exchange rate
- REER- = Cumulative sum of the negative components of real exchange rate
- IR+ = Cumulative sum of the positive components of lending rate
- IR- = Cumulative sum of the negative components of lending rate
- SPI+ = Cumulative sum of the positive components of stock price index
- SPI- = Cumulative sum of the negative components of stock price index
- C+ = Cumulative sum of the positive components of CP
- C- = Cumulative sum of the negative components of CP

Figure 1 exhibits the positive and negative components of each pair of series. It can be seen that the cumulative positive components are growing over time, while the negative components are decreasing over time.

Figure 1: Positive and negative components of variables for Australia and New Zealand





3. Methodology

The main goal of this study is to identify the short run and long run relationships between crude oil price and macroeconomic variables using both the standard cointegration approach of Engle and Granger (1991) and the hidden cointegration approach or Crouching Error Correction model (CECM) provided by Granger and Yoon (2002). Both these methods are used in the same study for more accuracy. The later approach is superior to the standard approach because it captures cointegrating relationships even in a nonlinear data generating process. Even if data series have no cointegration in conventional sense, it might be possible to have hidden cointegration in them (Granger and Yoon, 2002). Therefore, the intention is to apply both methods to compare the findings as well as use the more sophisticated approach to identify more accurately whether any relationship exists or not. Optimal lag length were selected by Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) since the sample size is relatively large (Liew, 2004).

In the standard procedure, the following type of equations for examining the long-run relationship between crude oil prices and macroeconomic variables are estimated:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln CP_t + \varepsilon_t \quad (1)$$

Where Y_t represents the macroeconomic variables at time t , CP_t stands for crude oil prices at time t and ε_t is the error term. α_0 is the measure for constant and α_1 measures the long run pass-through from crude oil price to macroeconomic variables.

The following Engle-Granger error correction model is estimated to examine the short term dynamics of diesel or petrol prices in response to the changes in CP:

$$\Delta \ln Y_t = \beta_1 \ln CP_t + \beta_2 \hat{\varepsilon}_{t-1} + v_t \quad (2)$$

Where Δ is the first difference operator; β_1 measures the short-term pass-through rate from crude oil prices to diesel or petrol prices; β_2 is the measure for error correction adjustment speed in the case of disequilibrium which is expected to be negative in the case of mean reversion and $\hat{\varepsilon}_{t-1}$ represents the extent of disequilibrium at $t-1$ period, which is the residual obtained from equation (1).

In the CECM procedure, the following type of long-run equations without or with trend for each pair of positive and negative components of macroeconomic variables and crude oil price series are estimated:

$$Y_t^+ = \alpha_0 + \alpha_1 C_t^+ + \varepsilon_t \quad (3)$$

$$Y_t^+ = \alpha_0 + \alpha_1 C_t^+ + \alpha_3 t + \varepsilon_t \quad (4)$$

Where Y_t^+ represents cumulative sum of positive components of any macroeconomic variables at time t , C_t^+ denotes cumulative sum of positive components of CP series at time t . α_0 is the measure for constant and α_1 measures long-run pass-through of shocks from CP to macroeconomic variables, and t measures trend. Similarly, models for all other components defined above are estimated to check cointegration. Residual series obtained from equation type (3) or (4) are examined by Augmented Dickey-Fuller (ADF) test for any unit roots. If they are found cointegrated, for example, Y_t^+ and C_t^+ are cointegrated, then we estimate the following type of CECM model:

$$\begin{aligned} \Delta Y_t^+ &= \gamma_0 + \gamma_1 \hat{\varepsilon}_{t-1} + \sum_{i=1}^k \gamma_{ci} \Delta C_{t-i}^+ + \sum_{j=1}^p \gamma_{rj} \Delta Y_{t-j}^+ + \mu_t \\ \Delta C_t^+ &= \phi_0 + \phi_1 \hat{\varepsilon}_{t-1} + \sum_{i=1}^k \phi_{ci} \Delta C_{t-i}^+ + \sum_{j=1}^p \phi_{rj} \Delta Y_{t-j}^+ + \nu_t \end{aligned} \quad (5)$$

Where γ_1 and ϕ_1 are the long run speed of adjustment parameters to hidden equilibrium, parameters associated with other lagged variables measure short term adjustment. $\hat{\varepsilon}_{t-1}$ is residual series obtained from equation (3) or (4).

4. Empirical results and discussions

At the outset of empirical tests, we check the stationary properties of all variables and their components by using ADF and Phillips-Perron (PP) unit root tests². The results of ADF and PP tests, as presented in Table 1, show that all logarithmic transformed series and positive and negative components carry unit roots in levels excepting IR in New Zealand. Although ADF indicates IR stationary at level, the PP test suggests that it is nonstationary. However, they all are stationary at their first differences, implying series are integrated at order 1, $I(1)$. This creates the premises for testing cointegration between series.

