ASSESSING FOR TIME VARIATION IN OIL RISK PREMIA: AN ADCC-GARCH-CAPM INVESTIGATION

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ABSTRACT

This paper focuses on oil market dynamics through the investigation of oil systematic risk and oil risk premium dynamics over the period 1997-2012, which includes several different economic episodes, enabling us to capture a considerable number of statistical properties for oil prices. Interestingly, unlike previous studies, the authors retained data for several developed and emerging oil markets and used different oil prices in order to provide a comprehensive and wide-ranging vision of oil price dynamics. To this end and in order to take eventual time variation and asymmetry in oil price dynamics into account, the authors applied recent econometrics tests associated with the ADCC-GARCH class of model. This modelling enabled us to appropriately specify the dynamics of oil conditional variance and time-varying oil risk premium. Accordingly, this study offers three interesting findings. First, the hypotheses of asymmetry and time variation in oil risk premia are not rejected. Second, the recent global financial crisis has increased systematic oil risk and oil risk premia in different regions. Finally, oil risk premia in emerging countries are significantly higher than those in developed countries, suggesting the inclusion of additional premium induced by political instability and geopolitical changes in emerging economies.

Keywords: oil price, systematic risk, risk premium, ADCC-GARCH-CAPM.

JEL CLASSIFICATION: Q4, C5, G1.

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1. INTRODUCTION

Oil price has been at the centre of several theoretical and empirical studies since the 1980s (Hamilton, 1983, 2003, 2009) for at least four reasons. First, changes in oil prices directly or indirectly affect investment choices, financial decisions, production and economic growth for both oil producers and consumer countries. Indeed, oil constitutes a major input for several production sectors, industries and manufacturers in developed countries, and is also a major resource for oil producing countries.[1] Second, with rapid financial globalization and financial innovation, together with the development of derivatives, oil products have become central to major investments and portfolios, and are held as a benchmark for derivatives (Hamilton and Wu, 2014). Third, in the aftermath of the recent global financial crisis (2008-2009), with the serious failure of conventional finance and major stock market losses, the oil market is considered as a form of refuge, an alternative form of finance and a source of diversification benefits (Alquist et al., 2013). Fourth, the 1973 and 1979 oil shocks are still present in the minds of bankers, economists, analysts and policymakers (Plourde and Watkins, 1998; Fleming and Ostdiek, 1999) as they had a considerable impact, not only on major developed and emerging economies but also on the trajectory of academic research in economics (Keynesian Theory and Philips Curve versus Monetarist Theory and New-Classical Theory, etc.).

Thus, even though demand for oil has fallen and has become more regulated over the last few decades thanks to the drive for new energy resources by firms and production systems, interactions with oil markets continue to increase, yielding new oil-input products and investments, resulting in significant changes in oil prices and volatility, and consequently changes in oil risk premium.

Analysts and scholars have put forward at least three different explanations to account for these rapid changes in oil price dynamics. First, the changes are due to an endogenous factor (rapid increase in oil products and high increase in investors' appetite for oil investment) because the oil market is a form of refuge for investors to escape from the losses made in the financial markets. Second, an exogenous factor that might justify changes in oil markets is associated with recent geopolitical events and changes in oil-producing countries (Iraq, Syria, Libya, Russia, Venezuela and Nigeria).[2] Indeed, political instability is an important source of oil volatility and oil systematic risk variation. It can also affect investor's attitude toward risk and oil risk premium, notably in view of the geopolitical risks.[3] Third, while concern and uncertainty relating to oil exhaustion in the near future led to a rise in oil prices and pushed OPEC to revise its oil exploitation process, the conduct of unconventional monetary policies by the Central Banks in the US and the EU since 2008 has had a direct or indirect impact on the evolution of oil prices.

Consequently, oil prices have alternated between falls (impact of the economic recession and deflation in the developed economies and therefore decrease in oil

[1] For example, Iran's dependency on oil and gas revenues is about 85%.

[2] Iraq is the second producer of oil among the OPEC (Organization of the Petroleum Exporting Countries) after Saudi Arabia. Nigeria exported about 2.2 million oil barrels a day in 2011. Syria exported about 100,000 barrels a day in 2011, notably to European countries (Germany: 32%, Italy: 31%, France: 11%).

[3] According to the French Institute of Energy, 15 to 20 US $ per barrel reflected the risk premium associated with the conflicts in Libya in 2011.

demand)[4] and rises (impact of exogenous factors such as geopolitical risks and political instability, as well as the effect of excess liquidity moving from developed to emerging countries), inducing further oil price volatility.[5] This volatility may be explained by further errors associated with forecasts in oil production and demand, a climate of change and risk, etc. However, as we can see, the evolution of oil prices and oil risk premium can also depend on the rhythm of oil production. Indeed, while oil production levels have remained unchanged since 2009 despite the geopolitical shocks, oil price and premium have nonetheless fallen in the last few years.

Overall, these different changes in economic circumstances, the end of the Great Moderation, the switch to unconventional monetary policies, geopolitical risk and all the above-mentioned stylized factors have led to diverse complex dynamics for oil prices. As mentioned earlier, several endogenous factors (oil demand, oil production, speculation, etc.) and exogenous factors (political instability, uncertainty about oil supply, sabotage of oil exploitation infrastructures in Iraq, etc.) can explain this instability in oil prices, although it is difficult to quantify their effects precisely. This can make future oil price forecasts a hard exercise (Dehn, 2001), and investors, managers and policymakers need to learn more about oil price dynamics in order to correctly revise and define their investment and financial choices.

In the literature, oil price is at the centre of a number of empirical studies that focus on oil price dynamics from different perspectives. Several studies have investigated oil price evolution through the lens of the origins and main effects of oil price variation on economic growth, firms' activities and householders' power parity (Chevallier and Sévi, 2013; Kilian, 2008; Manera and Cologni, 2008; Ferderer, 1996; Sadorsky, 1999, 2006; Lardic and Mignon, 2006, 2008). Other series of papers have studied the linkages between oil price and financial asset prices and/or commodities (Huang et al., 1996, Sadorsky, 1999; Arouri and Fouquau, 2009; Jawadi *et al.,* 2010, Ajmi *et al.,* 2014). Yet, other authors have investigated oil price volatility, either comparing it with other commodities[6] or with a focus on oil prices.

Otherwise, oil risk premium, while mentioned in several studies, has been relatively ignored in the literature. Moosa and Al-Lougani (1994) highlighted significant time variation in the risk premium of oil futures, and recommended the use of a GARCH model. McNown and Peroni (1998) and Kellard *et al.* (1999) showed the existence of a risk premium for futures of short maturities. Gorton and Rouwenhorst (2006)

[4] Oil demand fell in 2011 by 4% in European countries, 2.5% in the USA, 1.5% in Canada, while demand rose in Thailand (+6.4%), India (+3.6%) and Brazil (+2%).

