Asymmetric Effects of Oil Price Fluctuations in International Stock Markets*

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ABSTRACT

New evidence on the way oil price fluctuations affect international stock markets is provided in analysis of the exposure of 43 stock markets. Oil price spikes depress international stock markets, but oil price drops do not necessarily increase stock market returns. Moreover, the volatility of oil prices has a negative impact on international stock market returns. Both these effects apply only to stock markets of developed countries. Emerging market returns are not sensitive to oil price variations. In addition, the asymmetry of oil price changes impacts oil volatility; i.e., when oil prices soar, oil volatility also increases, while negative oil price changes dampen volatility. Finally, oil price fluctuations are a factor in creating downside risk for international country investment.

JEL classification: C23; G12; Q4; L72

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I. Introduction

Between January 2000 and the summer of 2008, the price of oil increased almost five times, to become a cause of considerable concern. Escalating oil prices are likely to endanger the pace of worldwide economic growth as countries need sources of energy. As stock markets are commonly seen as bellwethers of an economy, (see, e.g., Fama (1990) and Schwert (1990)), oil price variations are likely be reflected in stock market returns. Yet, there is inconsistent evidence on the importance of oil prices for stock markets. Jones and Kaul (1996) provide evidence that aggregate stock market returns in the U.S., Canada, Japan and the U.K. are negatively sensitive to the adverse impact of oil price shocks on those economies. Chen et al. (1986), Ferson and Harvey (1994b) and Huang et al. (1996), however, find that oil futures returns do not have much impact on broad-based market indices such as the S&P 500 and that there is no reward for taking oil price risk in stock markets.

We provide new evidence on the way oil prices move stock markets. First, we investigate whether the impact of oil prices is asymmetric; that is whether the impact depends on the deviation being positive or negative. Although some authors demonstrate that the impact of oil price changes on the macroeconomy is asymmetric, i.e., oil price hikes have a negative impact on GDP, but drops in oil prices do not necessarily have a positive impact on output (see Mork, 1989; Mork et al., 1994), the relation has not been formally tested in stock markets.

Second, we investigate whether oil price volatility impacts international stock market returns. Third, we link asymmetries in oil price sign with oil price risk. Do soaring oil prices aggravate or diminish uncertainty about oil prices? Finally, we use quantile regressions to better analyze the role of oil price returns in extreme variations of international stock market returns.

We analyze for the first time the exposure of a large sample of stock markets to oil price fluctuations. Our results show that oil price spikes depress international stock markets, but oil prices drops do not necessarily increase stock market returns. Overall, the results provide new evidence on the asymmetric effects of oil price fluctuations. Moreover, the volatility of oil prices impacts negatively international stock market returns. Both effects apply only for stock markets of developed countries. Emerging markets returns do not show sensitivity to oil prices variations. In addition, the asymmetry of oil price changes impacts oil volatility, i.e. when oil prices soar, oil volatility also increases, while negative oil price changes dampen volatility. Finally, oil price fluctuations are a factor creating downside risk for international country investment.

Controlling for the impact of oil price fluctuations has become a prominent factor in investment decisions and consequently risk management. Our analysis should be helpful in understanding the workings of oil price variation in international country diversification.

The structure of the paper is at follows. Section II describes the data and the methodology. Section III presents the results of the estimation. Section IV makes a series of robustness tests to the analysis based on quantile regressions. Section V concludes.

II. Methodology and Data

We separately describe the methodology and the data that we use to make inferences on the importance of oil prices as a factor in international stock markets.

A. Methodology

We take as an example a global investment manager that diversifies across a large number of international stock markets. We follow the authors who use international arbitrage pricing theory (APT) to examine the impacts of global factors on stock returns (see Ferson and Harvey, 1994b; Karolyi and Stulz, 2003).

Our choice of global risk factors follows the practice in standard empirical work on international asset pricing. Following Stulz (1981) and Adler and Dumas (1983), one factor is the world market portfolio. Solnik (1974) advocates that exchange rate risk should be priced when purchasing power parity fails. Adler and Dumas (1983) also present theoretical support for the pricing of exchange rate fluctuations in a global setting. Therefore, we test whether a country index exhibits sensitivity to currency rate changes. The final factor we use is oil prices. Based on the work of Chen et al. (1986) and Ferson and Harvey (1994b), we try to investigate whether a country market returns are exposed to oil price fluctuations in a global investment setting.