Table 1: Results of unit root tests

Variables	ADF test				PP test			
	Level		First difference		Level		First difference	
	AUS	NZ	AUS	NZ	AUS	NZ	AUS	NZ
CPI	-3.288	-3.070	-4.599 ^a	-4.770 ^a	-3.374	-3.941 ^b	-7.660 ^a	-5.976 ^a
CPI+	-3.183	-3.160	-4.549 ^a	-3.966 ^b	-3.456 ^b	-3.791 ^b	-7.605 ^a	-5.807 ^a
CPI-	-2.443	-1.647	-9.605 ^a	-9.270 ^a	-2.619	-1.732	-9.520 ^a	-9.187 ^a
IP/MP	-1.049	-1.237	-9.374 ^a	-9.537 ^a	-1.184	-1.479	-9.506 ^a	-9.552 ^a
IP/MP+	-1.679	-1.692	-10.215 ^a	-9.958 ^a	-1.715	-1.800	-10.217 ^a	-9.962 ^a
IP/MP-	-1.077	-1.268	-8.761 ^a	-8.899 ^a	-1.374	-1.384	-8.776 ^a	-8.968 ^a
REER	-1.277	-2.996	-9.441 ^a	-8.685 ^a	-1.495	-2.692	-9.317 ^a	-8.546 ^a
REER+	-2.305	-1.879	-7.992 ^a	-8.390 ^a	-1.775	-1.955	-7.991 ^a	-8.358 ^a
REER-	-1.565	-2.909	-10.902 ^a	-8.917 ^a	-1.573	-2.567	-10.905 ^a	-8.778 ^a
SPI	-2.262	-2.815	-9.584 ^a	-9.994 ^a	-2.554	-2.989	-9.485 ^a	-9.946 ^a
SPI+	-1.545	-1.781	-8.456 ^a	-9.930 ^a	-1.642	-1.848	-8.425 ^a	-9.946 ^a
SPI-	-2.327	-2.419	-10.293 ^a	-7.468 ^a	-2.501	-2.120	-10.309 ^a	-7.528 ^a
IR	-4.174	-4.587 ^a	-6.620 ^a	-8.453 ^a	-3.278	-2.325	-6.606 ^a	-8.539 ^a
IR+	-3.337	-3.450	-7.260 ^a	-6.240 ^a	-3.119	-2.517	-7.431 ^a	-5.028 ^a
IR-	-1.255	-2.670	-7.366 ^a	-5.797 ^a	-1.050	-2.668	-7.308 ^a	-5.770 ^a
C	-2.274	-1.899	-9.318 ^a	-8.998 ^a	-2.095	-1.974	-10.879 ^a	-9.809 ^a
C+	-3.313	-2.581	-9.086 ^a	-8.890 ^a	-2.670	-2.014	-8.986 ^a	-8.884 ^a
C-	-2.234	-1.914	-10.769 ^a	10.241 ^a	-2.279	-2.080	-10.923 ^a	-10.242 ^a

Note: The values are of t statistics and ^{a, b} indicate 1% and 5% level of significance respectively. ADF, Augmented Dickey Fuller; PP, Phillips-Perron.

Table 2 exhibits Engle-Granger cointegration results. Cointegration tests failed to identify any statistically significant long-run relationships between CP and macroeconomic variables in Australia and New Zealand with the exception of SPI. SPI of both Australia and New Zealand are found to maintain a long-run relationship with CP. Since CP and SPI are found to have linear relationship, we estimate ECM for them. Table 3 presents ECM results for SPI and CP estimated as per equation (2). Table 3 shows that neither short-term pass through (β_1) nor error correcting speed parameter (β_2) having appropriate sign are statistically significant for Australian SPI and CP, indicating no short or long-run adjustment to equilibrium. However, error correcting term (β_2) is statistically significant at 5% level of significance for New Zealand case; implying a long-run adjustment to equilibrium although the speed of adjustment is slower.

Table 2: Results of cointegration tests between oil price and macroeconomic variables

Dependent variable	Independent variable	tau-statistics	
		AUS	NZ
CPI	C	-3.143	-3.721
IP	C	-2.906	-1.143
REER	C	-2.634	-3.023
IR	C	-3.387	-2.755
SPI	C	-3.749 ^b	-4.862 ^b

Note: The values are of t statistics and ^b indicates 5% level of significance.

Table 3: Results of Engle-Granger ECM

	β_1	β_2	Adj. R ²
AUS SPI	0.018(0.343)	-0.001(-0.11)	-0.015
NZ SPI	-0.079(-1.167)	-0.024(-1.984 ^b)	0.029

Note: Values in parentheses are t-statistics and ^b indicates 5% level of significance.

Since standard cointegration procedure failed to identify long-run relationships between CP and macroeconomic variables, we proceed with the hidden cointegration approach. We first estimate Model 3 or 4 using the OLS method and then estimate cointegration models according to the Engle-Granger approach. The hidden cointegration is similar to the standard cointegration, except that we estimate models based on the decomposed positive and negative components (Honarvar, 2009). Table 4 displays results of the t-statistics for the hidden cointegration tests. The results show that there are statistically significant relationships between positive components of CPI and CP, positive components of CPI and negative components of CP, positive components of IP and negative components of CP, positive components of REER and positive components of CP, negative components of REER and negative components of CP, and positive components of IR and positive and negative components of CP in the case of Australia.