[5] The year 2007 was marked by significant oil price volatility. Indeed, the price of a barrel of oil reached 50.5 $ in January, but rose to 79 $ in July, 67.1 $ in August and 79 $ in September. It reached 124 $ in April 2011 and fluctuated between 120 $ and 130 $ in February 2012. This excess volatility may reflect the risk premium increase during periods of hurricanes.

[6] Plourde and Watkins (1998) found that crude oil price volatility during the 1985-1994 period was higher than price volatility for nine other commodities and that the differences were significant for six of them. Clem (1985) noted that during the 1975-1984 periods, agricultural commodities were the most volatile. Oil and coal were less volatile than many non-food materials during the three periods (1975-1984, 1979-1981, and 1982-1984). Pindyck (1999) studied oil, coal, and natural gas price changes during the period 1870-1996, but did not compare their volatilities. The author instead calculated a constant volatility measure over a very long period during which volatility is believed to have changed. Ewing et al. (2000) found a spillover effect in the interactions between the volatility of oil and gas prices.

suggested that oil risk premium is equal to the historical risk premium on stocks, and pointed to a positive relationship between the risk premium of oil assets and oil volatility. Interestingly, hedging pressure and systematic risk seem to be the two main determinants of futures premiums. Oil risk premium is also central to a recent paper by Hamilton and Wu (2014) who identified significant changes in oil future risk premia since 2005. Interestingly, the authors pointed to volatility excess in oil premia and to the presence of negative premium, suggesting further evidence of seasonal variation of risk premia over the month, but also the presence of investors who buy long-term futures from oil producers and sell short-term futures in order to index fund investors. In other words, it appears evident that increased participation by financial investors changes the nature of risk premia. The time-variation in oil risk premia is shown by Melolinna (2011) who highlighted the existence of oil risk premia that depend on the choice of the sample period. For Alquist et al. (2013), oil risk premia exist, and this can be explained by both macroeconomic risk and oil industry specificities (crude oil scarcity). At the same time, Deaves and Krinsky (1995) showed the significant impact of commodities on oil risk premium.

In this paper, we focus on the study of oil price volatility and oil risk premium, since both are important factors in explaining oil price dynamics and giving investors greater insights into oil industry investment and diversification opportunities in the context of the financial crisis and recent turbulence in the finance sector. In effect, the investigation of oil risk and premium drivers can help us to understand oil price changes and improve its forecasting. While previous studies have focused on specific oil markets, our study covers a large sample of oil markets in developed and emerging countries to provide a wide vista of oil price fluctuations. In addition, carrying out our modelling with recent data allows our investigation to capture the impact of the global financial crisis and more recent geopolitical changes. Furthermore, the application of the time-varying and asymmetrical approach has the advantage of offering a different take on dynamic and nonlinear oil price evolution. Accordingly, our findings point to significant time-varying oil risk premia, taking into account the impact of political instability (exogenous factors) and investors' aversion to risk change (endogenous factor). It contributes to the literature by investigating the properties of oil risk premium (asymmetry, time variation) to improve oil price forecasts.

The paper is organized into four sections. Section 2 presents the econometric methodology. The empirical results are discussed in section 3. The last section concludes.

2. ECONOMETRIC METHODOLOGY

2.1 Conditional Oil Risk Premium Modelling

The well-known CAPM (Capital Asset Pricing Model) developed by Sharpe (1964) and Lintner (1965), often used to determine risk premium, corresponds to:

$$E(r_t) - rf_t = \beta\left(E(r_{M,t}) - rf_t\right) \tag{1}$$

Where : rf_t and r_t denote the one period returns
of riskless asset and a risky asset (oil) respectively,
$r_{M,t}$ refers to the returns of the market portfolio over one period,
β refers to the market beta.

The above standard CAPM assumes that β is constant over time and that it is calculated using the variances and co-variances obtained from historical data that correspond to $\beta = \frac{cov(r_t, r_{M,t})}{\sigma^2(r_{M,t})}$. This implies that the distribution of returns is stable over time, although it has not been verified in practice.

Recently, Fama and French (2004) showed that the standard CAPM model is not sufficient to take the time-variation factor into account in risk premium and price of risk. To address this issue, the conditional CAPM was introduced. The latter has the advantage of allowing risk and return to vary over time. Formally, a conditional CAPM corresponds to

$$E(r_t \backslash \Omega_t) - rf_t = \beta \left(E(r_{M,t} \backslash \Omega_t) - rf_t\right) \quad (2)$$

Where : Ω_t is the available information set.

Accordingly, it is possible to provide a conditional and time-varying measure for the market beta defined as: $\beta = \frac{\mathrm{cov}(r_t, r_{M,t} \backslash \Omega_t)}{\sigma^2(r_{M,t} \backslash \Omega_t)}$. The oil equity premium is then calculated according to the following time-varying market beta and the conditional expected market equity premium $(E(r_{M,t} \backslash \Omega_t) - rf_t)$.

2.2 The ADCC-GARCH model

In order to reproduce time variation in asset price volatility, several conditional variances were introduced and applied, including Autoregressive Conditional Heteroscedasticity models (Engle, 1982) and GARCH models (Bollerslev, 1986). Interestingly, to enable correlations and variances to vary over time, several multivariate GARCH specifications have been developed. Among these developments, we may note the dynamic conditional correlation GARCH (DCC-GARCH) model introduced by Engle and Sheppard (2001) and the ADCC GARCH model of Cappiello, Engle and Sheppard (2006) who extended the DCC-GARCH model to allow for asymmetry in the time-varying conditional correlations. While this new class of dynamic correlation model is distinguished by its simplicity in that it is executed in a simple two-step algorithm, the ADCC-GARCH offers an excellent framework to improve variance and therefore risk premium modelling.
Formally, we note a vector of oil returns by r_t and specify its dynamics as follows:

$$r_t = \mu + \varepsilon_t \quad (3)$$

$$\begin{aligned} \textit{Where}: &\ r_t \text{ denotes the oil returns' vector,} \\ &\ \mu \text{ denotes the vector of conditional returns,} \\ &\ \varepsilon_t \text{ is the vector of mean-corrected returns of } n \text{ oil assets at time } t. \end{aligned}$$

We specify ε_t as:

$$\varepsilon_t = H_t^{\frac{1}{2}} z_t \tag{4}$$

$$\begin{aligned} \text{Where}: &\ H_t \text{ is a matrix of conditional variances of } \varepsilon_t, \\ &\ z_t \to i.i.d\ (0,\ I),\ I \text{ denotes the identity matrix.} \end{aligned}$$