The basic model is:

$$INDEX_{i,t} = \alpha_i + \beta_{WORLD} \cdot WORLD_t + \beta_{OIL} \cdot OIL_t + \beta_{CURR} \cdot CURRENCY_{i,t} + u_{i,t}, \quad (1)$$

where the dependent variable is the excess returns of the stock market of country i at time t ($INDEX_{i,t}$). The independent variables are the world market excess return on a risk-free rate at time t ($WORLD_t$); the return on an oil price index at time t (OIL_t); and the currency rate variations of country i at time t ($CURRENCY_{i,t}$). The β_k with $k \in \{WORLD, OIL, CURR\}$ are the coefficients of $INDEX_{i,t}$ on the risk factors. α_i, the intercept, accounts for possible heterogeneity among countries and is constant over time. This means that the effect of a change in one explanatory variable is the same for all countries and all periods, but the average level for country i may be different from that of country j. $u_{i,t}$ are the errors and represent the non-systematic excess returns relative to the factors. According to Ferson and Harvey (1994b), the factor model regressions provide information about the usefulness of global factors in controlling for the risks of international investments.

B. Data

We collect monthly returns for country indexes from Datastream, which provides extensive coverage of countries' total market capitalization. Datastream indexes are weighted by market capitalization.

Our sample covers 43 countries from December 1988 through June 2009, for a total of 247 monthly observations. This is an unbalanced panel because data are not available every month for all countries. Returns are expressed in U.S. dollars. We justify the choice of U.S. dollars as the reference currency by the fact that the price of oil is determined in U.S. dollars in international markets.

The stock market variables are the logarithm changes of the local market portfolio excess returns ($INDEX$) and the market portfolio computed using the logarithm changes of the world market portfolio index ($WORLD$). Both returns are in excess of a short-term interest rate, the one-month Eurodollar interest rate (see Ferson and Harvey, 1994a).

Table I, Panel A, reports the summary statistics for stock market indexes by country. Most countries have positive excess returns during the period. Only 13 of 41 stock markets indexes have negative excess returns. Volatility is lower in developed markets such as the U.S., Switzerland and the U.K. (with values ranging between 4% and 5%) and higher in emerging markets like Indonesia or Turkey, 21.475% and 16.394%, respectively. All countries have kurtosis values higher than three. We also observe that the distribution of excess returns is negatively skewed for the majority of the countries; only 5 of 42 present positive skewness. Consequently, the assumption of Gaussian returns is rejected by the Jarque-Bera test for almost all countries, except Japan.

Panel B of Table I reports summary statistics for the variables oil spot and futures prices, for the world market portfolio returns and for currency changes. For the variable WORLD we see a negative excess return for the period, as well as negative skewness. The Jarque-Bera test rejects the null hypothesis of normal returns.

$CURRENCY$ is the logarithm changes in currency rates against the U.S. dollar. As all bilateral rates are expressed in U.S. dollars by unit of the foreign currency, a positive change in the rate means the foreign currency has appreciated with respect to U.S. dollars. In Panel B we see summary statistics for currency variations against the U.S. dollar.

The evidence is that 23 of the 42 currencies depreciated against the U.S. dollar. Currency rates of Brazil and Indonesia are the worst volatiles with values over 7%. Overall, we observe that exchange rate variability is on average lower than the volatility of stock index returns. Since kurtosis is higher than three and there is negative skewness, the Jarque-Bera test lead us to reject the null of Gaussian returns.

The oil factor is proxied by the logarithm difference of oil prices (OIL). We use both spot and futures prices.[1] We use the price index of London Brent crude oil priced in U$/barrel and the NYMEX-light crude oil continuous-settlement price also priced in U$/barrel. Brent crude oil is sourced from the North Sea. It is used to price two-thirds of the world's internationally traded crude oil supplies, and is a benchmark for oil production from regions such as Europe, Africa and the Middle East. The NYMEX futures contract is the most widely traded futures contract on oil and it also is used as the benchmark to set oil product-related prices. Summary statistics about the time series are displayed in Table I, Panel B. The oil returns register a positive mean during the period, around 0.6 % monthly, with a standard deviation of almost 10 % monthly.