Relatively weaker evidence is found in the case of New Zealand. Table 4 also depicts that there are statistically significant cointegrating relationships between positive components of CPI and negative components of CP, negative components of MP and negative components of CP, and positive components of IR and positive and negative components of CP. In order to get a clearer idea about the long run relationships, we next estimate the CECM. Tables 5 to 12 report CECM results for Australian macroeconomic variables with CP,

while Tables 13 to 16 reports the same for New Zealand. Robust *t*-values are reported in the parentheses.

Table 4: Hidden cointegration between oil prices and Australian/New Zealand macroeconomic variables

Dependent variable	Australia				New Zealand			
	C+		C-		C+		C-	
	Without trend	With trend	Without trend	With trend	Without trend	With trend	Without trend	With trend
	t-statistics	t-statistics	t-statistics	t-statistics	t-statistics	t-statistics	t-statistics	t-statistics
CCPI+	-3.467 ^b	-2.076	-3.509 ^b	-3.327 ^c	-2.713	-2.102	-2.793	-3.942 ^b
CCPI-	-2.301	-2.521	-2.238	-2.499	-2.262	-2.021	-1.270	-2.740
CIP/MP+	-2.144	-2.053	-3.279 ^c	-2.822	-2.048	-2.950	-1.935	-1.728
CIP/MP-	-2.897	-1.214	-0.753	-0.827	-1.963	-1.246	-1.769	-3.218 ^c
CREER+	-3.308 ^c	-2.530	-1.586	-2.341	-2.478	-1.738	-1.960	-1.707
CREER-	-1.737	-2.378	-2.799	-3.282 ^c	-2.822	-2.881	-2.472	-2.474
CLSPI+	-2.290	-1.768	-2.752	-3.073	-2.439	-2.749	-2.624	-2.307
CLSPI-	-2.671	-2.176	-3.036	-3.714 ^c	-2.343	-2.638	-2.732	-2.712
CIR+	-3.537 ^b	-2.568	-3.036	-3.845 ^b	-2.312	-3.884 ^b	-2.840	-4.145 ^a
CIR-	-1.829	-1.686	-1.057	-2.963	-2.470	-2.772	-2.167	-2.523

Notes: The values are of *t* statistics and ^{a, b, c} indicate 1%, 5% and 10% level of significance respectively. C+ and C- refer to cumulative sum positive and cumulative sum of negative components in world crude oil prices (CP) respectively.

Table 5 reports results for CECM between positive components of CPI and CP. Statistically significant results are only reported for the convenience. The error correcting term has got the right sign and is statistically significant only in the CPI equation. This implies that the positive changes in the CP is the common stochastic trend responsible for long-run dynamic behaviour of positive changes in CPI (Granger and Yoon, 2002). The CECM results between positive components of CPI and negative components of CP with and without trend are shown in Tables 6 and 7. It can be noted that error correcting terms have the right signs and are statistically significant in both CPI and CP equations with or without trend. In this case, there are no common stochastic trends or in other words both CPI and CP are responsible for long-run dynamic behaviour in them. However, it is not trustworthy that Australian CPI increase will be responsible for the dynamic behaviour with the decrease in world crude oil prices. We thus emphasise on the previous result found in Table 5 that positive changes in CP is responsible for the long run relationship with CPI in Australia.

Table 5: Cointegration vectors and CECM between CPI+ and C+ in Australia

$$\Delta CPI^+ = 0.0014 - 0.011 \hat{\varepsilon}_{t-1} + 0.359 \Delta C_{t-1}^+ + 0.0326 \Delta C_{t-2}^+ + \mu_t$$

(2.749) (-1.883) (4.074) (3.712)

*Adj R*² = 0.431

$$\Delta C^+ = 0.0206 + 0.224 \Delta C_{t-1}^+ + \nu_t \quad Adj R^2 = 0.047$$

(3.556) (2.411)

Note: values in parentheses are t-statistics. Which refer to positive changes of cumulative sum of consumer price indices (CPI) and positive changes of cumulative sum of oil prices (CP).

Table 6: Cointegration vectors and CECM between CPI+ and C- in Australia

$$\Delta CPI^+ = 0.001 - 0.017 \hat{\varepsilon}_{t-1} + 0.375 \Delta CPI_{t-1}^+ + 0.353 \Delta CPI_{t-2}^+ - 0.009 \Delta C_{t-2}^- + \mu_t$$

(2.154) (-1.886) (4.336) (4.088) (-1.983)

*Adj R*² = 0.450

$$\Delta C^- = -0.028 - 0.395 \hat{\varepsilon}_{t-1} + \nu_t \quad Adj R^2 = 0.025$$

(-2.880) (-2.235)

Note: values in parentheses are t-statistics. Which refer to positive changes of cumulative sum of consumer price indices (CPI) and negative changes of cumulative sum of oil prices (CP).