The matrix H_t is defined as follows:

$$H_t = D_t\ R_t\ D_t \tag{5}$$

$$\begin{aligned} \textit{Where}: &\ D_t \text{ is the diagonal matrix of time-varying} \\ &\ \text{standard deviations,} \\ &\ R_t \text{ is the conditional correlation matrix of the standardized residuals} \end{aligned}$$

The matrix D_t is based on time-varying standard variations from the univariate GARCH model and corresponds to

$$D_t = \begin{bmatrix} \sigma_{1,t} & 0 & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & 0 & \cdots & 0 \\ 0 & 0 & \sigma_{3,t} & & \vdots \\ \vdots & \vdots & & \ddots & 0 \\ 0 & 0 & \cdots & 0 & \sigma_{n,t} \end{bmatrix} \tag{6}$$

The diagonal elements of D_t are obtained from the following GARCH (p, q) specification:[7]

$$\sigma_t^2 = k + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + v_t \tag{7}$$

[7] The specification of σ_t is defined so that appropriate stationarity conditions can be checked.

$$\begin{aligned}
&\text{Where : } k \text{ is a constant}, v_t \to N(0,\sigma_v^2),\\
&\qquad \alpha_i \text{ and } \beta_j \text{ are the ARCH and GARCH}\\
&\qquad \text{parameters respectively},\\
&\qquad p \text{ and } q \text{ are the max - lag numbers.}
\end{aligned}$$

The matrix R_t reproduces conditional correlation of the standardized residuals ($\varepsilon_t = D_t^{-1} r_t \sim N(0, R_t)$) and corresponds to:

$$R_t = \begin{bmatrix} 1 & \rho_{12,t} & \rho_{13,t} & \cdots & \rho_{1n,t} \\ \rho_{21,t} & 1 & \rho_{23,t} & \cdots & \rho_{2n,t} \\ \rho_{31,t} & 0 & 1 & & \vdots \\ \vdots & \vdots & & \ddots & \\ \rho_{n1,t} & \rho_{n2,t} & \rho_{n3,t} & \cdots & 1 \end{bmatrix} \tag{8}$$

In practice, a GARCH structure is used to model the correlation dynamics. Thus, an ADCC process of order (M, N) can be described as:

$$R_t = \left(Q_t^*\right)^{-1} Q_t \left(Q_t^*\right)^{-1} \tag{9}$$

$$Q_t = (1-a-b)\,\overline{Q} - c\overline{T} + a\left(\varepsilon_{t-1}\varepsilon_{t-1}\right) + b\,Q_{t-1} + c\left(e_{t-1}e_{t-1}^{'}\right)$$

$$\begin{aligned}
&\textit{Where}: \overline{Q} = E\left(\varepsilon_t\, \varepsilon_t^{'}\right) : \text{ denotes the unconditional and time - invariant variance - covariance matrix,}\\
&\qquad a \text{ and } b \text{ measure the effects of shocks and dynamic correlations respectively},\\
&\qquad Q^* \text{ is a diagonal matrix containing the square root of the diagonal elements of } Q_t,\\
&e_t = I(\varepsilon_t < 0) \circ \varepsilon_t, \ (\circ \text{ denotes the Hadmard product elementwise matrix multiplication}),\\
&\overline{T} = E\left(e_t e_t^{'}\right).
\end{aligned}$$

To check the stationarity and positivity of Q_t, the following conditions are required:

$$(1-a-b)\overline{Q} - c\overline{T} > 0 \tag{10}$$

$$\begin{aligned}
&Q_0 > 0\\
&a + b + d\,c < 1\\
&\qquad \textit{Where}: d \text{ measures the maximum eigenvalue of } \overline{Q}^{-\frac{1}{2}}\,\overline{TQ}^{-\frac{1}{2}}
\end{aligned}$$

We define Q_t^{*} as:

$$Q_t^{*} = \begin{bmatrix} \sqrt{q_{11,t}} & 0 & 0 & \cdots & 0 \\ 0 & \sqrt{q_{22,t}} & & \cdots & 0 \\ 0 & 0 & \sqrt{q_{33,t}} & 0 & 0 \\ \vdots & \vdots & 0 & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & \sqrt{q_{nm,t}} \end{bmatrix} \quad \textbf{(11)}$$

The next section proposes an empirical investigation for oil risk premium using conditional CAPM and ADCC-GARCH specifications.

3. EMPIRICAL ANALYSIS

3.1 Data and Preliminary Results

This study uses different oil indexes obtained from the Morgan Stanley Capital International (MSCI) database and covering several oil markets to provide material for a large sample of oil prices, offering an interesting basis for an international comparison. In particular, our sample includes the MSCI World Energy Index that is designed to capture the large and mid-cap segment markets (DM), and the 11 sub-indices, including those that capture the main oil price characteristics for a couple of emerging and developed indexes. For emerging markets, we retained six large oil indexes: the MSCI BRIC index covers oil quotas for Brazil, Russia, India and China; the MSCI EM index is designed to measure energy market performance in the global emerging markets; the MSCI EM ASIA Standard concerns the oil-emerging markets in Asian countries including China, India, Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand; the MSCI EM EASTERN EUROPE Standard captures large and mid-cap representations across 4 emerging markets, namely, the Czech Republic, Hungary, Poland and Russia; the MSCI emerging markets EMEA Index captures large and mid-cap representation across eight emerging markets (EM) in Europe, the Middle East and Africa (EMEA); and the MSCI emerging markets (EM) from the Latin America Index captures large and mid-cap representations across five emerging markets (EM) in Latin America, including Brazil, Chile, Colombia, Mexico and Peru.

For the developed countries, we retained five oil indexes: the MSCI EAFE Standard (the developed market EAFE acronym stands for Europe, Australasia and the Far East); the MSCI EUROPE that consists of the following 15 developed market country indexes: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom; the MSCI G7 index as a benchmark for oil prices in the G7 countries; the MSCI Pacific Index that consists of the following 5 developed market countries: Australia, Hong Kong, Japan, New Zealand, and Singapore; and the MSCI North America Index which is designed to measure the performance of the large and mid-cap segments of the US and Canada markets. All data are expressed in US $ in order to eliminate exchange risk. Data are monthly and cover the period January 1997-September 2012.

To simplify the presentation of tables and figures hereafter, the following notations are used: BRIC for the MSCI BRIC index, EAFE for the MSCI EAFE Standard index, EM for the MSCI EM index, EMASI for the MSCI EM ASIA Standard index, EMASTEUR for the MSCI EM EASTERN EUROPE Standard index, EMEMEA for the MSCI Emerging Markets EMEA Index, EMLATAME for the MSCI Emerging Markets Latin America Index, EURO for the MSCI EUROPE index, G7 for the MSCI G7 index, NORAME for the North America Standard (Large+Mid Cap) index, and PACI for the MSCI Pacific Index.

