SEEDS
Surrey **E**nergy **E**conomics
Discussion paper **S**eries

SURREY
ENERGY
ECONOMICS
CENTRE

The direct and indirect effects of oil shocks on energy related stocks

David C. Broadstock, Rui Wang and Dayong Zhang

April 2014

SEEDS 146
ISSN 1749-8384

School of Economics
University of Surrey

The **Surrey Energy Economics Centre (SEEC)** consists of members of the School of Economics who work on energy economics, environmental economics and regulation. The School of Economics has a long-standing tradition of energy economics research from its early origins under the leadership of Professor Colin Robinson. This was consolidated in 1983 when the University established SEEC, with Colin as the Director; to study the economics of energy and energy markets.

SEEC undertakes original energy economics research and since being established it has conducted research across the whole spectrum of energy economics, including the international oil market, North Sea oil & gas, UK & international coal, gas privatisation & regulation, electricity privatisation & regulation, measurement of efficiency in energy industries, energy & development, energy demand modelling & forecasting, and energy & the environment.

SEEC research output includes SEEDS - Surrey Energy Economic Discussion paper Series and SEERS - Surrey Energy Economic Report Series (details at www.seec.surrey.ac.uk/Research/SEEDS.htm) as well as a range of other academic papers, books and monographs. SEEC also runs workshops and conferences that bring together academics and practitioners to explore and discuss the important energy issues of the day

SEEC also attracts a large proportion of the School's PhD students and oversees the MSc in Energy Economics & Policy. Many students have successfully completed their MSc and/or PhD in energy economics and gone on to very interesting and rewarding careers, both in academia and the energy industry.

Enquiries:

***Director of SEEC and Editor of SEEDS*:**
Lester C Hunt
SEEC,
School of Economics,
University of Surrey,
Guildford GU2 7XH,
UK.

Tel: +44 (0)1483 686956
Fax: +44 (0)1483 689548
Email: L.Hunt@surrey.ac.uk

www.seec.surrey.ac.uk

Surrey Energy Economics Centre (SEEC)
School of Economics
University of Surrey

SEEDS 146
ISSN 1749-8384

THE DIRECT AND INDIRECT EFFECTS OF OIL SHOCKS ON ENERGY RELATED STOCKS

David C. Broadstock, Rui Wang and Dayong Zhang

April 2014

ABSTRACT

We attempt to consolidate (at least in part) the vast literature on oil shocks and stock returns by decomposing the influence of oil shocks into two channels of effect: ‘direct’ and ‘indirect’. Using a simple empirical asset pricing model it is shown that oil shocks can affect stocks not only directly, but also indirectly through general market risk (which is shown to be due in part to oil shocks), or put another way that additional oil price risk exposure is embedded in the traditional market beta. As far as is known, this is the first paper explicitly quantifying both effects together. By doing so we offer a more complete picture of when and how oil shocks impact stock returns, thus allowing investors to make more informed responses to oil shocks. The results are illustrated using daily data from all (active) listed energy related stock portfolios in the Asia Pacific Region, and are robust to structural instability and the specification of oil-shock used.

JEL Classifications: G12, G15.

Key Words: Oil Prices, Energy Related Stocks, Threshold GARCH, Asset Pricing, Structural Break.

The direct and indirect effects of oil shocks on energy related stocks.

David C. Broadstock[a,b] Rui Wang[a] Dayong Zhang[a]

[a]TIERS, Southwestern University of Finance and Economics, China.

[b]**Corresponding author:** davidbroadstock@swufe.edu.cn; TIERS, Southwestern University of Finance and Economics, 55 Guanghuacun Street, Chengdu, China, 610074. Tel. +86 152 0834 0910. Surrey Energy Economics Centre, Department of Economics, University of Surrey, UK.

1 Introduction

There already exists an extensive and high-profile literature demonstrating that oil shocks can impact upon stock market behavior. The accumulated wisdom of previous research points toward two distinct ways in which oil shocks can influence stock returns. Consider a single stock (or sub-index portfolio), the first channel of influence that might be considered is a 'direct' response to oil shocks. For example Huang et al. (1996), Faff and Brailsford (1999), Sadorsky (2001), Hammoudeh and Li (2004), El-Sharif et al. (2005) and Boyer and Filion (2007), all investigate how oil price shocks affect industry specific returns, reporting what we refer to here as a 'direct' effect. The empirical nature of the direct effect is highly variable. These previous studies demonstrate that some industries are not immediately affected by changing oil prices, whereas others are. Sensible justifications for these differences are easy enough to posit: Supply chain issues become much more relevant when considering the individual stock (portfolio) insofar as oil price exposure depends on the exposure of the full supply chain to oil prices. If any stage is exposed, then some sensitivity to oil shocks should be seen since they directly pass through operational costs. Huang et al. (1996) for example show that crude oil futures impact oil company stock returns, but do not affect some other industries. Gogineni (2010) reinforces this assertion by explicitly considering the energy consumption structure of industries. When industries are classified into oil-intensive and non-oil intensive groups the influence of daily oil price shocks on stock returns varies. Some further studies considering individual industry sectors or sub-indexes include those by Scholtens and Yurtsever (2012), Arouri (2012), Broadstock et al. (2012), Narayan and Sharma (2011), Arouri (2011), Elyasiani et al. (2011), Mohanty et al. (2011), Arouri and Nguyen (2010), Kilian and Park (2009), Nandha and Faff (2008), Boyer and Filion (2007), El-Sharif et al. (2005) and Hammoudeh and Li (2005). The general consensus from these studies is that the Oil & Gas sector, and also the Mining sector, tends to be positively affected by positive changes in oil prices, whereas the reverse holds true for other sectors.

A second channel of effect highlighted by existing research is that from oil oil shocks to the wider stock market as a whole. Broadly speaking existing studies suggest a negative relationship between oil shocks and the performance/returns of whole stock markets (see, *inter alia*, Filis and Chatziantoniou (2013); Ciner (2012); Lee and Chiou (2011); Filis (2010); Chen (2010); Miller and Ratti (2009); Driesprong et al. (2008); Nandha and Faff (2008); O'Neill et al. (2008); Park and Ratti (2008); Bachmeier (2008); Henriques and Sadorsky (2008); Sadorsky (2001); Papapetrou (2001); Ciner (2001); Gjerde and Saetten (1999); Huang et al. (1996); Jones and Kaul (1996)). Maintaining focus on the single stock (portfolio), we argue that this second channel represents an 'indirect' effect whereby the influence upon the whole market is subsequently embedded into the value of the individual stock (portfolio). To motivate the 'indirect' influence of oil, and notwithstanding the empirical support from previous papers as listed above, it is useful recognize some of the core asset pricing literature. The widely used Capital Asset Pricing Model (CAPM) originally proposed by Sharpe (1964) offered the insight that the value of a stock (or portfolio) is often heavily influenced by the return of the wider stock market that the stock (portfolio) is from. Then, if the wider stock market is affected by oil shocks, and additionally the stock (portfolio) is affected by the market value, it follows that oil shocks are transmitted indirectly through the market risk. Rationalizing the dependence of the wider stock market upon oil is straightforward, since higher oil prices can be viewed as a signal of overall inflation in the economy and central banks therefore respond to such increase by raising the interest rate. Among other things, this can lead to a tighter monetary environment, which will negatively influence stock prices in all areas of the market. Taken together, these point towards the fact that often it should be easy to rationalize and quantify at least (i) some influence of oil shocks upon the value of the wider stock market and (ii) some dependence of the stock (portfolio) upon the value of the market (the traditional 'market beta'). Cumulatively these define what we refer to here as the 'indirect' effect.