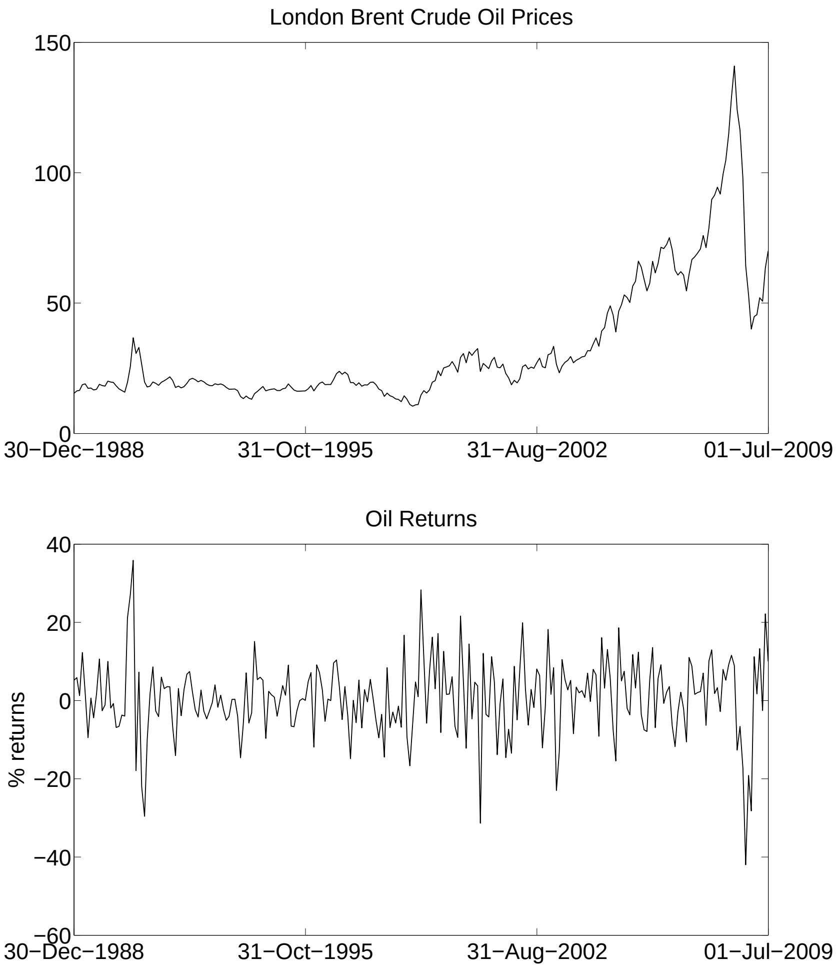

Figure 1. Oil price (first panel) and oil returns in percentage (second panel).

Figure 1 depicts the oil price index and oil returns over the sample period. In the first graph,

[1]The correlation between spot and futures oil prices is quite high, with a value of 0.9187.

the price of oil fluctuates little until around 1998. There is some turbulence in the summer of 1990, which coincides with the beginning of the invasion of Kuwait and the Gulf War, but prices drop to normal levels after the end of the war in February 1992. In 1999, rise again, but then drop after 2000 and 2001. Then they rose to over \$50/BBL in 2005, 100\$/BBL in 2007 and almost \$150/ BBL in July 2008. As many countries worldwide experienced economic recession, prices continued to slide until the end of 2008, to peak again during 2009. The value in June 2009 was again close to \$70/BBL.

The second graph in Figure 1 depicts the variations in oil prices. Many large monthly variations are visible as great as $+/-20\%$. There are four large declines in price that correspond to December 1990 and January 1991, the end of the Gulf War; December 2000; March 2003 and more recently October and December 2008. Price spikes can be seen in July, August and September of 1990, the beginning of the Gulf War; March 1999; May 2000; March 2002; January 2005 and May 2009.