We began our analysis by exploring the properties of oil prices for the different regions. First, we applied unit root tests (Augmented Dickey Fuller and Philips-Peron tests), and both tests pointed to the presence of a unit root in the oil indexes, suggesting that all indexes are I(1). Accordingly, we focused on oil returns. Second, we investigated their main statistical properties that we reported in Table 1. Here, we noted that the MSCI emerging markets Latin America Index provided the highest return in mean, while the MSCI EM EASTERN EUROPE Standard index showed the highest risk. The distribution of oil indexes is asymmetrical, indicating that the left tail is longer and that the mass of the distribution is concentrated on the right (left-skewed distribution). Second, while the distributions of MSCI EM EASTERN EUROPE Standard index, the MSCI Emerging Markets EMEA Index and the MSCI Emerging Markets Latin America Index seem to be leptokurtic with fat tails, indicating the frequentation of abnormal values, we noted the platykurtic property for the other indexes. Finally, normality was strongly rejected for all the oil indexes under consideration.

Table 1: Descriptive Statistics

	BRIC	EAFE	EM	EMASI	EMASTEUR	EMEMEA	EMLATAME	EURO	G7	NORAME	PACI
Mean	0,0035	0,0015	0,0026	0,0013	0,0024	0,0033	0,0044	0,0021	0,0018	0,0022	0,0006
Median	0,0094	0,0039	0,0053	0,0029	0,0106	0,0099	0,0105	0,0048	0,0050	0,0050	0,0009
Maximum	0,1011	0,0529	0,0687	0,0845	0,1148	0,0749	0,0816	0,0576	0,0448	0,0451	0,0694
Minimum	-0,1748	-0,0979	-0,1482	-0,1195	-0,2625	-0,1599	-0,1850	-0,1037	-0,0877	-0,0857	-0,0856
Std	0,0399	0,0229	0,0332	0,0347	0,0478	0,0347	0,0390	0,0249	0,0206	0,0211	0,0236
Skewness	-0,9456	-0,8708	-1,1383	-0,4936	-1,4842	-1,3421	-1,2764	-0,8047	-0,8741	-0,7851	-0,3720
Kurtosis	2,4513	1,7089	3,0078	0,6044	5,6199	3,8923	3,8650	1,6688	1,6135	1,2843	0,5254
Jarque-Bera	71,8548	44,8718	106,9224	10,1183	302,5030	167,9781	161,0002	40,3913	42,7310	31,1199	6,1740

Next, we computed unconditional correlation (Table 2) in order to investigate linkages between oil prices in the developed and emerging markets. While our analysis pointed to strong and significant correlation between the world oil indexes and the other oil country indexes, we can note that while oil price correlations across the oil markets under consideration are significant, the bilateral correlation varies per oil market. This may suggest that oil risk perception and oil risk premium might also vary, depending not only on global factors (World Oil Market) but also on specific and national drivers.

Table 2: Unconditional Correlation Matrix

	world	BRIC	EAFE	EM	EMASI	EMASTEUR	EMEMEA	EMLATAME	EURO	G7	NORAME	PACI
world	1	0.770	0.962	0.841	0.750	0.717	0.815	0.802	0.946	0.997	0.966	0.803
BRIC		1	0.771	0.938	0.815	0.820	0.865	0.941	0.736	0.755	0.717	0.697
EAFE			1	0.835	0.747	0.714	0.825	0.785	0.972	0.946	0.859	0.856
EM				1	0.928	0.842	0.916	0.924	0.791	0.826	0.788	0.768
EMASI					1	0.701	0.756	0.760	0.681	0.736	0.699	0.743
EMASTEUR						1	0.900	0.792	0.695	0.705	0.672	0.623
EMEMEA							1	0.855	0.801	0.799	0.750	0.721
EMLATAME								1	0.763	0.790	0.763	0.678
EURO									1	0.927	0.856	0.715
G7										1	0.976	0.797
NORAM											1	0.697
PACI												1

Table 3: ARCH Test

	BRIC	EAFE	EM	EMASI	EMASTEUR	EMEMEA	EMLATAME	EURO	G7	NORAME	PACI
Critical values	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415
Test statistic p-values	2.58e-004	3.78e-004	0.14 e-004	0.127e-004	0.27e-004	0.11e-004	0.18e-004	1.12e-004	0.001	0.002	0.129e-004
Test statistic	12.752	12.634	21.207	23.283	12.153	24.512	17.956	14.919	9.967	9.476	22.941
h – Test rejection decisions	1	1	1	1	1	1	1	1	1	1	1

Note: (1) denotes the rejection of the null hypothesis of the "No ARCH effect".

This analysis supposes however the constancy of oil price moments, which cannot be verified in practice. In order to check for time variation in oil return dynamics, we carried out the Engle's ARCH Test. Our analysis highlighted the presence of conditional heteroscedasticity in oil price data. Overall, we noted strong correlations between oil indexes in Tables 1, 2, and significant asymmetry and ARCH effect in oil data. We used ADCC-GARCH modelling in order to investigate these three properties (asymmetry, correlation and heteroscedasticity) jointly, while enabling both correlation and variance dynamics to vary over time.