Table 7: Cointegration vectors and CECM between CPI+ and C- with trend in Australia

$$\Delta CPI^+ = 0.004 - 0.025 \hat{\varepsilon}_{t-1} + 0.265 \Delta CPI_{t-1}^+ + 0.249 \Delta CPI_{t-2}^+ - 0.008 \Delta C_{t-1}^- - 0.000 trend + \mu_t$$

(4.033) (-2.787) (2.976) (2.826) (-1.755) (-3.370)

*Adj R*² = 0.495

$$\Delta C^- = -0.430 \hat{\varepsilon}_{t-1} - 3.002 \Delta CPI_{t-1}^+ + \nu_t \quad Adj R^2 = 0.021$$

(-2.345) (-1.690)

Note: values in parentheses are t-statistics. ΔCPI^+ and ΔC^- refer to positive changes

Table 8 reports the results of CECM between positive components of IP and negative components of CP. Although it sounds reasonable that IP increases with the decrease of CP, the error correcting term is not statistically significant in IP equation rather in CP equation. This implies that not the changes in CP but positive changes in Australian IP are the common stochastic trend responsible for the long-run dynamic behaviour between them. Again, it is hard to accept this result because an individual country's IP may not influence the changes in world CP.

Table 8: Cointegration vectors and CECM between IP+ and C- in Australia

$$\Delta IP^+ = 0.004 + 0.015 \Delta C_{t-1}^- + \mu_t$$

(6.297) (1.878)

$$Adj R^2 = 0.017$$

$$\Delta C^- = -0.043 - 1.058 \hat{\varepsilon}_{t-1} + 1.783 \Delta C_{t-1}^- + \nu_t \quad Adj R^2 = 0.075$$

(-5.961) (-3.435) (1.716)

Notes: values in parentheses are t-statistics. ΔIP^+ and ΔC^- refer to positive changes of cumulative sum of industrial production indices (IP) and negative changes of cumulative sum of oil prices (CP).

Tables 9 and 10 show results of CECM between positive and negative components of REER and CP. It can be viewed that error correcting terms are statistically significant at CP equations only - meaning changes in CP is not responsible for the long-run relationships between them. We do not accept this result on the ground that error correcting terms have got the wrong signs and REER of a single country can hardly influence the changes in world CP although exchange rates of the USA has been found influential to CP (Cooper, 1994; Brown and Phillips, 1986; Yousefi and Wirjanto, 2004; Zhang *et al.*, 2008).

Table 9: Cointegration vectors and CECM between REER+ and C+ in Australia

$$\Delta REER^+ = 0.005 + 0.325 \Delta REER_{t-1}^+ - 0.058 \Delta C_{t-1}^- + \mu_t$$

(5.078) (3.638) (-2.375)

$$Adj R^2 = 0.123$$

$$\Delta C^+ = 0.016 + 0.275 \hat{\varepsilon}_{t-1} + 0.194 \Delta C_{t-1}^- + \nu_t \quad Adj R^2 = 0.115$$

(4.093) (3.137) (2.262)

Notes: values in parentheses are t-statistics. $\Delta REER^+$ and ΔC^+ refer to positive changes of cumulative sum of REER and positive changes of cumulative sum of CP.

Table 10: Cointegration vectors and CECM between REER- and C- with trend in Australia

$$\Delta REER^- = -0.009 + \mu_t$$

(-3.411)

$$Adj R^2 = -0.001$$

$$\Delta C^- = -0.0340 + 0.338 \hat{\varepsilon}_{t-1} + 0.971 \Delta REER_{t-1}^- + \nu_t \quad Adj R^2 = 0.094$$

(-3.229) (2.077) (2.613)

Notes: values in parentheses are t-statistics. $\Delta REER^-$ and ΔC^- refer to negative changes of cumulative sum of real effective exchange rate (REER) and negative changes of cumulative sum of oil prices (CP).

Table 11 exhibits CECM between negative components of stock price indices and negative components of CP. It can be seen that the error correcting term is statistically significant only in SPI equation signalling that the CP is responsible for the long-run dynamic behaviour between them. This relationship may be explained, in such a way, that when CP increases, the SPI keeps falling even when the CP starts to decrease.

Table 11: Cointegration vectors and CECM between SPI- and C- with trend in Australia

$$\Delta SPI^- = -0.013 - 0.107 \hat{\varepsilon}_{t-1} + \mu_t \quad Adj R^2 = 0.030$$

(-2.691) (-2.508)

$$\Delta C^- = -0.036 + 0.464 \Delta SPI_{t-1}^- + \nu_t \quad Adj R^2 = 0.045$$

(-3.453) (2.383)

Notes: values in parentheses are t-statistics. ΔSPI^- and ΔC^- refer to positive changes of cumulative sum of stock price indices (SPI) and negative changes of cumulative sum of oil prices (CP).

The estimation outputs of CECM for the components of IR and CP are shown in Tables 12 and 13. In Table 12, it can be seen that error correcting terms are statistically significant in both IR and CP equations; implying no common stochastic trends responsible for the long-run behaviour between

positive components of IR and positive components of CP, while Table 13 shows that negative components of CP is responsible for the long-run relationships between C- and IR+. This can be interpreted that because of oil price shock, the IR increases and it keeps rising even when the CP starts falling.