III. Empirical Results

First we present results of the basic factor model. Second, we add to the model variables to test for asymmetric effects. Third, we see whether the volatility of oil impacts stock market returns, and finally we relate the asymmetric effects of oil price fluctuations to volatility of oil.

A. Baseline Model

Our starting point is the baseline model in equation (1). Because of the structure of the data, we estimate model (1) using panel data techniques. One advantage of this approach is that it enhances the quality and quantity of data and allow the study of the dynamics of the variable of interest with a relatively short time series. Moreover, intercepts can differ according to country for capturing cross-sectional heterogeneity.[2]

[2] To test equation (1), we estimate fixed and random effects panels. The advantage of a fixed effects panel is that it accounts for the fact that the explanatory variables may be correlated with the unobserved country effects.

The main results of the estimation of equation (1) are presented in Table II. Panel A uses oil spot prices and Panel B uses oil futures prices. Models (2) and (4) include time dummies in order to account for possible shifts in the level of country excess returns. Given the similarity of results, we comment on spot and futures prices together.

First, note that the coefficient of the variable *WORLD* is close to one and statistically significant. Therefore the International-Capital Asset Pricing Model (I-CAPM) cannot be rejected. Second, the variable *CURRENCY* also has a statistically significant positive coefficient much as in the results of Carrieri and Majerbi (2006). This means that appreciations of the local currency against the U.S. dollar have a positive effect on market returns. Finally, the coefficient on the variable OIL is not statistically significant, consistent with results of Chen et al. (1986) and Ferson and Harvey (1994b).

The Hausman test tests the null hypothesis that the country effects are not correlated with the factors. If there is no correlation, the random effects estimator is consistent and efficient, while the fixed effects estimator is merely consistent. Hence, rejection of the null hypothesis justifies use of the fixed effects model, which we will follow from now on.

B. Asymmetric Effects of Oil Price Changes

A large literature has reported that oil price fluctuations have an asymmetric impact on the macroeconomy. That is, while oil price spikes lead to reduced outputs, oil price drops do not necessarily lead to an increase in output (see Mork, 1989; Mork et al., 1994; Ferderer, 1996; Huntington, 1998; Balke et al., 2002). Nothing is known about this relation in stock markets, however.

Although results are quite similar, the Hausman test indicates that the fixed effects specification is often more appropriate. Therefore, hereafter we present estimation results for the fixed effects models. Finally, in order to calculate unbiased standard errors of the fixed effects panels, we cluster errors in two dimensions simultaneously, i.e., country and time (see Petersen, 2009).

To examine this we test the model,

$$
\begin{aligned}
INDEX_{i,t} = \;& \alpha_i + \beta_{WORLD} \cdot WORLD_t + \beta_{OIL_+} \cdot D \cdot OIL_t + \beta_{OIL_-} \cdot (1-D) \cdot OIL_t + \\
& \beta_{CURR} \cdot CURRENCY_{i,t} + u_{i,t},
\end{aligned} \tag{2}
$$

where D is a dummy variable that takes a value of one if the change in the oil price is positive and zero if it is negative; and β_{OIL_+} and β_{OIL_-} are coefficients corresponding to up and down movements in oil prices, respectively. All other variables are as defined for equation (1).

To confirm the asymmetry of the coefficients, we test two null hypotheses:

$$
\begin{aligned}
H_{01} &: \beta_{OIL_+} = 0 \text{ and } \beta_{OIL_-} = 0 \\
H_{02} &: \beta_{OIL_+} = \beta_{OIL_-}
\end{aligned}
$$

If oil prices have no effect on stock markets, consistent with Table II results, the null H_{01}: $\beta_{OIL_+} = 0$ and $\beta_{OIL_-} = 0$ cannot be rejected. Note that if oil prices have a symmetric effect on stock markets, the null H_{01} will be rejected. To gauge this, we test the null $H_{02} : \beta_{OIL_+} = \beta_{OIL_-}$. Therefore the asymmetry will be confirmed by the rejection of both H_{01} and H_{02}.