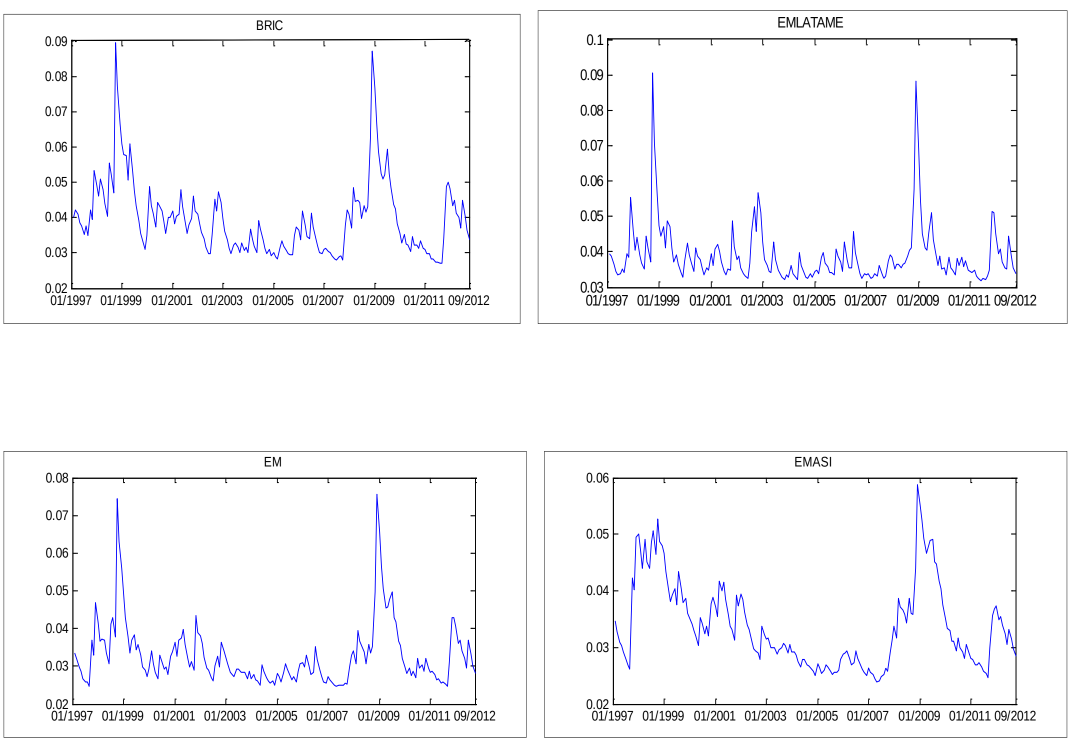
3.2 ADCC-GARCH Modelling

In order to model conditional variance for oil prices while taking conditional correlation into account, we tested different specifications and applied a number of tests. Accordingly, the ADCC (1,1)-GARCH (1,1) model was retained as the most appropriate specification, which is also in line with previous studies. We estimated this relationship and reported the main results in Table 4. From these, we noted various results. First, the ARCH and GARCH coefficients (α and β) are statistically significant and show appropriate economic signs. In addition, their sum is less than the unity for all indexes, confirming the stationarity and appropriateness of the GARCH specification. Second, the asymmetry coefficient c is significant for only five indexes (-the MSCI EAFE Standard index, the MSCI Emerging Markets Latin America Index, the MSCI EUROPE index, the North America Standard (Large+Mid-Cap) index, and the MSCI G7 index), suggesting that negative shocks on these markets may have more impact than positive shocks. Finally, regarding coefficients a and b, which reproduce the impact of past standardized shocks and lagged dynamic conditional correlations respectively on the current dynamic conditional correlations, we showed that these parameters are statistically significant for all indexes, confirming the hypothesis of dynamic conditional correlations between oil prices.

Table 4: The ADCC(1,1)-GARCH(1,1) Estimate

Parameters		BRIC	EAFE	EM	EMASI	EMASTEUR	EMEMEA	EMLATAME	EURO	G7	NORAME	PACI
μ	value	0,0064	0,0028	0,0052	0,0041	0,0064	0,0061	0,0068	0,0038	0,0031	0,0031	0,0018
	T-stat	2,1640	1,4725	1,8686	1,5705	2,0564	2,4719	2,0803	2,0700	1,8646	2,0497	1,0958
K	value	0,0002	0,0001	0,0002	0,0001	0,0003	0,0003	0,0005	0,0000	0,0000	0,0000	0,0000
	T-stat	1,6180	1,3347	1,4963	1,0274	2,4234	2,8668	1,5106	1,5116	1,1430	0,8316	1,0771
α	value	0,7203	0,5878	0,6736	0,8095	0,6314	0,4068	0,5212	0,7963	0,8136	0,8060	0,7925
	T-stat	6,7524	2,5253	5,1578	8,3202	7,3368	3,6977	2,5662	11,6177	13,8196	14,9115	9,0602
β	value	0,1910	0,1640	0,1879	0,1186	0,2857	0,4133	0,1902	0,1404	0,1530	0,1842	0,1375
	T-stat	2,4084	2,5871	2,7832	2,7595	3,2564	3,1000	2,6747	3,2162	3,7156	3,6059	2,6738
a	value	0,0342	0,0357	0,0637	0,1070	0,0994	0,0373	0,0160	0,0706	0,0850	0,0705	0,0941
	T-stat	82,6165	24,3898	50,3986	45,1317	78,8131	2,9972	60,0110	96,9541	57,8233	91,4267	148,6878
c	value	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
	T-stat	1,2582	402,1876	0,6766	0,5999	0,8088	0,7243	4,4298	20,4198	42,6316	126,1558	0,4117
b	value	0,9514	0,9109	0,9214	0,8742	0,8776	0,9346	0,9656	0,9119	0,9031	0,9105	0,8939
	T-stat	1903,5723	417,7796	459,9476	292,4372	742,6298	69,2046	4599,4900	904,9251	581,1479	1136,7236	1235,0326
Log Likelihood		347,4910	454,0480	382,4190	375,7100	323,1490	378,4410	348,5160	440,4950	476,2380	472,3980	445,9330

Next, these results were used to estimate the conditional volatility of oil prices for the World market as well as for the other specific oil indexes. We reported the main results obtained in Figures 1a and 1b. Accordingly, we noted at least three significant results. First, the recent global financial crisis (2008-2009) has led to increased volatility, and therefore risk, for oil prices in both developed and emerging countries, as well as for the world, implying periods of high and low volatility (volatility clustering). Second, a significant time-variation property and asymmetry seem to characterize the dynamics of oil volatility, confirming the conditional dynamics specification. Third, conditional oil volatilities for emerging markets are significantly higher than those of developed markets and world oil volatility. The conditional volatility of the world index evolves in a substantially similar manner to the Pacific index and the G7 index. Furthermore, while volatility excess characterizes the developed market at the end of the period, the 1990s represented a period of high oil volatility for emerging markets. Overall, this time variation in oil volatility might be explained differently: i) the pressure on oil markets and the return to the oil industry as a form of refuge by investors, ii) the impact of the end of the Great Moderation and the impact of the Great Economic Depression (less oil demand ⬀ oil price decrease), iii), the geopolitical changes that affected emerging markets far more than developed markets, iv) the effect of political instability (Iraq, Russia, Syria), which induces additional risk that may increase oil volatility.