Table 12: Cointegration vectors and CECM between IR+ and C+ in Australia

$$\begin{aligned} \Delta IR^+ &= -0.142 - 0.031 \hat{\varepsilon}_{t-1} + 0.413 IR^+_{t-1} + \mu_t & Adj R^2 &= 0.249 \\ &(-2.644) \quad (-2.931) & (5.105) & \\ \Delta C^+ &= 0.018 - 0.001 \hat{\varepsilon}_{t-1} + 0.188 \Delta C^+_{t-1} + \nu_t & Adj R^2 &= 0.046 \\ &(4.908) \quad (-1.779) & (2.109) & \end{aligned}$$

Notes: values in parentheses are t-statistics. ΔIR^+ and ΔC^+ refer to positive changes of cumulative sum of lending rate (IR) and positive changes of cumulative sum of oil prices (CP).

Table 13: Cointegration vectors and CECM between IR+ and C- with trend in Australia

$$\begin{aligned} \Delta IR^+ &= 0.435 - 0.044 \hat{\varepsilon}_{t-1} + 0.345 IR^+_{t-1} - 0.003 trend + \mu_t & Adj R^2 &= 0.297 \\ &(4.295) \quad (-3.253) & (4.166) \quad (-3.166) & \\ \Delta C^- &= -0.032 + \nu_t & Adj R^2 &= -0.0004 \\ &(-2.578) & & \end{aligned}$$

Notes: values in parentheses are t-statistics. ΔIR^+ and ΔC^- refer to positive changes of cumulative sum of lending rate (IR) and negative changes of cumulative sum of oil prices (CP).

Table 14 demonstrates results for the CECM between positive components of CPI and negative components of CP. The error correcting terms have wrong signs in both equations although they are statistically significant. We do not accept these results of long-run relationships because the positive signs indicate that return to equilibrium after deviation is not possible. Further, there is no common stochastic trend between CPI+ and C-.

Table 14: Cointegration vectors and CECM between CPI+ and C- with trend (New Zealand)

$$\Delta CPI^+ = -0.005 + 0.018 \hat{\varepsilon}_{t-1} + 0.525 \Delta CPI_{t-1}^+ + 0.000 trend + \mu_t$$

(-4.489)
(1.921)
(6.672)
(3.263)

$$Adj R^2 = 0.537$$

$$\Delta C^- = 0.440 \hat{\varepsilon}_{t-1} - 2.417 \Delta CPI_{t-1}^+ + \nu_t \quad Adj R^2 = 0.082$$

(3.448)
(-2.287)

Notes: values in parentheses are t-statistics. ΔCPI^+ and ΔC^- refer to positive changes of cumulative sum of consumer price indices (CPI) and negative changes of cumulative sum of oil prices (CP).

Table 15 shows that negative components of MP of New Zealand is responsible for the long-run behaviour of MP and CP. It is not convincing that the decline of New Zealand MP would be influential enough for the decline in CP; also the adjusted R squared in MP equation is negative -implying poor estimation. We thus do not accept this result as robust.

Table 15: Cointegration vectors and CECM between MP- and C- with trend (New Zealand)

$$\Delta MP^- = 0.002 + 0.172 \Delta MP_{t-1}^- + \mu_t$$

(2.649)
(1.659)

$$Adj R^2 = -0.004$$

$$\Delta C^- = 0.033 - 1.187 \hat{\varepsilon}_{t-1} + 3.647 \Delta MP_{t-1}^- + \nu_t \quad Adj R^2 = 0.10$$

(2.980)
(-2.840)
(3.398)

Notes: values in parentheses are t-statistics. ΔMP^- and ΔC^- refer to positive changes of cumulative sum of manufacturing production indices (MP) and negative changes of cumulative sum of oil prices (CP).

The long-run relationships between IR and CP are also ambiguous in the case of New Zealand. Table 16 shows that error correcting term is significant only in the CP equation implying positive changes in IR is responsible for the long-run equilibrium relationships between IR and CP. Like previous cases, it is not convincing that IR of a single small country, e.g. New Zealand, will have much influence to moderate the relationship with world CP. Table 17

exhibits estimation outputs for the CECM between positive components of IR and negative components of CP. The results can be discarded on the ground that error correcting terms are significant in both equations and also the term has wrong sign in the IR equation.

Table 16: Cointegration vectors and CECM between IR+ and C+ with trend (New Zealand)

$$\Delta IR^+ = 0.596 \Delta IR_{t-1}^+ - 0.250 \Delta IR_{t-2}^+ + \mu_t$$

(5.616) (-2.348)

$$Adj R^2 = 0.256$$

$$\Delta C^+ = -0.024 - 0.007 \hat{\varepsilon}_{t-1} + 0.193 \Delta C_{t-1}^+ + \nu_t \quad Adj R^2 = 0.048$$

(-2.031) (-1.946) (1.784)

Notes: values in parentheses are t-statistics. ΔIR^+ and ΔC^+ refer to positive changes of cumulative sum of lending rates (IR) and positive changes of cumulative sum of oil prices (CP).