Whilst both channels of influence discussed above are broadly accepted within the literature, empirical studies looking at the returns of an individual stock (or portfolio) offer surprisingly limited discussion of them both at the same time, i.e. their cumulative effect.[1] This has resulted in what seems to be an overly disparate discourse as to whether or not oil shocks affect stock returns. The main aim of this paper therefore is to empirically emphasize the two channels of effect, both 'direct' and 'indirect'. Specifically, we specify a simple empirical asset pricing model for all (active) listed energy stock portfolios in the Asia Pacific Region, statistically testing for the influence of oil shocks using daily returns. Under the (standard) assumption that market returns affect the portfolio and not vice versa, the empirical problem reduces to two independent regressions that can be estimated using single equation GARCH methods. In application we allow the GARCH volatility process is allowed to be asymmetric, allowing for news impact curves to be derived, and structural instability is explicitly modeled to account for the effects of the recent global financial crisis. Additional robustness checks are given to demonstrate the

[1] One exception is Hammoudeh and Li (2004), however in attempting to quantify this using weekly data from GCC stock markets they were unable to produce statistical evidence to support their conjectures.

influence of using different definitions of oil shocks i.e. oil price returns, oil price increases only (OPI), or 'net' oil price increases (NOPI).

Our results show that there is *always* some effect of oil price shocks upon energy stocks but that the nature of effect differs from one market to the next. The distinguishing feature is that the direct effect does not always exist, but the indirect effect does. The effects from oil shocks are clearly subject to structural instability, where in most cases a stronger relationship with oil prices exists following the empirically identified structural break, similar to the results in Broadstock et al. (2012). For the indirect effect this break is always in 2008, reinforcing the role of the global financial crisis, but for the direct effect other break dates are observed in some cases. The qualitative nature of the results are generally robust to using different measures of oil price shocks, though with some changes in magnitude of the effect.

We contribute to the existing literature in two distinct aspects: Firstly, we quantify both direct and indirect effects of oil shocks upon stock returns, thus highlighting that oil is always a risk factor for listed energy related stock portfolios, at least in the Asia Pacific Region. Secondly, we demonstrate to some extent the generality of this result by highlighting its insensitivity to (i) choice of stock market; (ii) choice of oil price; (iii) choice of oil price transformation; and (iv) structural change. We expect that these results generalize much further than the Asia Pacific Region, as already (partially) demonstrated in some existing literature.

The paper is structured as follows: Following this introduction, we outline the data used in the analysis, outlining our sample selection procedure. Section 3 describes the empirical framework, while Sections 4 and 5 respectively present the results and conclusions.

2 Data

This section outlines the data we use for analysis, outlining firstly the stock market data and then the oil shocks. We choose to use daily frequency time series on the premise that news regarding oil price shocks spread almost instantly throughout markets, met by reactions (from stock investors as well as the general consumer in the economy) and counter-reactions within the space of hours in some cases, or just a few days in others. In this regard, it is possible that weekly (or monthly etc.) aggregation of data may 'mask' some interesting price dynamics, and in particular the true magnitude of stock market response to oil price shocks.

The aim of the empirical analysis is to demonstrate that oil shocks affect stock returns both directly and indirectly. To provide a balanced assessment, it is appropriate to consider several different stock markets. For this purpose we consider all markets within the Asia Pacific Region, which is sensible given that this contains some of the largest energy consumers, at highest growth economies in the world today. Our sampling frame is to choose energy related stock portfolios as the main point of interest, and these must be (i) active portfolios and also (ii) officially listed as a sub-index. For instance, the Hang Seng index in Hong Kong had a listed energy sub-index (Hang Seng Composite Oil and Resources), however this index stopped trading in September of 2006, and so is not included in our study. Similarly, the Chinese stock markets do not have an officially listed energy sub-index, and are therefore excluded here. Our sampling frame results in six indexes from four countries:

Japan

- Tokyo Stock Exchange Tokyo Price Index (TPX): The TOPIX general index and the TOPIX Oil sub-index. The sub-index runs from January 5^{th} 1998.

- Nikkei (NKY): The Nikkei 225 stock index and the Nikkei 500 Oil sub-index.[2] The sub-index runs from January 5^{th} 1998.

India

- Bombay Stock Exchange I (SENSEX I): The SENSEX general index and the SENSEX Oil and Coal sub-index. The sub-index runs from February 1^{st} 1999.
- Bombay Stock Exchange II (SENSEX II): The SENSEX general index and the SENSEX Power sub-index. The sub-index runs from January 3^{rd} 2005.

Korea

- Korea Composite Stock Price Index (KOSPI): The KOSPI general index and the KOSPI 200 Energy chemical sub-index. The sub-index runs from January 2^{nd} 2008.

Taiwan

- Taiwan Stock Exchange (TWSE): The TWSE general index and the Taiwan Taiex Oil, electricity and gas sub-index. The sub-index runs from July 2^{nd} 2007.

For the whole stock market index data (TOPIX, NKY, SENSEX, KOSPI and TWSE), all series are available from January 1^{st} 1984, and all series (including the sub-indexes) end October 24^{th} 2012. All data are taken from the BLOOMBERG financial database and are all measured in in US dollars.[3] The financial market data therefore cover differing time-frames. Given the nature of our study we use the most available data for each time

[2]It is noted that the energy sub-index can therefore include members who are not part of the Nikkei 225 sub-index, however the effects of this are assumed to be nominal, and given the nature of the results and also that the Japanese TOPIX index is also tested, it was not felt necessary to correct for this.

[3]Noting that in the subsequent empirical analysis we use returns series, and for the purposes of comparison simply require all series to be measured in a common currency, the use of US dollars is arbitrary.

series rather than, for instance, restricting the Japanese market data to cover the same (much shorter) overlapping time-frame as the Taiwanese market data.

The context of the empirical analysis, described in full in the next section, utilizes a simple empirical asset pricing model relating the returns of an index to some other variables. The returns of some index I can be calculated from the index value P as follows:

$$R_{It} = 100\left(\ln\left(\frac{P_{It}}{P_{It-1}}\right)\right) \tag{1}$$

Where P_t is the index value on day t.

In addition to the general stock market data, oil price data are required to generate the oil shock series. In this paper we use the West Texas Intermediate (WTI), quoted in US dollars per barrel as a proxy for global oil price dynamics. Maghyereh (2004) notes that European Brent may be a better measure of global oil prices, since around 60% of daily consumption at that time was of Brent, however we opt for WTI since (i) the daily data are more easily accessed for a much longer time frame than for Brent and (ii) it is still a widely used measure in many empirical studies.[4] Using the price series, the price shocks are defined initially as the returns on the oil price series, calculated in the same way as the returns for an index as described above. A selection of recent studies using the same definition includes Broadstock et al. (2012), Arouri et al. (2011), Lee et al. (2001), Park and Ratti (2008) and Cunado and de Gracia (2003) among others.

[4] A simple test of cointegration would suggest that these two series co-vary. This test was to check that the ratio of prices is stationary i.e.

$$\frac{P_{WTI}}{P_{BRENT}} \sim N(1,\sigma^2)$$

A simple Phillips-Perron test shows the ratio to be stationary, with a Dickey-Fuller test statistic of -52.40 and a p-value of 0.001 (against the null hypothesis on non-stationarity). We do note however that an augmented Dickey-Fuller test gives the opposite conclusion. Understanding the difference in these series, and how analysts should respond to them, is a valid and important direction for future research.

3 Empirical framework

The empirical framework is developed to be consistent with existing studies, and requires estimating two different equations, one to capture the direct effect and another to capture the indirect effect. This section thus prescribes specific estimable functional forms for these relationships, additionally describing how the proposed hypotheses are evaluated.