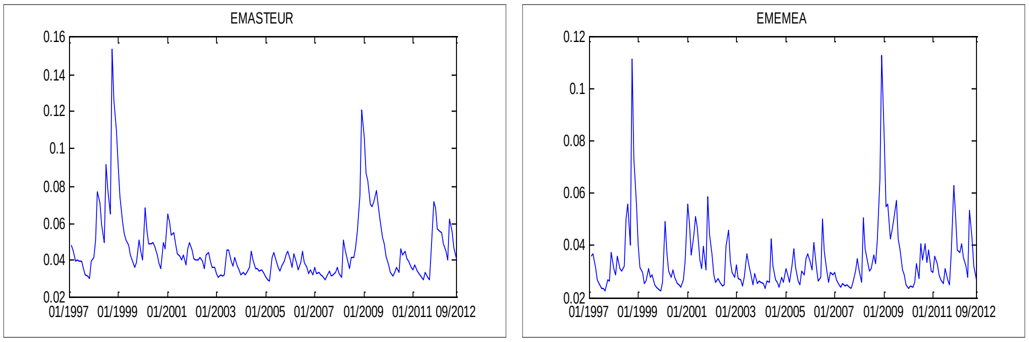


Figure 1a: Conditional Volatility for Emerging Markets

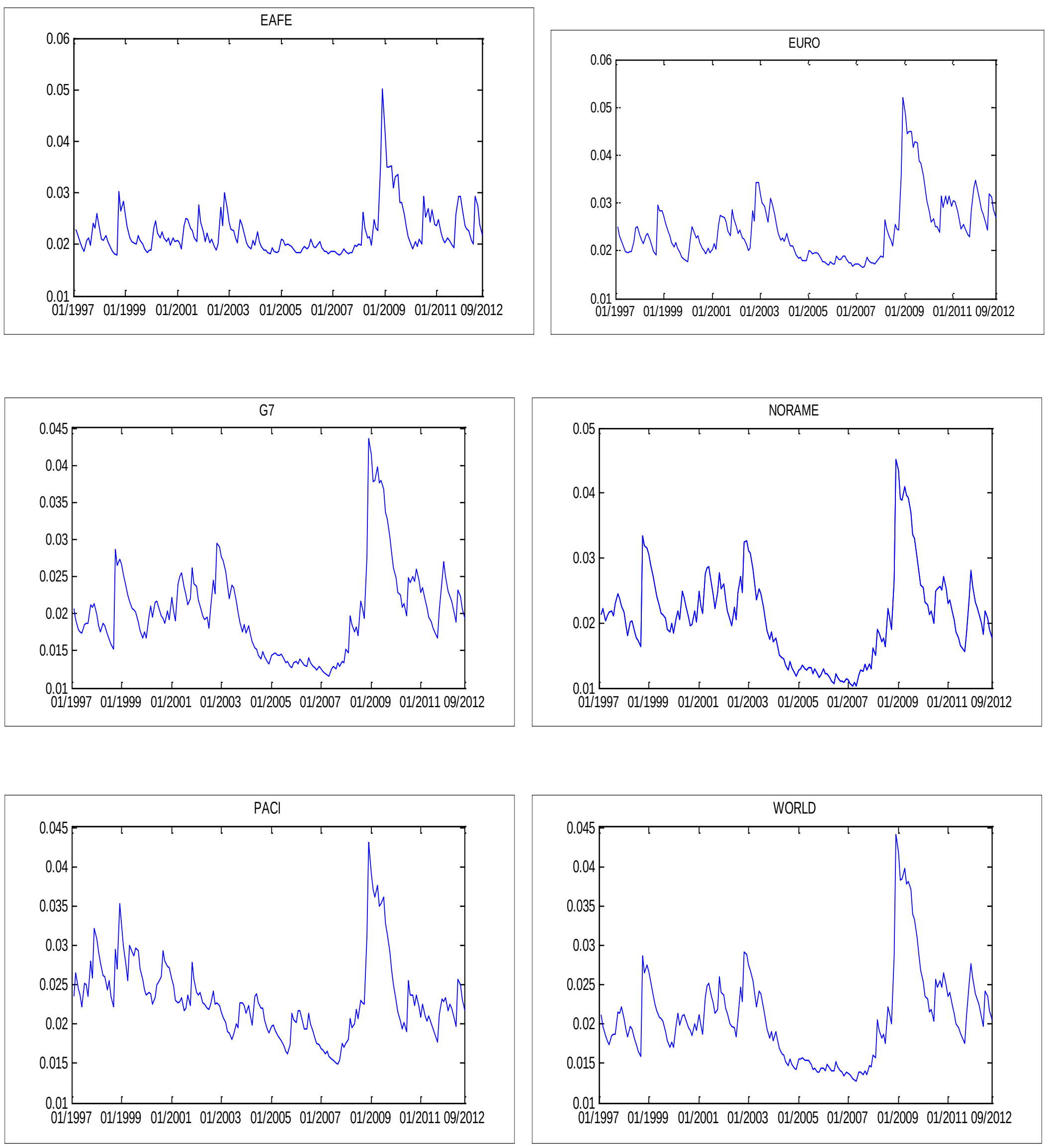


Figure 1b: Conditional Volatility for Developed Markets and the World

In order to better characterize the risk associated with investment in these oil markets, we focused on modelling oil systematic risk. To do this, we estimated a time-varying Market Beta, taking into account the conditional time variation characterizing oil return correlations and volatilities. Formally, we used this relationship:

$$\beta_{i,t} = \frac{\hat{H}_{12,t}}{\hat{H}_{22,t}}$$

Where : $\widehat{H}_{12,t}$ denotes the conditional volatility for the World oil market

$\widehat{H}_{22,t}$ denotes the conditional covariance

between the World oil market and the oil price i. **(12)**

with $\widehat{H}_{22,t}$ and $\widehat{H}_{12,t}$, respectively the conditional volatilities of the WORLD Standard market and the conditional covariance between asset i and the WORLD Standard market.

This estimation of time-varying market beta, reported in Figure (2a, 2b), provides a conditional measure of oil systematic risk, and enables investors to learn more about oil industry investment risks. The analysis of these figures provides some interesting results in line with the previous analysis of conditional oil volatility estimates. Indeed, the time variation is beta, and therefore oil systematic risk is not rejected and suggests further evidence of significant oil price variations for the different markets. Interestingly, oil prices in the emerging markets always showed higher levels of time-varying beta than oil prices in developed countries. In particular, beta reached 2.2 for the BRIC index, exceeded 3.0 for the EM Eastern Europe index, was about 2.0 for the MSCI emerging index and 2.5 for the MSCI Emerging Latin American index at the beginning of the period, characterized by several factors and geopolitical changes for the emerging markets (Asian crisis, Russian crisis, etc.), as well as the creation of the Euro area and its impact on emerging economies. It may also reflect the unconventional monetary policies recently carried out by policymakers in the US and Europe, which have led to higher inflation, a "currency war" and a rise in oil prices in emerging countries. As for the developed markets, the estimated beta is often equal to one, suggesting further stability that again reflects the relative decrease in economic activity and therefore in oil demand for the developed economies.