Table 17: Cointegration vectors and CECM between IR+ and C- with trend (New Zealand)

$$\Delta IR^+ = 0.151 \hat{\varepsilon}_{t-1} + 0.457 \Delta IR_{t-1}^+ + \mu_t$$

(3.141) (4.222)

$$Adj R^2 = 0.335$$

$$\Delta C^- = 0.037 - 0.019 \hat{\varepsilon}_{t-1} + 0.052 \Delta IR_{t-1}^+ + \nu_t \quad Adj R^2 = 0.006$$

(2.136) (-1.807) (1.958)

Notes: values in parentheses are t-statistics. ΔIR^+ and ΔC^- refer to positive changes of cumulative sum of lending rates (IR) and negative changes of cumulative sum of oil prices (CP).

Overall, the empirical results indicate poor or no long-run relationships between CP and macroeconomic variables of Australia and New Zealand, which is a broad reflection of standard cointegration results. Although hidden cointegration identified fewer long-run relationships between CP and macroeconomic variables, in most cases CP did not statistically qualify to be responsible for the long-run dynamic behaviour between CP and macroeconomic variables. Only few convincing results are found for Australia. The positive

changes in CP are responsible for the increase of CPI in the long-run, consistent with Valadkhani and Mitchell (2002); negative changes in CP are responsible for the decrease of SPI and increase in IR in Australia. No evidence of CP being responsible for the changes in macroeconomic variables in the long-run is found. The results of this study are largely consistent with Alom et al. (2013) in the sense that world crude oil prices have less or no influences on the macroeconomic activities in Australia and New Zealand. The reason for this is discussed below.

Although Australia and New Zealand have small amounts of proven oil reserves, these countries possess many other mineral resources which dominate the energy sector. For example, according to the International Energy Association (IEA), in 2008, Australia produced 99% of its electricity using different fuels, including coal as the major source (76%), with only 1% of their electricity coming from oil. In 2008, New Zealand produced 99.97% of its electricity from other sources than oil, of which 75% comes from hydro and gas plants: only 0.03% is produced using oil as fuel. The main use of oil in these countries is for transportation and since industrial production indices do not include individual transport cost directly, that could be one of the possible reasons that IP/MP are found to be not responsive to oil price shocks. Their alternative mineral resources help Australia to accommodate oil supply shocks. Moreover, the intensity of oil usage in the Australian economy has declined since the 1970s (Rosewell *et al.*, 2008). Further, both of these countries maintain inflation-targeting monetary policy, which could be the reason why they successfully accommodated the CP shock through inflation and interest rates.

5. Conclusions

The objective of this study is to assess the relationships between CP and macroeconomic variables in Australia and New Zealand using both standard and hidden cointegration approaches to contribute to the literature on oil price-macroeconomic relationships in the Asia Pacific region with updated data and sophisticated econometric tool of CECM. The study reveals weak or no evidence of long-run relationships between CP and macroeconomic variables. In the case of Australia, it has been found that positive changes in CP impacts to increase CPI and negative changes in CP influence the decrease in SPI and IR. In the case of New Zealand, macroeconomic variables are found to be non-responsive to the changes in CP in the long-run. Based on the empirical findings, the study concludes that CP does have very insignificant impact on the macroeconomic variables in Australia and New Zealand, which is consistent with findings by Alom et al. (2013). The empirical findings of this study provide insights to policymakers and business practitioners. Dependencies on crude oil play a vital role in absorbing global oil price shocks. Since Australia and New

Zealand possess huge deposits of mineral resources other than oil, the global oil price shock has no or little impacts on the macroeconomic variables of these countries. Due to less dependency on oil and inflation-targeting monetary policies, these countries survived very well during the recent oil price shocks of 2007-08 and 2010. To be more shock-resistant in the future, these countries may focus on using more local mineral and renewable resources while continuing their inflation-targeting monetary policies.

Notes

- ¹ In order to calculate cumulative positive and negative components, we first calculated the change in prices/variables ($dp = p_t - p_{t-1}$) and then took the positive components following $dp > 0$, dp or 0 otherwise and the negative components following $dp < 0$, dp or 0 otherwise. Having defined the positive and negative components, we added them to get cumulative sum of positive/negative components.
- ² Apart from conventional unit root tests, Lee-Strazicich (LS) and Lumsdaine-Pappel (LP) unit root tests were conducted with the expectation of having possible structural breaks in time series data. However, no remarkable evidence of structural breaks was found.

References

- Akram, Q.F. (2004) "Oil Prices and Exchange Rates: Norwegian Evidence", *Econometrics Journal*, 7: 476-504.
- Aleisa, E.A. and Dibooglu, S. (2002) "Sources of Real Exchange Rate Movements in Saudi Arabia", *Journal of Economics and Finance*, 26: 101-110.
- Alom, F., Ward, B.D. and Hu, B. (2013) "Macroeconomic Effects Of World Oil And Food Price Shocks in Asia and Pacific Economies: Application of SVAR models", *OPEC Energy Review*, 37: 327-372.
- Amano, R.A. and Van Norden S. (1998) "Oil Prices and the Rise and Fall of the US real exchange rate", *Journal of International Money and Finance*, 17: 299-316.
- Apergis, N. and Miller, S.M. (2009) Do Structural Oil Shocks Affect Stock Prices, *Working paper* 0917, University of Nevada, Las Vegas: Department of Economics.
- Basher, S.A. and Sadorsky, P. (2006) "Oil Price Risk and Emerging Stock Markets", *Global Finance Journal*, 17: 224-251.
- Benassy-Quere, A., Mignon, V. and Penot, A. (2005) China and the Relationship Between the Oil Price and the Dollar, *Working Papers*, CEPII Research Center.
- Bjornland, H.C. (2000) "The Dynamic Effects Of Aggregate Demand, Supply And Oil Price Shocks- A Comparative Study", *The Manchester School*, 68: 578-607.