Results of the estimation of (2) are displayed in Table III. Panel A shows the results using oil spot prices and Panel B the results for futures prices. Model (1) shows results using all the sample countries. In this case, coefficients on the variables $WORLD$ and $CURRENCY$ are statistically significant, similar to the results in Table II. For the variable OIL, both panels show results consistent with a conjecture of asymmetry for oil spot prices. The coefficient of β_{OIL_+} is negative and β_{OIL_-} is positive, both statistically significant at standard levels of confidence for oil spot prices (Panel A) but not statistically significant for oil futures (Panel B). The sign of the coefficients suggests that when oil prices soar, international stock market returns drop, but when oil prices plunge, international stock markets do not climb; rather stock returns are again likely to drop.

To understand these results better, in Table III we separate the sample into developed and emerging markets. The coefficients of OIL_+ and OIL_- are now statistically significant for developed markets for both spot and futures prices. Tests on the coefficients consistently confirm the hypothesis of asymmetric effects in developed countries. Emerging markets countries, however, do not show statistically significant exposure to oil price fluctuations; therefore we cannot reject the null H_{01}.

To summarize this, Table III suggests that oil price changes move international stock markets in a non-linear way, but only for developed market stock returns. Emerging markets are not affected by oil price fluctuations. Interestingly, exposure is greater for oil spot price fluctuations than for oil futures fluctuations, as measured by the coefficients.

C. Impact of Oil Volatility

We next examine whether oil volatility impacts international stock market returns. The measure of oil volatility (VOL_OIL) taken from Kogan et al. (2009), is the absolute returns of oil price changes.

We extend equation (1) to include oil volatility and test the model:

$$\begin{aligned} INDEX_{i,t} = \quad & \alpha_i + \beta_{WORLD} \cdot WORLD_t + \beta_{OIL} \cdot OIL_t + \beta_{VOL\_OIL} \cdot VOL\_OIL_t + \\ & \beta_{CURR} \cdot CURRENCY_{i,t} + u_{i,t}. \end{aligned} \tag{3}$$

Table IV shows the results of the estimation of equation (3). Panel A uses oil spot prices as the explanatory variable, and Panel B uses oil futures prices. The results confirm the results of Table II, showing again that OIL is not statistically significant. The volatility of oil prices (VOL_OIL) has a negative effect on international stock market returns. When prices soar, this depresses international stock market returns. The major difference between Panels A and B is that the coefficient is statistically significant only when using oil spot prices (Panel A). For oil future volatility the impact is never statistically significant.

We next separate the sample countries into developed markets [models (3)-(4)] and emerging markets [models (5)-(6)], and the differences become clear. Developed market stock returns drop if oil price becomes more volatile measured by either spot or futures prices, while emerging markets return do not show any exposure to oil price risk.

Overall, the results show that stock markets of developed countries are quite sensitive to the instability of oil prices. Again we find greater sensitivity in terms of coefficients of spot prices than futures prices.

D. Impact of Asymmetric Effects of Oil Price Changes on Oil Volatility

So far we have documented that oil price changes have asymmetric effects on international stock market returns and that oil price volatility reduces international stock market returns. A related issue is whether asymmetry in the sign of oil prices affects oil volatility. To examine this relation, we use as a proxy of volatility the square of the standardized residuals obtained from fitting a GARCH(1,1) model to the oil returns. We specify a GARCH (1,1) model for oil returns:

$$\begin{aligned} y_t = & \ \mu + \varepsilon_t \\ \sigma_t^2 = & \ \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \end{aligned}$$

where $\varepsilon_t \sim N(0,1)$. Our asymmetry test consists of regressing the square of the standardized residual estimates given by $\widehat{res2_t} = \left(\frac{y_t - \hat{\mu}}{\hat{\sigma}_t}\right)^2$ on a constant, $OIL+$ and $OIL-$.

$$\widehat{res2_t} = \phi_0 + \phi_1 OIL_{+,t} + \phi_2 OIL_{-,t} + u_t \tag{4}$$

and test the null hypotheses that $H_{03} : \phi_1 = \phi_2 = 0$ and $H_{04} : \phi_1 - \phi_2 = 0$, where $OIL_{+,t}$ and $OIL_{-,t}$ are defined as before.