Figure 2a: Time-varying beta in Emerging Markets

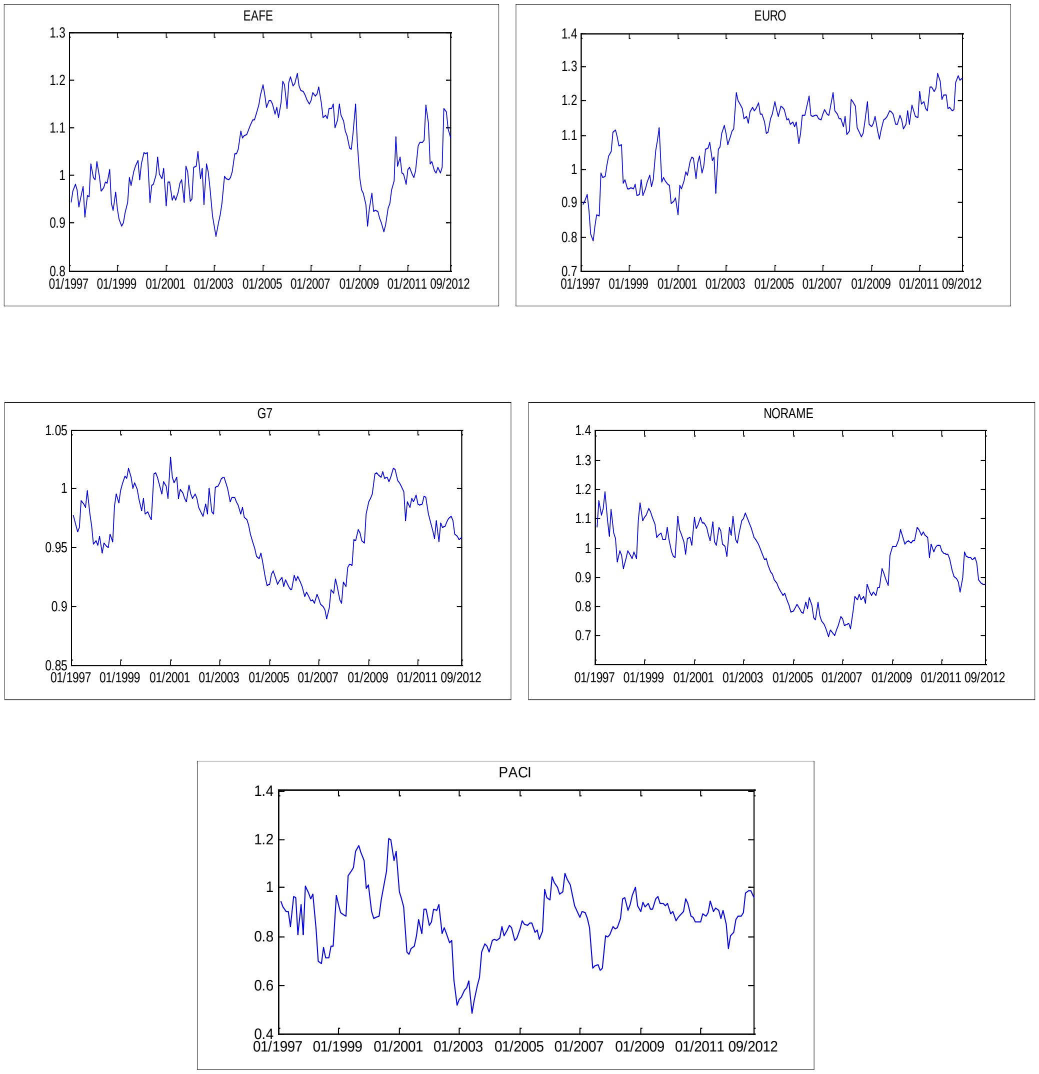


Figure 2b: Time-varying beta in Developed Markets

After identifying significant time variation and conditional dependency in oil price volatility and covariance across a large sample of oil indexes in developed and emerging countries, we finally focused on the test and modelling of time variation and asymmetry in crude risk premia. This issue is particularly interesting as it enables us to characterize the attitude of investors with regard to risk when acting on oil markets. It can also help us to better understand the evolution of oil prices during calm and turbulent times across the major developed and emerging markets.

Formally, time-varying oil risk premia are estimated using the relationship in Equation (2), and the main related empirical results are reported in Figures (3a, 3b).

Accordingly, our findings provide a number of interesting results. First, time variation in oil risk premium is significantly retained, and premiums appear to increase during periods of booms and crashes, suggesting that investors include additional risk when the economic cycle shows negative signs that give rise to doubt and concerns about the future. Second, as an illustration, the highest oil risk premium is observed at the end of the period, following the global financial crisis, indicating that investors are more attentive to the reasons for precaution and security, include crisis and financial risk in their strategy, and therefore ask for higher risk premiums. Third, as for market beta and conditional volatility, oil risk premia in emerging markets are higher than risk premia in developed countries, which can be explained by the fact that investors require higher premiums in order to be covered against oil price variations, but also against possible geopolitical risk or political instability which is often frequent in these emerging regions. Interestingly, oil risk premium is sometimes negative, which is explained differently according to the scholars: i) presence of long-horizon investors, ii) presence of investors who are looking for risk, and iii) the context of controlled inflation. Indeed, when investors trust policymakers but show concern about short rates, they prefer long rates and horizons, and their actions therefore contribute to decreasing risk premia.