- Blanchard, O.J. and Gali, J. (2007) The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so Different from the 1970s?, *Economics Working Papers*, Universitat Pompeu Fabra: Department of Economics and Business.
- Blein, R. and Longo, R. (2009) Food price volatility-how to help Smallholder Farmers Manage Risk and Uncertainty, *Discussion Paper*, Rome: IFAD.
- Bohi, D.R. (1991) "On the Macroeconomic Effects of Energy Price Shocks", *Resources and Energy*, 13: 145-162.
- Breitenfeller, A. and Cuaresma, J.C. (2008) "Crude Oil Prices and USD/EUR Exchange Rate", *Monetary Policy and the Economy*, Q4/08.
- Brown, S.P.A. and Phillips, K.R. (1986) "Exchange Rates and World Oil Prices", *Federal Reserve Bank of Dallas Economic Review*, 1-10.
- Burbidge, J. and Harrison, A. (1984) "Testing for the Effects of Oil-Price Rises using Vector Autoregressions", *International Economic Review*, 25: 459-484.
- Chen, N., Roll, R., and Ross, S.A. (2007) Economic Forces and the Stock Market, in Lo, A.W. (ed.) *Static Asset Pricing Models*, Mass: Elgar, pp 365-385.
- Cologni, A and Manera, M. (2009) "The Asymmetric Effects of Oil Shocks on Output Growth: A Markov-Switching Analysis for the G-7 Countries", *Economic Modelling*, 26: 1-29.
- Cong, R.-G, Wei, Y.-M., Jiao, J.-L. and Fam, Y. (2008) "Relationships between Oil Price Shocks and Stock Market: An Empirical Analysis from China", *Energy Policy*, 36: 3544-3553.
- Cooper, R.L. (1994) "Changes in Exchange Rates and Oil Prices for Saudi Arabia and Other OPEC Member Countries", *The Journal of Energy and Development*, 20: 109-128.
- Cuñado, J. and Gracia, F.P. (2003) "Do oil price shocks matter? evidence for some European countries", *Energy Economics*, 25: 137-154.
- Davis, S.J. and Haltiwanger, J. (2001) "Sectoral Job Creation and Destruction Responses to Oil Price Changes", *Journal of Monetary Economics*, 48: 465-512.
- Davis, S.J., Loungani, P. and Mahidhara, R. (1997) Regional Labour Fluctuations: Oil Shocks, Military Spending and Other Driving Forces, Board Governors of the Federal Reserve System, *International Finance Discussion Paper*, No. 578.
- Engle, R.F. and Granger, C.W.J. (1991) Cointegration and Error Correction: Representation, Estimation, and Testing, in Engle, R.F. and Granger, C.W.J. (eds.) *Long-run Economic Relationships: Readings in Cointegration*, Oxford University Press: Oxford, pp.81-111.

- Faff, R.W. and Brailsford, T.J. (1999) "Oil Price Risk and the Australian Stock Market", *Journal of Energy Finance & Development*, 4: 69-87.
- Finn, M.G. (2000) "Perfect Competition and the Effects of Energy Price Increases on Economic Activity", *Journal of Money, Credit and Banking*, 32: 400-416.
- Francesco, G. (2009) The Economic Effects of oil Price Shocks on the UK Manufacturing and Services Sector, *MPRA No.* 16171.
- Gil-Alana, L.A. (2003) "Unemployment and Real Oil Prices in Australia: A Fractionally Cointegrated Approach", *Applied Economics Letters*, 10: 201-204.
- Gisser, M. and Goodwin, H.T. (1986) "Crude Oil and Macroeconomy: Tests for Some Popular Notions", *Journal of Money, Credit and Banking*, 18: 95-103.
- Gounder, R. and Bartlett, M. (2007) *Oil Price Shocks and Economic Growth: Evidence for New Zealand, 1989-2006*, Paper presented at the New Zealand Association of Economist Annual Conference, Christchurch 27-29 June 2007.
- Granger, C.W. and Yoon, G. (2002) *Hidden cointegration*, Department of Economics, *Working Paper*, San Diego : University of California.
- Hamilton, J.D. (1983) "Oil and the Macroeconomy since World war II", *Journal of Political Economy*, 91: 228-248.
- Hamilton, J.D. (1996) "This is what Happened to the oil Price-Macroeconomy Relationship", *Journal of Monetary Economics*, 38: 215-220.
- Hamilton, J.D. (2003) "What Is an oil shock?", *Journal of Econometrics*, 113: 363-398.
- Honarvar, A. (2009) "Asymmetry in Retail Gasoline and Crude Oil Price Movements in the United States: An Application of Hidden Cointegration Technique", *Energy Economics*, 31: 395-402.
- Hooker, M.A. (1996) "What Happened to the Oil Price-Macroeconomy Relationship?", *Journal of Monetary Economics*, 38: 195-213.
- Huang, B.-N., Hwang, M.J. and Peng, H.-P. (2005) "The Asymmetry of the Impact of Oil Price Shocks on Economic Activities: An Application of the Multivariate Threshold Model", *Energy Economics*, 27: 455-476.
- Huang, R.D., Masulis, R.W. and Stoll, H.R. (1996) "Energy Shocks and Financial Markets", *Journal of Futures Markets*, 16: 1-27.
- Jones, C.M. and Kaul, G. (1996) "Oil and Stock Markets", *The Journal of Finance*, 51: 463-491.
- Keane MP and Prasad ES. (1996) "The Employment and Wage Effects of Oil Price Changes: A Sectoral Analysis", *Review of Economics and Statistics*, 78: 389-400.