Table V displays the results of modeling equation (4), as before with spot returns in Panel A and futures oil returns in Panel B. The results show that oil price spikes increase volatility, while oil price drops dampen oil volatility. Both coefficients are statistically significant at standard levels of confidence.

IV. Robustness Analysis

We apply several robustness tests to the results. We use quantile regression to check whether results are robust to extreme observations. This approach is helpful in uncovering potential differences in factors across quantiles of returns, specially at high or low levels. The quantile regression approach also produces more robust inferences in some cases of non-Gaussian, especially skewed, error distributions or in the presence of outliers (Meligkotsidou et al. (2009)).

Equations (1), (2) and (3) are reestimated using quantile regressions. $\beta_{i(p)}$ displays how the factor affects the returns of stock markets at the level of the pth quantile. The different regression quantiles we chose are 5th, 25th, 50th, 75th and 95th.

Table VI shows the results of the estimation of equation (1). The first quantile refers to the lowest returns, and last quantile to the highest returns. The first thing to notice is that the sign of WORLD and CURRENCY is consistently positive across all quantiles, although value are slightly decreasing. The coefficients are nevertheless statistically significant in all quantiles.

Note next that, the sign of OIL changes over quantiles. The sign is positive for the lowest quantiles and negative for the highest quantiles. This seems consistent with earlier results that the effect of oil price fluctuations is not consistent across returns. Overall, OIL is not statistically significant at standard levels of confidence, confirming the results in Table II, and we confirm that extreme observations do not drive the results. Results are consistent whether we use spot oil prices (Panel A) or oil futures prices (Panel B).

Tables VII and VIII investigate the role of extreme observations in driving the asymmetric results. Spot oil prices are in Table VII and oil futures prices in Table VIII. Because the results are similar, we comment on them together.

Equation (2) is estimated using quantile regression. Panel A analyzes the entire sample. Again, the signs of $WORLD$ and $CURRENCY$ are not very different across quantiles. The impact of oil price fluctuations, whether positive or negative, is stronger in explaining returns in the lowest quantiles. Therefore oil price variations are an important cause of downside variation in international stock market returns.

We also separate the sample into developed and emerging markets, Panel B and Panel C, respectively. We confirm again that oil price deviations have a stronger impact in developed markets. Coefficients are statistically significant for the 5th, 25th and 50th quantiles, while for emerging markets the coefficient is statistically significant only for the lowest quantile (5%).

Tables IX and X reestimate equation (3) using quantile regression for spot and futures oil prices. The results again are similar, so we discuss the tables together. In Panel A we see that oil volatility has a negative impact on the lowest returns in international stock markets. In developed versus emerging markets, Panels B and C respectively, we see that the effect is pervasive for developed markets in almost all quantiles, but for emerging markets in the lowest quantiles only. Therefore oil volatility affects developed market stock returns, but emerging market returns only marginally, in the lowest quantiles.

V. Conclusion

We have documented several new facts about the influence of oil price fluctuations in international stock markets by analyzing 43 stock markets over 1988-2009. The results show that international stock markets are sensitive to the world market portfolio and currency rate changes consistent with models in Solnik (1974), Stulz (1981), and Adler and Dumas (1983). Oil price changes, however, have an asymmetric effect on stock market returns. When oil prices soar, stock markets plummet, but declines in oil prices do not lead to raising stock market returns. Moreover, oil price uncertainty depresses international stock market returns.

Both these effects are quite pervasive in developed markets. The effect is different for emerging markets, which do not show exposure to oil price changes or oil price volatility, even accounting for asymmetry of signs. The evidence that developed and emerging markets are not driven by the same factors supports the idea that emerging markets are a separate asset class and that including emerging markets in an international portfolio provides diversification benefits.

Price asymmetries in oil can impact oil volatility; that is oil price spikes increase uncertainty about oil prices, while oil price drops reduce oil price volatility. Results of the quantile regressions suggest that oil price fluctuations are a factor that creates downside risk for international portfolio diversification. Results are robust to a battery of tests.

This research has direct implications for understanding and controlling the risks of country diversification strategies. Considerable work remains to be done to understand why the reaction to oil price changes is asymmetric.

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