3.1 Testing for a direct effect

To examine the direct effect of oil price shocks upon energy related stocks, we apply an extended CAPM type model relating share price exposure to general market risk as well as variability in oil prices. The model can be written as:

$$R_{e,t} = \gamma + \beta R_{m,t} + \delta Oil_t^{(j)} + \varepsilon_t \tag{2}$$

$j = \{R_{O,t}, OPI_t, NOPI_t\}$, where $R_{O,t}$, OPI and $NOPI$ are alternative oil shock measures to be defined later. Where $R_{e,t}$ are the daily returns on energy related stocks, $R_{m,t}$ are the daily returns on the market index and $Oil_t^{(j)}$ are the daily returns on oil prices. The parameter β captures market risk and parameter δ represents the direct exposure of energy related stock returns to changing oil prices. Considering the high frequency and clustered volatility common in daily data, GARCH (1,1) effects are controlled for and specifically are assumed to follow a GJR-GARCH(1,1), or threshold GARCH, process:[5]

$$\epsilon_t \sim JSU(0, h_t\sigma^2, \nu, \tau) \tag{3a}$$

$$h_t = a_0 + a_1 h_{t-1} + a_2\epsilon_{t-1}^2 + a_3\epsilon_{t-1}^2 \mathbb{I}\{\epsilon_{t-1} < 0\} \tag{3b}$$

[5]See Glosten et al. (1993). This specification for GARCH is more general than a standard GARCH structure, allowing for asymmetries in the underlying volatility process.

The use of the Jonhson SU distribution allows for additional skew and shape transformations via ν and τ respectively, and provides a generally more flexible assumption regarding the nature of the error term. The threshold effect is determined by the significance of a_3, which when significant allows an asymmetric role for ϵ^2_{t-1} upon h_t. The combination of the threshold GARCH specification with this flexible distribution assumption on the error term helps to ensure that volatility is more accurately modeled.

Given the above model specification, evaluating the existence of a direct effect reduces to a simple hypothesis test of the coefficient δ. If this coefficient is statistically significant, we can conclude that oil shocks can directly influence energy related stocks (with direction equal to the sign of the coefficient)and otherwise (i.e. if δ is insignificant) we cannot conclude a direct effect.

3.2 Testing for an indirect effect

To model the indirect effect the following regression model is estimated:

$$R_{m,t} = \alpha + \kappa Oil^{(j)}_t + \epsilon_t \tag{4}$$

$j = \{R_{O,t}, OPI_t, NOPI_t\}$. Where the terms are generally as defined above, and GARCH effects are also modeled in the same way as done for the direct effect. In this model, κ represents the influence of oil shocks upon the whole stock-market index.

Given this model structure, to evaluate the existence of an indirect effect upon a given portfolio of energy related stocks requires first that β from Equation (2) is significant, hence confirming that the energy related stock portfolio is susceptible to general market risk, and second that κ in Equation (4) is significant. If either of these is not true, then no indirect effect can be supported. To make this more clear, Equation (4) can be substituted into Equation (2). Ignoring for simplicity the error terms, this gives:

$$R_{e,t} = \gamma + \beta(\alpha + \kappa Oil_t^{(j)}) + \delta Oil_t^{(j)} \tag{5}$$

Therefore, even if there is no direct effect of oil through δ, in other words $\delta = 0$, and assuming that $0 < |\beta| < \infty$, or more specifically that there is some non-diversifiable risk for the portfolio, then:

$$R_{e,t} = \gamma + \beta\alpha + \beta\kappa Oil_t^{(j)} \tag{6}$$

hence:

$$\frac{\partial R_{e,t}}{\partial Oil_t^{(j)}} = \beta\kappa \tag{7}$$

Thus, so long as both β and κ are statistically different from zero, an indirect effect will exist. If additionally there is a direct effect also (i.e. $\delta \neq 0$), the above derivative will become:

$$\frac{\partial R_{e,t}}{\partial Oil_t^{(j)}} = \beta\kappa + \delta \tag{8}$$

Since the market and portfolio returns models are estimated separately, the indirect effect is evaluated using a series of individual t-tests. To summarize, the significance of the terms β, κ and δ determine the nature of effects and whether they are direct, indirect or both. The analysis therefore results on four possible scenarios, all of which are empirically possible:

- **No effect:** The first possibility is that oil exerts no influence on the energy sub-index (i.e. $\beta = \kappa = \delta = 0$);

- **Direct effect only:** The second possibility is that oil shocks only influence the energy related sub-index, but have no impact upon the wider market (i.e. $\beta = \kappa = 0$, and $\delta \neq 0$);

- **Indirect effect only:** An alternative possibility is that oil shocks affect the whole market only (i.e. the aggregate index such as NIKKEI 250) and not the energy sub-index (i.e. $\beta \neq 0$ and $\kappa \neq 0$ but $\delta = 0$); and

- **Direct and indirect effects at the same time:** The final, and most interesting possibility is that oil shocks have one effect directly upon the energy sub-index, but at the same time have a second effect that comes indirectly though general market risk (i.e. $\beta \neq 0$, $\kappa \neq 0$ and $\delta \neq 0$).

3.3 Allowing for structural instability

The methodology described so far has concentrated on identifying the two channels of influence that oil shocks might have upon energy related stock portfolios. However, existing literature already documents instability in the relationships, most recently Broadstock et al. (2012) who show for China that a direct effect does not always exist.[6] With this in mind, here we treat structural instability as a core part of the analysis rather than a robustness check.

To identify and allow for structural instability in the analysis, we apply Andrews and Ploberger (1994) type tests, which are now fairly widely used. As opposed to classical break test procedures proposed by Chow (1960) or Quandt (1960), the Andrews and Ploberger (1994) method evaluates all possible break dates and then use the largest

[6] It is perhaps useful to note that although Broadstock et al. (2012) show that such studies are possible for China, Chinese market data is not included in the present study since there is no officially listed oil or energy related stock portfolio. Instead, such portfolios need to be constructed from industrial classification codes.

value to identify the break point (see also Andrews (1993)). Thus the break-point is treated as unknown, and then statistically identified. The tests are applied to look for 'full' structural breaks in the estimation equations, where all coefficients are allowed to differ either side of a break-point. For brevity, in the results section the full break tests results are not reported, only the identified break-date when significant.

3.4 Alternative oil shock definitions

An understated feature of the existing literature relates to the way in which oil shocks are measured. A number of alternative specifications have been proposed over the years, though existing studies offer relatively little insight as to when and how to discriminate between them. In this regard, it is worth openly considering the (relatively subjective) influence that alternative choices may have.

Alternative definitions arguably emerged from the desire to model asymmetric price responses. Hamilton (1983) pointed towards the fact that oil prices only seemed to influence an economy during periods of price rises, but otherwise seem to have relatively little effect. This inspired various price decompositions to capture oil shocks from different types of price changes, most generally when prices are rising relative to when they are falling. Definitions by Hamilton (1983) and Mork (1989) have been widely used when studying oil prices in different contexts. In this paper, in addition to the oil price returns measure discussed above, i.e.:

$$R_{O,t} = 100\left(\ln\left(\frac{P_{O,t}}{P_{O,t-1}}\right)\right) \tag{9}$$

We also consider two further alternative specifications, namely the Hamilton (1983) measure of 'net oil price increases' (NOPI) and the slightly less restrictive measure of

Mork (1989).[7] Both approaches have merit, as will be discussed, starting with NOPI a formal definition can be given as:

$$NOPI_t = Oil_t - max(Oil_{t-1}, ..., Oil_{t-n}) \quad \forall \quad Oil_t > max(Oil_{t-1}, ..., Oil_{t-n}) \tag{10}$$

NOPI therefore suggests that oil price increases are only relevant when they are greater than the largest oil price hike over the preceding n periods. Using monthly data Hamilton (1983) sets $n = 12$, thus using daily data we set $n = 365$.

