4. Methodology

We provide a description of the event study methodology in this section. Two types of event study are introduced, i.e., mean adjusted model and market model. The measures of abnormal returns estimated from event study are then regressed with various IEA’s and company-level factors that may influence the abnormal returns of oil-related markets.

4.1 Event study methodology

Empirical investigations concerning the efficiency of financial markets often examine the effect of a particular event on a firm’s returns. The main purpose of an event study is to assess the extent to which security price performance around the time of an event is abnormal, i.e. the extent to which security returns are different from those given by the model determining equilibrium expected returns (Mackinlay, 1997). A number of different empirical models have been employed in the literature to estimate abnormal performance around the event. These include the market model, market adjusted model and mean adjusted model. For these traditional event study estimators, we compute abnormal returns in two ways. First, we will consider the mean adjusted model specification as the benchmark concerning the samples of IPE Brent Crude futures and oil price indices in Japan, Canada, France, the United States, the United Kingdom and Norway. Second, we also use market model to calculate abnormal returns and cumulative abnormal returns for each company in these six countries with the individual market return index. The two models applied in our research are in the following.

4.1.1 The mean adjusted model

The mean adjusted model is consistent with the Capital Asset Pricing Model (CAPM) under the assumption that the unsystematic, firm-specific risk is assumed to be zero and the systematic, market-specific risk set to one. It assumes the anticipated expected return is equal to $E(R_{nt})$. Therefore, the predicted ex post expected return in the event period t is also equal to $E(R_{nt})$. That is, the mean adjusted model is generated by the following process:

$$ R_{nt} = E(R_{nt}) + \varepsilon_{nt} $$
Although the mean-adjusted model is perhaps the simplest model, Brown and Warner (1980, 1985) find it often yields results similar to those of more sophisticated models. Besides, by constructing an estimate of $E(R_{nt})$, we avoid the trouble of choosing a market index which in the markets of IPE Brent Crude futures and oil price indices may be unnecessary.

The expected return $E(R_{nt})$ is estimated from non-event period returns. In this estimation period, we calculate the normal mean and variance for every event $n$:

$$\bar{R}_n = \frac{1}{T} \sum_{t=1}^{T} R_{nt} \quad \sigma^2_n = \frac{1}{(T-1)} \sum_{t=1}^{T} (R_{nt} - \bar{R}_n)^2$$

where the return on day $t$ in the non-event period are given by $R_{nt}$ and $T$ is the number of observations in the non-event period. However, to apply this methodology in our study, we cannot obtain too many observations predating the IEA announcement before we start picking up prices observed a few days after the announcement in the previous month. This also constrains the number of usable days after the announcement. Here, we use 18 trading days around the event day to avoid any confounding effects between two consecutive event days in our analysis. That is, we calculate $\bar{R}_n$ using 7 observations from day -12 (relatively to the event day 0) to the day -6. We then calculate the 11 standardized abnormal returns in the period -5 to +5 for any event $n$:

$$AR_{nt} = (R_{nt} - \bar{R}_n) / \sigma_n$$

For each of the 10 days (-5 to +5) surrounding the event day (day 0) and including the event day, the standardized abnormal returns are combined in equally weighted portfolios and the portfolio standardized abnormal return is calculated:

$$AR_t = \frac{\sum_{n=1}^{N} AR_{nt}}{N}$$

where $N$ is the number of standardized abnormal returns in day $t$. If $R_{nt}$ follows a normal distribution with $\bar{R}_n$ and variance $\sigma^2_n$, then $AR_{nt}$ follows a univariate student-t distribution with mean zero. Under the Central Limit Theorem, the portfolio returns, $AR_t$, 

where $E(\epsilon_{nt}) = 0$
will be normally distributed with mean 0 and variance $1/N_t$. The null hypothesis is then transformed into testing whether portfolio abnormal returns are significantly different from zero at the day $t$. The test statistic is

$$Z = \frac{(AR_t - 0)}{\frac{1}{\sqrt{N}}}$$

The following diagram helps explain this procedure for any announcement $n$.