- Lee, K. and Ni, S. (2002) "On the Dynamic Effects of oil Price Shocks: A Study using Industry Level Data", *Journal of Monetary Economics*, 49: 823-852.
- Lee, K., Ni, S. and Ratti, R.A. (1995) "Oil Shocks and the Macroeconomy: The Role of Price Variability", *Energy Journal*, 16: 39-56.
- Lescaroux, F. (2011) "The Oil Price-Microeconomy Relationship is Alive and Well", *Energy Journal*, 32: 25-47.
- Lescaroux, F. and Mignon, V. (2009) "The symposium on 'China's Impact on the Global Economy': Measuring the Effects of Oil Prices on China's Economy: A Factor-Augmented Vector Autoregressive Approach", *Pacific Economic Review*, 14: 410-425.
- Liew, V.K.-S. (2004) "Which Lag Length Selection Criteria Should we Employ?", *Economics Bulletin*, 3: 1-9.
- Lippi, F. and Nobili, A. (2009) Oil and the Macroeconomy: A Quantitative Structural Analysis, *Bank of Italy Working Paper*, No. 704.
- Liu, M.-H., Margaritis, D. and Tourani-Rad, A. (2010) "Is There an Asymmetry in the Response of Diesel and Petrol Prices to Crude Oil Price Changes? Evidence from New Zealand", *Energy Economics*, 32: 926-932.
- Lizardo, R.A. and Mollick, A.V. (2010) "Oil price Fluctuations and U.S. dollar Exchange Rates", *Energy Economics*, 32: 399-408.
- Mork, K.A. (1989) "Oil and Macroeconomy When Prices go up and Down: An Extension of Hamilton's Results", *Journal of Political Economy*, 97: 740-744.
- Papapetrou, E. (2001) "Oil Price Shocks, Stock Market, Economic Activity and Employment in Greece", *Energy Economics*, 23: 511-532.
- Park, J. and Ratti, R.A. (2008) Oil Price Shocks and Stock Markets in the U.S. and 13 European Countries", *Energy Economics*, 30: 2587-2608.
- Raymond, J.E. and Rich, R.W. (1997) "Oil and the Macroeconomy: A Markov State-Switching Approach", *Journal of Money, Credit, and Banking*, 29: 193-213.
- Rosewell, T., Arculus, R. and Pickering, C. (2008) "Oil price and the Australian economy", *Reserve Bank of Australia Bulletin* September: 1-6.
- Rotemberg, J.J. and Woodford, M. (1996) "Imperfect Competition and the Effects of Energy Prices Increases on Economic Activity", *Journal of Money, Credit and Banking*, 1: 549-577.
- Sadorsky, P. (1999) "Oil Price Shocks and Stock Market Activity", *Energy Economics*, 21: 449-469.
- Sadorsky, P. (2003) "The Macroeconomic Determinants of Technology Stock Price Volatility", *Review of Financial Economics*, 12: 191-205.
- Segal, P. (2007) Why do Oil Price Shocks no Longer Shock?, *Working Paper* No. 35, Oxford Institute of Energy Studies.
- Sims, C.A. (1980) "Macroeconomics and Reality", *Econometrica*, 48: 1-48.

- Tang, W., Wu, L. and Zhang, Z. (2010) "Oil price Shocks and Their Short and Long-Term Effects on the Chinese Economy", *Energy Economics*, 32: S3-14.
- Valadkhani, A. and Mitchell, W.F. (2002) "Assessing the impact of Changes in Petroleum Prices on Inflation and Household Expenditures in Australia", *Australian Economic Review*, 35: 122-132.
- Yousefi, A. and Wirjanto, T.S. (2004) "The Empirical Role of the Exchange Rate on the Crude-Oil Price Formation", *Energy Economics*, 26: 783-799.
- Zhang, Q. and Reed, M. (2008) "Examining the Impact of the World Crude Oil Prices on China's Agricultural Commodity Prices: The Case of Corn, Soybean and Pork", The Southern Agricultural Economics Association Annual Meetings, Dallas, TX, 2-5 February, 2008.
- Zhang, Y.-J., Fan, Y., Tsai, H.-T. and Wei, Y.-M. (2008) "Spillover Effect of US Dollar Exchange Rate on Oil Prices", *Journal of Policy Modeling*, 30: 973-991.