Mork (1989) took a less restrictive approach to considering the role of oil price rises, known as oil price increases (OPI), which assumes that all price rises are 'relevant', not just those which recent and excessive. This can be written as:

$$OPI_t = Oil_t \quad \forall \quad Oil_t > Oil_{t-1} \tag{11}$$

[7] These are not the only alternatives. For example OPI can also include oil price decreases into the decomposition see for example Mork (1989), Cong et al. (2008), Arouri et al. (2011), Jimenez-Rodriguez and Sanchez (2005), Lee et al. (2001), Chen (2010). Similarly NOPI can be specified to include net oil price decreases as in Engemann et al. (2011). Another measure used in some recent papers is 'scaled oil price increases' (SOPI) (Lee and Ni (2002), Jimenez-Rodriguez and Sanchez (2005), Arouri et al. (2011), Park and Ratti (2008), Cunado and de Gracia (2003), Chen (2010)) which utilize and control for (estimated) price volatility. Ferderer (1996) define oil price volatility as an n period moving standard-deviation of real oil prices. Huang et al. (1996) and Chang et al. (2012) take a quite different approach using information in oil price futures to identify genuine spot price volatility.

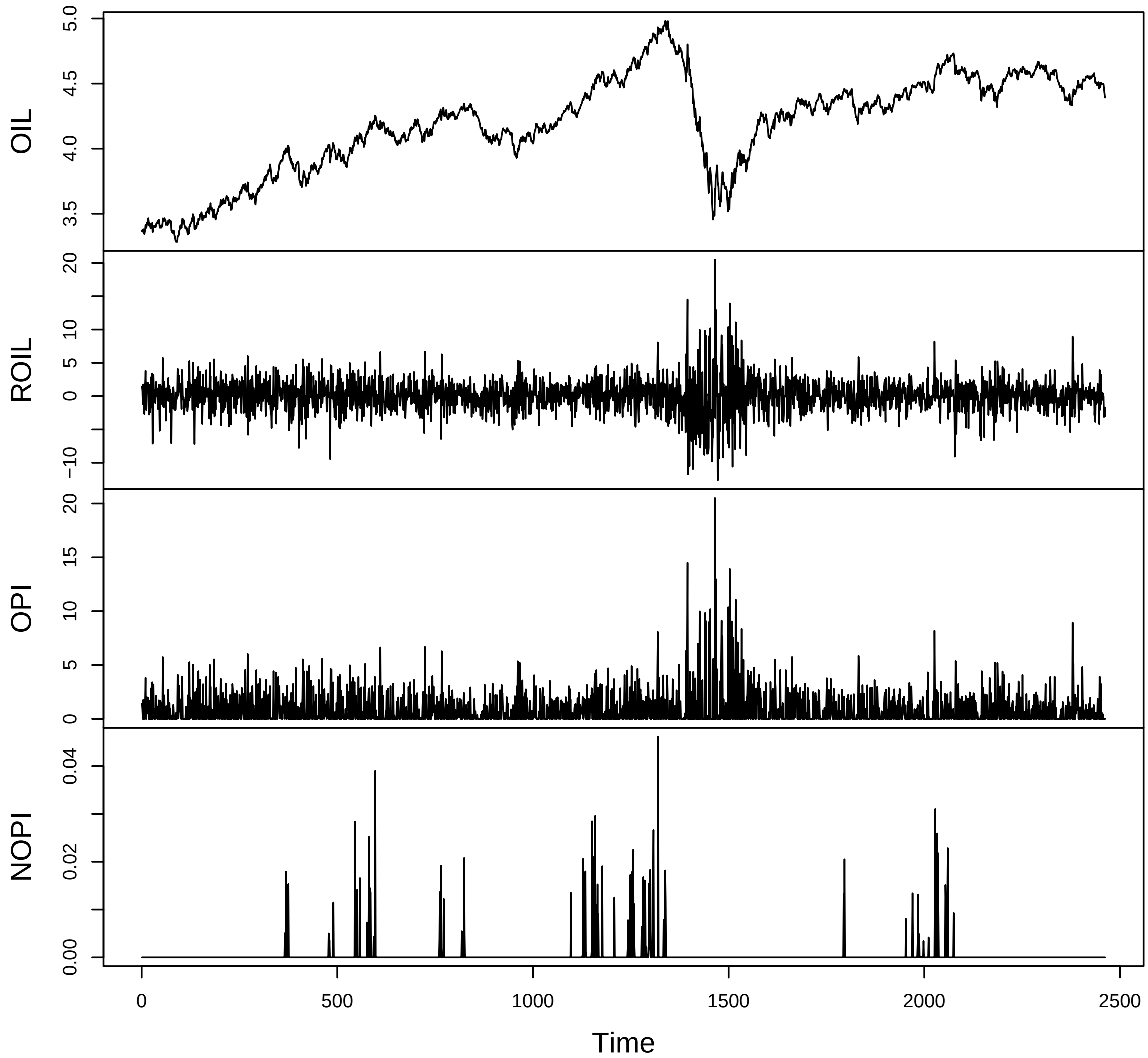

Figure 1: *Summary oil price transformation series for WTI.*

As suggested, both measures have merit. Mork's approach acknowledges that all historic price information may play a role in today's actions, which is not unreasonable. On the other hand Hamilton's approach suggests that (i) older information is less relevant, to the point that it can in fact be ignored and also (ii) that reactions to price changes only occur when those price changes are excessive, within recent memory. The concept that decision makers tend to rely more heavily upon more recent and excessive price information is again not unreasonable. Deciding which price transformation to use is a largely subjective matter, however as Figure (1) demonstrates, which contains oil price in log-levels as well as the three 3 transformations used for estimation. They each result in extremely different measures of price shocks. Arguably, NOPI excludes key dynamics observed during the 2008 financial crisis, which are better reflected in OPI for instance which is stable able to highlight increased price volatility during this period.

4 Empirical results

In this section we present and discuss the results of the empirical analysis. Results for the direct and indirect effects are reported separately, followed by a more general section discussing the role of alternative oil shock definitions. Given the use of the asymmetric GARCH model, the results section ends with a brief discussion of the estimated news impact curves from the estimated models.

4.1 Evidence of a direct effect

Table (1) reports the estimation results for Equation (2). In addition to the estimated coefficients, Table (1) reports R^2 values and distributional test results denoted g_{20} and g_{50}.[8] These results are for the Vlaar and Palm (1993) test, discussed also in Palm (1996), which is a Pearson Chi-squared test adjusted to account for non-normal distributions. Under the null hypothesis, the estimated Johnson SU distribution is an appropriate fir

[8] The subscript values 20 and 50 refer to the number of 'bins' used in the test. Given the relatively small sample sizes in some of the series, 20 might be considered preferred to 50 since for instance when using 50 bins for the KOSPI index there may be as few as 35 observations per bin. However, with 20 bins this rises to 88 per bin. The trade-off is in having enough observations per bin to make each bin representative, while also having enough bins to capture the structure of the distribution.

for the model residuals. Therefore assuming a 5% significance level, when the reported p-value is greater than 0.05, the null hypothesis that the estimated distribution follows the true empirical distribution, cannot be rejected. The p-values all exceed 0.05, and thus the Johnson SU distribution is a reasonable choice for the data.