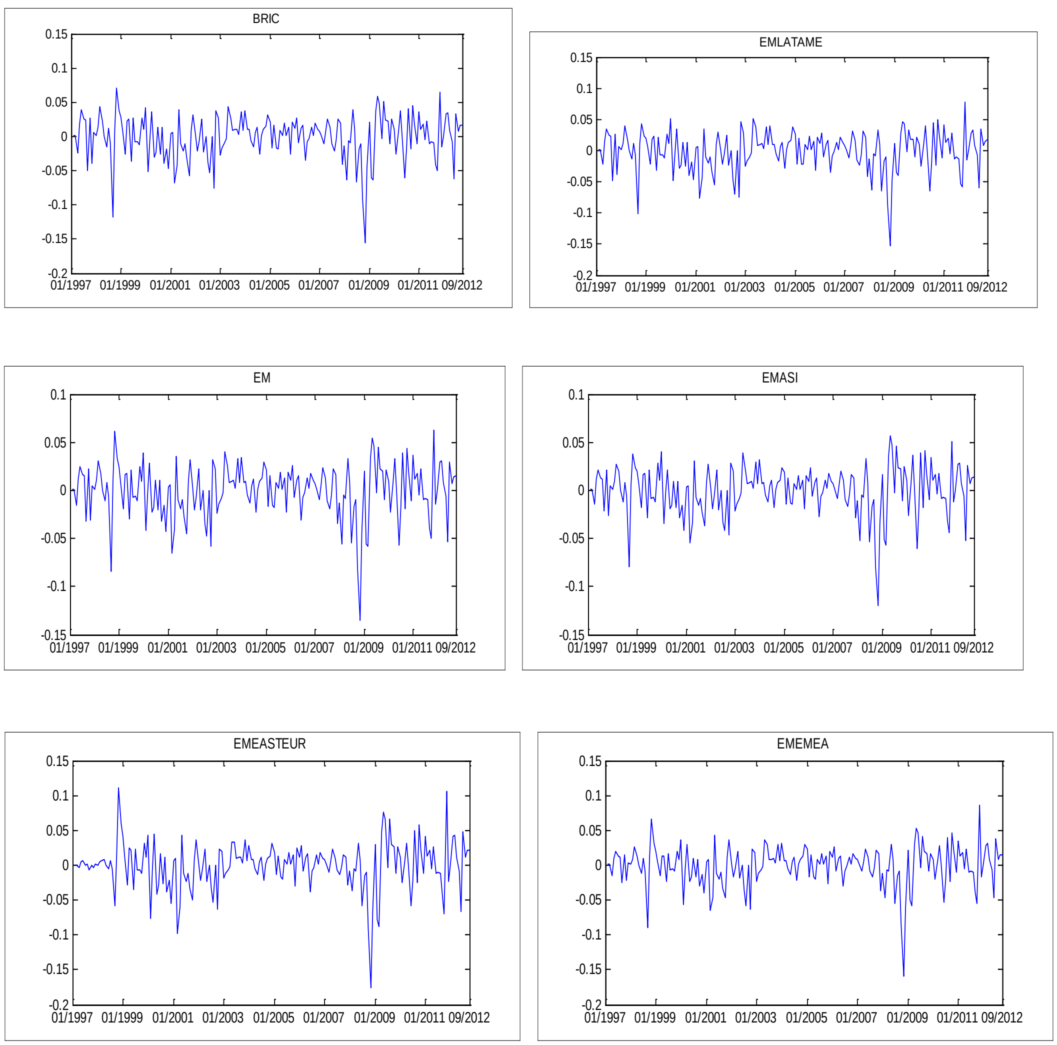


Figure 3 a: Time-varying risk premia in Emerging Markets

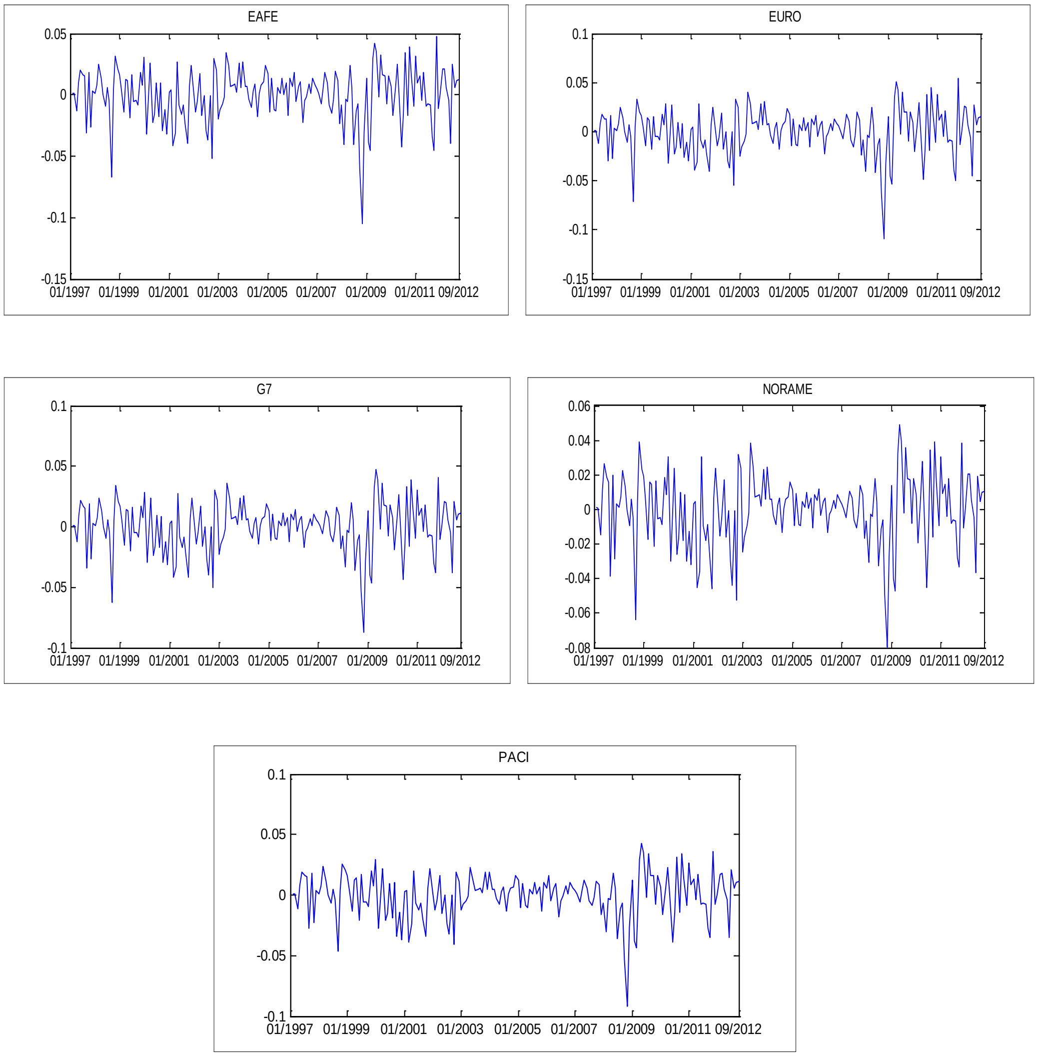


Figure 3 b: Time-varying risk premia in Developed Markets

4. CONCLUSION

This paper studies oil risk premia for large oil indexes in several developed and emerging markets over recent years. To this end, both conditional CAPM and asymmetrical DCC-GARCH models were employed to provide robust estimations. Accordingly, our findings found significant evidence of time-varying risk premia in oil markets that also exhibit asymmetry. Interestingly, the global financial crisis seems to have resulted in increased oil risk premia in both developed and emerging countries. However, it is shown that oil premia in emerging countries are higher than oil risk premia in developed markets, reflecting the effects of geopolitical changes and political instability in these regions. Thus, while drivers of oil premia might differ and vary per region, some common factors may exist, and a further extension of this study would be to test for comovements in oil risk premia between countries.

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