4.1.2 The market model

In the market model, the abnormal returns are estimated as follows:

$$AR_{it} = R_{it} - \hat{R}_n = R_{it} - \hat{\alpha}_i \hat{\beta}_i R_{mt}$$

where $AR_{it}$ is the abnormal return for company $i$ for these six countries in day $t$, $R_{it}$ is the observed stock return in day $t$, $\hat{R}_n$ is the estimated normal return in day $t$; and $\hat{\alpha}_i\hat{\beta}_i$ is the market-wide movement. The abnormal return is defined as the difference between the actual return and the normal return. This is the part of the actual return that cannot be explained by market movements and captures the effect of the event.
Here we use the main market index for each country seen in Table 4-1 as our proxy for market returns. The estimates of $\alpha_i$ and $\beta_i$ for the above regression come from ordinary least squares regression procedures over the period $t= -12$ to -6 relative to event day 0.

These abnormal returns are accumulated to form an equally weighted abnormal return for the portfolio of sample stocks in each day relative to substantial IEA announcements.

$$AR_t = \frac{\sum_{i=1}^{N} AR_{it}}{N}$$

where $N$ is the number of abnormal returns in day $t$.

Cumulative abnormal returns ($CAR_t$) are computed by summing the portfolio abnormal returns across time.

$$CAR_t = \sum_{i=t}^{t'} AR_i$$

Significance tests are reported using a $t$ statistic to test the null hypothesis that the portfolio abnormal return in each day is zero $H_0 : CAR_t = 0$. The reported statistics are calculated using a portfolio variance computed on the assumption that stock returns are independent and identically distributed in event time, i.e., the portfolio variance ($\sigma_n^2$) is computed as a weighted average of the security abnormal return variance over the estimation period.

### Table 4-1 The Main Stock Market Index for Each Country

<table>
<thead>
<tr>
<th>Country</th>
<th>Price Index ($R_{ma}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Nikkei 225 Stock Average</td>
</tr>
<tr>
<td>Canada</td>
<td>S&amp;P TSX Composite Index</td>
</tr>
<tr>
<td>France</td>
<td>France CAC 40</td>
</tr>
<tr>
<td>United States</td>
<td>S&amp;P 500</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>FTSE 100</td>
</tr>
<tr>
<td>Norway</td>
<td>OSE All Share</td>
</tr>
</tbody>
</table>
\[ t_{\text{CAR}} = \frac{\text{CAR}}{\sigma_n} \]

4.2 Cross-sectional regressions

Regression analysis has been used to identify the associations between explanatory variables and abnormal security returns in previous research on announcement effects in the financial market (Josev, Chan and Faff, 2004). We use cross-sectional analysis to regress the abnormal return on an intercept term, supply and demand variables representing the monthly change forecasted by IEA, some company-level variables including volume and size for each company, and dummy variable for each country are also included. Cumulative abnormal returns are accumulated over the event window \([-1 \text{ to } +1]\) because we assume some event uncertainty resulted from having time differences for different countries when IEA announces reports may exist. More formally, the following ordinary least squares (OLS) regression model is used:

\[
\text{CAR}_i = \beta_0 + \beta_1 \text{NOS}_i + \beta_2 \text{NAD}_i + \beta_3 \text{CD}_i + \beta_4 \text{LVol}_i + \beta_5 \text{LSize}_i + \beta_6 D_{\text{Japan}} + \beta_7 D_{\text{Canada}} + \beta_8 D_{\text{France}} + \beta_9 D_{\text{Kingdom}} + \beta_{10} D_{\text{Norway}} + \varepsilon_i
\]

Where:

- \( \text{CAR}_i \) = cumulative abnormal return for company \( i \),
- \( \text{NOS}_i \) = change of Non-OPEC supply in IEA’s announcements,
- \( \text{NAD}_i \) = change of North America demand in IEA’s announcements,
- \( \text{CD}_i \) = change of China demand in IEA’s announcements,
- \( \text{LVol}_i \) = the natural logarithm of turnover by volume, the number of shares traded on day \( t \) for company \( i \),
- \( \text{LSize}_i \) = the natural logarithm of firm size, market value of common equity at day \( t \) for company \( i \),
- \( D_j \) = A dummy variable taking a value of unity for companies in \( j \) country and zero otherwise,
- \( \varepsilon_i \) = error term.