Table 1: **Subsample estimation results for direct effect**

	TPX	NKY	SENSEX (1)	SENSEX (2)	KOSPI	TWSE
Break date	12/29/2004	11/2/2004	12/16/2008	10/10/2008	2/28/2011	5/31/2011
Pre-break						
Intercept	0.0008	0.0004	0.0003	0.0002	0.0005	0.0003
	(0.0005)	(0.0006)	(0.0002)	(0.0003)	(0.0004)	(0.0003)
	[0.1307]	[0.5145]	[0.2305]	[0.6391]	[0.1955]	[0.4447]
Market	0.7344	0.6127	1.0046	0.9984	1.0160	0.7664
	(0.0494)	(0.0558)	(0.0215)	(0.0233)	(0.0502)	(0.0415)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Oil	-0.0056	0.0074	0.0236	-0.0142	-0.0006	0.0125
	(0.0202)	(0.0196)	(0.0100)	(0.0124)	(0.0533)	(0.0192)
	[0.7805]	[0.7055]	[0.0187]	[0.2536]	[0.9917]	[0.5140]
R^2	0.39	0.34	0.80	0.82	0.88	0.43
g_{20}	0.67	0.27	0.10	0.33	0.49	0.19
g_{50}	0.32	0.18	0.40	0.38	0.72	0.11
Post-break						
	TPX	NKY	SENSEX (1)	SENSEX (2)	KOSPI	TWSE
Intercept	-0.0002	0.0000	-0.0005	-0.0006	-0.0009	0.0001
	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0007)	(0.0007)
	[0.5715]	[0.8803]	[0.0415]	[0.0077]	[0.2119]	[0.8276]
Market	1.0388	0.8797	0.9433	0.8848	1.3260	0.8888
	(0.0268)	(0.0232)	(0.0257)	(0.0211)	(0.0467)	(0.0755)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Oil	0.0292	0.0163	0.0012	0.0157	-0.0282	0.0980
	(0.0121)	(0.0152)	(0.0229)	(0.0077)	(0.0376)	(0.0356)
	[0.0161]	[0.2834]	[0.9586]	[0.0407]	[0.4535]	[0.0059]
R^2	0.59	0.59	0.80	0.84	0.80	0.51
g_{20}	0.36	0.81	0.49	0.37	0.63	0.84
g_{50}	0.79	0.93	0.78	0.91	0.88	0.81

Notes:

(i) P values are calculated using the Hansen (1997) method.

(i) Standard errors in parentheses '(·)'

(i) P-values in brackets '[·]'

Prior to discussing the coefficients, for each of the six energy sub-indices considered structural breaks are found; 2004 for the Japanese indices; 2008 for the Indian indices;

and 2011 for Korea and Taiwan. Thus for the energy specific sub-indices while there is structural instability, it is not clear that this is due to a common event, particularly the 2008 financial crisis. However, regarding the results for Korea and Taiwan, it is worth recalling that these series start in 2008 and 2007 respectively, and in this regard (and given the 'trimming points' used for structural break testing) it is not surprising that they do not find a break within 2008.

Turning now to the main parameter of interest, δ the estimated coefficient are significant in four out of the six markets analyzed. For the Japanese TPX oil has a significant and positive effect (coefficient of 0.0292) from the start of 2005, but not before this. For SENSEX 1 (oil and coal), oil shocks are significant prior to December 2008 (coefficient of 0.0236), but not after, while for SENSEX 2 the opposite is seen, with no significance before the break date in October 2008, but a positive and significant effect after (coefficient of 0.0157). The TWSE is significantly influenced by oil shocks after May 2011 (coefficient of 0.0980). The common feature therefore is that when significant, the direct effect of oil shocks upon energy related stocks in the Asia Pacific Region is positive. However, for two of the markets there is no significant influence from oil shocks. Thus even when confining analysis to energy related stock portfolios, a direct effect from oil shocks cannot always be guaranteed.

Turning next to the β coefficients on market risk, as expected all coefficients on market returns are significant and positive both before and after the break dates, with estimated values being generally close to unity. The strong explanatory power of the market returns in explaining the behaviors of the energy related stock returns is consistent with the capital asset pricing model and empirical findings in the wider financial literature. The R^2 values are generally decent ranging between 0.44 (Taiwan) to 0.74 (Korea). As might be expected, the intercept terms are insignificant suggesting that changes in energy portfolio values must be driven by some market force, and are not purely exogenous.

Since all of the estimated β coefficients in Table (1) are always significant there is a possible indirect effect of oil shocks also, the existence and nature of which depending on the estimation results for Equation (4), which are presented next.

Table 2: **Subsample estimation results for indirect effect**

	TPX	NKY	SENSEX (1)	SENSEX (2)	KOSPI	TWSE
Break date	8/20/2008	8/19/2008	6/12/2008	7/3/2008	10/10/2008	12/25/2008
Full sample						
Intercept	0.0000	0.0000	-	-	-	0.0000
	(0.0002)	(0.0002)				(0.0004)
	[0.9894]	[0.8792]				[0.9641]
Oil	0.0396	0.0495	-	-	-	0.1150
	(0.0120)	(0.0140)				(0.0172)
	[0.0010]	[0.0004]				[0.0000]
R^2	0.01	0.01	-	-	-	0.05
g_{20}	0.97	0.50	-	-	-	0.65
g_{50}	1.00	0.16	-	-	-	0.03
Pre-break						
Intercept	-	-	0.0018	0.0014	-0.0039	-
			(0.0004)	(0.0005)	(0.0014)	
			[0.0000]	[0.0038]	[0.0046]	
Oil	-	-	0.0352	0.0578	0.1035	-
			(0.0160)	(0.0209)	(0.0503)	
			[0.0285]	[0.0058]	[0.0396]	
R^2	-	-	0.01	0.01	0.08	-
g_{20}	-	-	0.49	0.65	0.34	-
g_{50}	-	-	0.21	0.79	0.08	-
Post-break						
Intercept	-	-	0.0001	0.0001	0.0005	-
			(0.0005)	(0.0005)	(0.0005)	
			[0.7965]	[0.7965]	[0.2807]	
Oil	-	-	0.2540	0.2540	0.2316	-
			(0.0242)	(0.0242)	(0.0262)	
			[0.0000]	[0.0000]	[0.0000]	
R^2	-	-	0.13	0.13	0.08	-
g_{20}	-	-	0.71	0.71	0.94	-
g_{50}	-	-	0.77	0.77	0.68	-

Notes:

(i) P values are calculated using the Hansen (1997) method.

(i) Standard errors in parentheses '(·)'

(i) P-values in brackets '[·]'

4.2 Evidence of an indirect effect

Regarding the indirect effect, Table (2) reports the estimation results for Equation (4). The Pearson Chi-squared tests, when using 20 bins, all support the use of the Johnson SU assumption in the GARCH model, when using 50 bins the TWSE marginally rejects (with a p-value of 0.03). Given the relatively shorter time-series for this index, the we favor the results with fewer bins, and as such consider the test results as generally supportive of the Johnson SU distribution.

The estimated δ coefficients are significant in all six instances. For the TPX and NKY indices and also the TWSE index, there is no evidence of a structural break, whereas for SENSEX 1, SENSEX 2 and KOSPI, there are breaks in June, July and October of 2008 respectively, possibly suggesting an important role for the 2007/2008 global financial markets. For TPX the effect is positive (coefficient of 0.0396), and is roughly a similar order of magnitude for the NKY index (coefficient of 0.0495). The TWSE index is generally much more exposed to oil shocks (coefficient of 0.1150). For SENSEX 1 (oil and gas) the effect of oil shocks are small before the 2008 break (coefficient of 0.0352) rising by several orders of magnitude after the break (coefficient of 0.2540). For SENSEX 2 (oil and gas) a similar pattern persists but with a slightly larger influence before the break (coefficient of 0.0578) but the same after.[9] Finally, for KOSPI it is also seen that a small impact (coefficient of 0.1035) strengthens substantially after the break (coefficient of 0.2316). The common feature therefore is that the direct effect of oil shocks upon energy related stocks in the Asia Pacific Region is positive.[10]

Bringing the results together, namely the direct and indirect effects combined, for

[9] This similarity between SENSEX 1 and SENSEX 2 is entirely expected. The data for these two results are the same except for the sample size, with SENSEX 2 covering a shorter time frame for consistency with the data available for the SENSEX power portfolio.

[10] There is notable variation in the size of effect across the markets. It would be presumptuous without closer analysis to explain why these differences are so large, although the energy consumption structures of the economies probably have something to do with it, as alluded to by Gogineni (2010).

all of the markets considered there exists an indirect effect during all periods, since the market beta is always significant for the energy related stock portfolio and further since oil shocks always affect the full market. It follows immediately then that oil shocks are always important for these markets, at least indirectly. Four of the markets also exhibit a direct response to oil shocks (TPX, SENSEX 1, SENSEX 2 and TWSE), while two of the markets are not directly exposed (NKY and KOSPI). This therefore provides useful information to market investors in these regions as to when and how they need to respond to oil shocks. As mentioned previously, loosely speaking β tends towards 1, and so a quick comparison of δ and κ can give a rough approximation as to whether the direct or indirect effect is more severe.[11] The range of values for δ (the direct effect) are from 0.00157 to 0.0980, while for κ (the indirect effect) are 0.0352 to 0.2540. Clearly the indirect effect is much more severe than the direct effect.

4.3 The impact of alternative oil shock definitions

The above analysis has demonstrated the existence of two channels of effect that oil shocks can transmit onto a stock market portfolio. Here, we wish to establish the robustness of our conclusions to the definition of oil shock chosen. As discussed, this involves re-estimating the above results substituting oil returns ($R_{O,t}$) for OPI and NOPI. Tables (3) and (4) summarize the results of the extra analysis, concentrating on two features only, first the estimated break dates, and second the oil shock coefficients. For brevity standard errors are not reported, but p-values are still given.

The first column of Table (3) shows just how important the choice of oil shock is. The pre-break results for the TPX index support all possibilities: (i) for $R_{O,t}$ there is no effect; (ii) for OPI there is a significant and negative effect; and (iii) for NOPI there is

[11] A more formal calculation would take account of the breaks in both the direct and indirect effects, however the difference in magnitude of κ and δ are obvious, reducing the need for specificity.

a significant and positive effect. In absolute terms, the impact implied by NOPI is ten times greater than that of OPI. This is perhaps the most severe example, but nonetheless reinforces the impact of choice of oil shock definition emphatically, both in terms of sign and magnitude. The post break results for the same index (TPX) are all positive and significant, but nonetheless also differ substantially in magnitude. As a rule, it seems to be that the coefficient magnitude is ordered thusly $|NOPI| > |OPI| > |R_{O,t}|$, but this is not a perfect rule by any means. A more pleasing feature of the results is that the estimated break dates are very consistent, often being the exact same day.

Table 3: **Alternative oil shock definitions: Direct effect.**

	TPX	NKY	SENSEX (1)	SENSEX (2)	KOSPI	TWSE
Break date						
$R_{O,t}$	12/29/2004	11/2/2004	12/16/2008	10/10/2008	2/28/2011	5/31/2011
OPI	12/30/2004	12/28/2004	1/3/2008	10/10/2008	2/28/2011	6/8/2011
NOPI	11/3/2004	12/28/2004	12/16/2008	10/10/2008	2/28/2011	5/12/2009
Pre-break						
$R_{O,t}$	-0.0056	0.0074	0.0236	-0.0142	-0.0006	0.0125
	[0.7805]	[0.7055]	[0.0187]	[0.2536]	[0.9917]	[0.5140]
OPI	-0.0572	-0.0392	0.0120	-0.0296	-0.0188	0.0174
	[0.0728]	[0.2077]	[0.9581]	[0.1258]	[0.2410]	[0.6510]
NOPI	0.5010	0.3884	0.1165	0.0089	0.0743	-1.1818
	[0.0010]	[0.0001]	[0.0807]	[0.9327]	[0.2041]	[0.0841]
Post-break						
$R_{O,t}$	0.0292	0.0163	0.0012	0.0157	-0.0282	0.0980
	[0.0161]	[0.2834]	[0.9586]	[0.0407]	[0.4535]	[0.0059]
OPI	0.0467	0.0328	0.0466	0.0215	-0.0350	0.1528
	[0.0328]	[0.0774]	[0.0034]	[0.0390]	[0.5182]	[0.0110]
NOPI	0.3792	0.4085	-0.0804	0.0419	-0.1350	0.1379
	[0.0011]	[0.0001]	[0.6566]	[0.2266]	[0.3179]	[0.0490]

Notes:

(i) P-values in brackets '[·]'

For the indirect effect the results are reported in Table (4). Again the TPX results serve as a useful first benchmark. Whether using OPI or NOPI, no significant effect from oil shocks can be found, in contrast to the positive significant effect when using $R_{O,t}$. Thus for TPX the indirect effect could be shown under differing assumptions not to exist. In contrast for the NKY index the effect implied by OPI is almost identical to that from using $R_{O,t}$, but NOPI is three times larger and with the opposite sign, thus an effect exists but the sign of effect is not determined. The estimated break dates are generally consistent, but with less closeness than for the direct effect, some breaks disappear (see NOPI results for SENSEX 1 and SENSEX 2) and others emerge (see OPI and NOPI results for TWSE).

Table 4: **Alternative oil shock definitions: Indirect effect.**

	TPX	NKY	SENSEX (1)	SENSEX (2)	KOSPI	TWSE
Break date						
$R_{O,t}$	-	-	6/12/2008	7/3/2008	10/10/2008	-
OPI	-	-	12/9/2008	12/30/2008	2/6/2009	1/26/2009
NOPI	-	-	-	-	10/10/2008	5/8/2009
Full sample						
$R_{O,t}$	0.0396	0.0495				0.1150
	[0.0078]	[0.0099]			]	[0.0450]
OPI	0.0355	0.0428				
	[0.2036]	[0.0507]				
NOPI	-0.1319	-0.1578	-0.2912	-0.1068		
	[0.1419]	[0.0547]	[0.0345]	[0.2380]		
Pre-break						
$R_{O,t}$			0.0352	0.0578	0.1035	
			[0.0285]	[0.0058]	[0.0396]	
OPI			0.0543	0.0787	0.1160	0.0602
			[0.0195]	[0.0042]	[0.0162]	[0.1370]
NOPI					-0.0856	1.8978
					[0.4009]	[0.0470]
Post-break						
$R_{O,t}$			0.2540	0.2540	0.2540	
			[0.0000]	[0.0000]	[0.0000]	
OPI			0.3811	0.3811	0.3404	0.1707
			[0.0000]	[0.0000]	[0.0000]	[0.0000]
NOPI					-0.0856	-0.1742
					[0.4009]	[0.0925]

Notes:

(i) P-values in brackets '[·]'

Given these results, one concern is the seemingly arbitrary nature of selecting the definition of oil-shocks used. The potential exists to obtain a significant result simply by using one definition over the other.

4.4 News Impact Curves

As a closing feature of the empirical analysis, we briefly present the empirical news impact curves derived from estimated models.

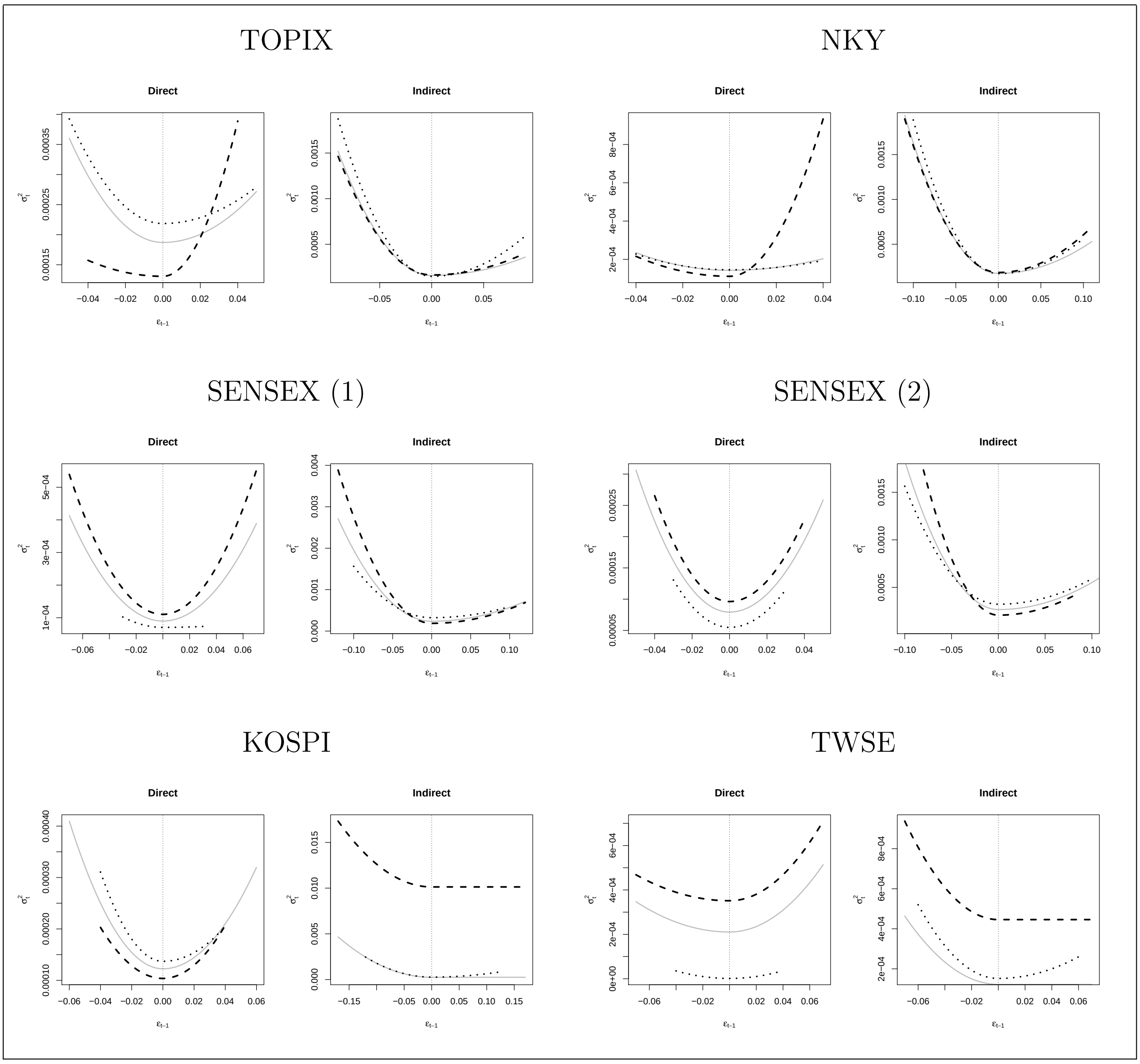

Figure 2: *Estimated asymmetric News Impact Curves.*

These types of curve, first introduced by Engle and Ng (1993), illustrate the responsiveness of the conditional heteroskedasticity to positive and negative news. Since the estimated models use a GJR/threshold asymmetric specification, the responses to positive and negative news can be quite different. Figure (2) plots the NIC curves for both the direct and indirect effect models, using *ROil* as the measure of oil shocks. Each plot contains three lines (i) a solid gray line showing the full-sample NIC and (ii) a dashed black line showing the pre-break NIC and (iii) a dotted black line showing the post-break NIC.

In trying to discern a common pattern, the following might be offered. For the indirect effect, i.e. the market returns equation, negative news increases the market volatility (captured within the conditional heteroskedasticity) whereas for the direct effect, i.e. the portfolio returns equation, the reverse is sometimes true, with positive news often impacting the volatility more than (or at least as much as) negative news. We appreciate that understanding this difference between the market and energy related stocks may offer some benefits/opportunities in hedging against unexpected risk, though do not discuss this further here.

5 Conclusions

In this paper we have investigated how oil price shocks impact energy related stock portfolios in the Asia Pacific Region. Owing to conflicting debates in the related literature regarding the existence of any effect, we consider two possible channels of effect, one direct and another indirect. Both channels are discussed in existing studies, but there nonetheless remains a general lack of empirical work considering the inter-relation between the two effects, resulting in a focus on one or the other, but not both at the same time. By doing so here we offer a more complete picture of when and how oil shocks effect stock returns, thus allowing investors to make more informed responses to oil shocks. The results are illustrated using daily data from all (active) listed energy related stock portfolios in the Asia Pacific Region.

It is shown that oil shocks can effect stocks directly, but also indirectly through general market risk, which is shown to be due in part to oil shocks. We demonstrate that the direct effect is not always present, even when concentrating upon energy specific stock portfolios. However the indirect is always present, thus for the six indices considered there is always some effect of oil shocks. These effects, when significant are positive, which is to say that a sudden rise in oil prices leads to positive returns on energy related stocks. The findings are robust to structural breaks, which appear in almost all cases. The indirect effect turns out to be larger than the direct effect, but this is perhaps to be expected since the direct effect, at least in the context of our empirical framework, represents an additive effect to any indirect risk exposure embedded in the traditional market beta. Without attempting to detract from the value of our analysis, we are confident the result that oil shocks are always significant will not generalize to all empirical cases, but we are more confident that the possibility of direct and indirect co-existing can add important value to existing research. What is presented here hopefully offers a different perspective on the way to analyze such problems.

To further establish the robustness of the findings, alternative definitions of an oil shock are considered. In addition to oil price returns, two other measures are also considered, namely oil price increases and net oil price increases. This robustness assessment muddies the results a little, highlighting the sensitivity of the results, in particular sign and magnitude of effect, to the choice of definition. A potential concern therefore is in the arbitrariness in selection of the definition of oil-shocks used. Potential exists to obtain a significant result simply by choosing one definition over another, but doing so may lead to different conclusions both in term of magnitude and sign of effect. Additional research is needed in this direction.

6 Acknowledgements

We would like to thank participants at the RIEM winter research retreat (China, December 2012) for useful comments and advice. Seminar participants at Shandong University (China, March 2013), and participants of the IAEE 2013 International conference (Korea, June 2013).

7 References

Andrews D.W.K., 1993. Test for parameter instability and structural change with unknown change point. *Econometrica* **61**, 821–856.

Andrews D.W. K. and Ploberger W., 1994. Optimal tests when a Nuisance Parameter is present only under the alternative. *Econometrica* **62**(6), 1383–1414.

Arouri, M.E.H., 2011. Does crude oil move stock markets in Europe? A sector investigation. *Economic Modelling* **28**, 1716–1725.

Arouri, M.E.H. 2012. Stock returns and oil price changes in Europe: A sector analysis. *The Manchester School* **80**, 23–261.

Arouri, M.E-H., Foulquier, P., Fouquau, J., 2011. Oil Prices and Stock Markets in Europe: A Sector Perspective. *Recherches economiques de Louvain, De Boeck Universite* **77**(1), pages 5–30.

Arouri M.E.H. and Nguyen D.K., 2010. Oil prices, stock markets and portfolio investment: Evidence from sector analysis in Europe over the last decade. *Energy Policy* **38**, 4528–4539.

Bachmeier, L. 2008. Monetary policy and the transmission of oil shocks. *Journal of Macroeconomics* **30**, 1738–1755.

Boyer, M.M., and Filion, D., 2007. Common and Fundamental Factors in Stock Returns of Canadian Oil and Gas Companies. *Energy Economics* **29**, 428–453.

Broadstock, D.C., Cao, H., and Zhang, D., 2012. Oil shocks and their impact on energy related stocks in China. *Energy Economics* **34**(6), 1888–1895.

Chang, C-L., McAleer, M.J., Tansuchat, R., 2012. Modelling Long Memory Volatility in Agricultural Commodity Futures Returns, *Econometric Institute Report EI 2012–15*, Erasmus University Rotterdam, Econometric Institute.

Chen, S.S., 2010. Do Higher Oil Prices Push the Stock Market Into Bear Territory? *Energy Economics* **32**, 490–495.

Chow G.C., 1960. Tests of equality between sets of coefficients in two linear regressions. *Econometrica* **28**(3), 591–605.

Ciner C., 2001. Energy shocks and financial markets: nonlinear linkages. *Studies in Nonlinear Dynamics & Econometrics* **5**, 203–212.

Ciner, C. 2012. Oil and stock returns: Frequency domain evidence. *Journal of International Financial Markets, Institutions and Money* **23**, 1–11.

Cong R.G., Wei Y.M., Jiao J.L. and Fan Y., 2008. Relationships between oil price shocks and stock market: an empirical analysis from China. *Energy Policy* **36**, 3544–3553.

Cunado, J., de Gracia, F.P., 2003. Do oil price shocks matter? Evidence for some European countries. *Energy Economics* **25**, 137–154.

Driesprong, G., Jacobsen, B., Maat, B. 2008. Striking oil: another puzzle? *Journal of Financial Economics* **89**, 307–327.

El-Sharif, Brown D., Burton B., Nixon B. and Russell A., 2005. Evidence on the nature and extent of the relationship between oil prices and equity values in the UK. *Energy Economics* **27**, 819–830.

Elyasiani, E., Mansur, I. and Odusami, B., 2011. Oil Price Shocks and Industry Stock Returns. *Energy Economics* **33**, 966–974.

Engemann, K.M., Owyang, M.T., Wall, H.J., 2011. Where is an oil shock?, *Working Papers 2011-016, Federal Reserve Bank of St. Louis.*

Engle F.R., and Ng V.K., 1993. Measuring and testing the impact of news on volatility. *The Journal of Finance* **48**(5), 1749–1778.

Faff R.W., Brailsford T.J., 1999. Oil price risk and the Australian stock market. *Journal of Energy Finance & Development* **4**(1), 69–87.

Ferderer, J.P. 1996. Oil price volatility and the Macroeconomy: A solution to the asymmetry puzzle. *Journal of Macroeconomics* **18**, 1–16.

Filis, G., 2010. Macro Economy, Stock Market and Oil Prices: Do Meaningful Relationships Exist Among Their Cyclical Fluctuations? *Energy Economics* **32**(4), 877–886.

Filis, G., Chatziantoniou, I. 2013. Financial and monetary policy responses to oil price shocks: evidence from oil-importing and oil-exporting countries. *Review of Quantitative Finance and Accounting* 1–21.

Gjerde, O., Saettem, F. 1999. Causal relations among stock returns and macroeconomic variables in a small, open economy. *Journal of International Financial Markets, Institutions and Money* **9**, 61–74.

Glosten, L. R., R. Jagannathan and D. E. Runkle 1993, On the Relationship Between the Expected Value and the Volatility of the Nominal Excess Returns on Stocks. *Journal of Finance* **48**, 1779–1801.

Gogineni S., 2010. Oil and the stock market: an industry level analysis. *Financial Review* **45**, 995–1010.

Hamilton J.D., 1983. Oil and the macroeconomy since World War II. *Journal of Political Economy* **91**, 228–248.

Hammoudeh, S., Li, H.M., 2004. Risk-Return Relationships in Oil-sensitive Stock Markets. *Finance Letters* **2**(3), 10–15.

Hammoudeh, S., Li, H. 2005. Oil sensitivity and systematic risk in oil-sensitive stock indices. *Journal of Economics and Business* **57**, 1–21.

Hansen B.E., 1997. Approximate asymptotic p values for structural-change tests. *Journal of Business & Economic Statistics* **15**(1), 60–67.

Henriques I. and Sadorsky P., 2008. Oil prices and the stock prices of alternative energy companies. *Energy Economics* **30**, 998–1010.

Huang R.D, Masulis R.W. and Stoll H.R., 1996. Energy shocks and financial markets. *Journal of Futures Markets* **16**, 1–27.

Jimenez-Rodriguez, R., Sanchez, M., 2005. Oil price shocks and real GDP growth: empirical evidence for some OECD countries. *Applied Economics* **37**, 201-228.

Jones C.M., Kaul G., 1996. Oil and the stock markets. *The Journal of Finance* **51**, 463–491.

Kilian, L. and C. Park, 2009. The Impact of Oil Price Shocks on the US Stock Market, *International Economic Review* **50**(4), 1267–1287.

Lee, Y-H., Chiou, J-S. 2011. Oil sensitivity and its asymmetric impact on the stock market. *Energy* **36**, 168–174.

Lee K., Ni S., 2002. On the dynamic effects of oil shocks: A study using industry level data. *Journal of Monetary Economics* **49**, 823–852.

Lee B.R., Lee, K., S., and R.A. Ratti, 2001. Monetary policy, oil price shocks, and the Japanese economy. *Japan and the World Economy* **13**(3), 321–349.

Maghyereh A., 2004. Oil price shocks and emerging stock markets: A generalized VAR approach. *International Journal of Applied Econometrics and Quantitative Studies* **1**, 27–40.

Miller J. I., Ratti R.A., 2009. Crude oil and stock markets: Stability, instability, and bubbles. *Energy Economics* **31**, 559–568.

Mohanty, S.K., Nandha, M., Turkistani, A.Q., Alaitani, M.Y. 2011. Oil price movements and stock market returns: Evidence from Gulf Cooperation Council (GCC) countries. *Global Finance Journal* **22**, 42–55.

Mork K. A., 1989. Oil and the macroeconomy when prices go up and down: An extension of Hamilton's results. *Journal of Political Economy* **91**, 740–744.

Nandha, M. and R. Faff, 2008. Does Oil Move Equity Prices? A Global View, *Energy Economics*, **30** 986–97.

Narayan, P.K., Sharma, S.S. 2011. New evidence on oil price and firm returns. *Journal of Banking and Finance* **35**, 3253–3262.

O'Neill, T.J., J. Penm, and R.D. Terrell, 2008. The Role of Higher Oil Prices: A Case of Major Developed Countries. *Research in Finance* **24**, 287–99.

Palm F.C., 1996. GARCH models of volatility, *Handbook of Statistics*, **14**, 209–240.

Papapetrou, E. 2001. Oil price shocks, stock market, economic activity and employment in Greece. *Energy Economics* **23**, 511–532.

Park J.W., Ratti R.A., 2008. Oil price shocks and stock markets in the US and 13 European countries. *Energy Economics* **30**(5), 2587–2608.

Quandt R.E., 1960. Tests of the hypothesis that a linear regression system obeys two separate regimes. *Journal of American Statistical Association* **55**, 324–330.

Sadorsky P., 1999. Oil price shocks and stock market activity. *Energy Economics* **21**, 449–469.

Sadorsky P., 2001. Risk factors in stock returns of Canadian oil and gas companies. *Energy Economics* **23**, 17–28.

Scholtens, B., Yurtsever, C. 2012. Oil price shocks and European industries. *Energy Economics* **34**, 1187–1195.

Sharpe, W.F., 1964. Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *The Journal of Finance* **3**, 425–442.

Vlaar, P.J.G. and Palm, F.C. 1993, The Message in Weekly Exchange Rates in the European Monetary System: Mean Reversion Conditional Heteroskedasticity and Jumps. *Journal of Business and Economic Statistics* **11**, 351-360.

Surrey Energy Economics Centre (SEEC)
School of Economics
University of Surrey
Guildford
Surrey GU2 7XH

SURREY

ENERGY

ECONOMICS

DISCUSSION PAPER

SERIES

For further information about SEEC please go to:

www.seec.surrey.ac.uk