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Summary

The identification of the forces that drive oil stock prices is extremely important given the size of the Oil&Gas industry and its links with the energy sector and the environment. In the next decade oil companies will have to deal with international policies to contrast climate change. This issue is likely to affect companies' shareholder values. In this paper we focus on the long-run financial determinants of the stock prices of six major oil companies (Bp, Chevron-Texaco, Eni, Exxon-Mobil, Royal Dutch Shell, Total-Fina-Elf) using multivariate cointegration techniques and vector error correction models. Weekly oil stock prices are analyzed together with the relevant stock market indexes, exchange rates, spot and future oil prices over the period January 1998-April 2003. The empirical results confirm the statistical significance of the major financial variables in explaining the long-run dynamics of oil companies' stock values.

Keywords: Cointegration, Vector error correction models, Oil companies, Oil stock prices, Hydrocarbon fuels, Energy, Non-renewable resources, Environment

JEL: C32, L71, Q30, Q40

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Introduction

The identification of the forces that drive stock prices is a major concern in theory and practice. This assessment is particularly relevant in the Oil & Gas (O&G) sector, given the importance and size of this market, as well as its relationships with the energy sector and its impact on the environment.

O&G is one of the largest industries in the world, involving different companies and business in the different chains of production, distillation and distribution. A recent analysis (Credit Suisse First Boston, 2002) estimates a US\$ 770 billion-per-year global O&G commodity market, that is dominated by the Integrated Oil Companies. The physical crude oil market is alone worth US\$ 570 billion each year, business not including the vast amount of financial derivatives.

The United Nations Environment Programme (2003) explicitly recognizes the intimate link between the O&G industry and the environment. The extraction, transportation and use of primary fossil fuels (oil and gas in particular) and generation and transmission of electricity affect the environment at the global, regional, and local levels. From a global perspective, the effects of the release of carbon dioxide and other greenhouse gases as emissions from energy systems are crucial for the earth's climate system. For these reasons, O&G related companies will have to deal with at least a major issue in the next decade, namely the prospect of policies to contrast global warming. This issue is likely to affect companies' sales, operating costs, asset values, and shareholder

values. In a case study of sixteen leading oil and gas companies, Austin and Sauer (2002a) find that the corporate impact of this issue may be substantial, but it is not yet reflected in stock prices. Moreover, few companies have disclosed the degree to which they are financially exposed to this issue, and no company has attempted to quantify the financial implications for its shareholders. Although extremely interesting, the results are scenario-specific (see Austin and Sauer, 2002b, for details on this methodology). In particular, the scenarios used to analyze the financial implications of the climate change issue range from no action to widespread adoption of the Kyoto Protocol, which implies potential impacts varying from a five percent loss in shareholder value to a slight gain. As admitted by the authors, the large degree of subjectivity implicit in the assumptions underlying those scenarios is very likely to affect the conclusions.

In this paper we follow a classical time series approach. However, given the lack of reliable time series data on climate change effects, our analysis focuses on the financial determinants of oil stock prices. From this viewpoint, our paper can be considered as the first important step towards the econometric modelling of the joint effects of economic and environmental variables on the long-run dynamics of oil stock prices.

Ideally, the universe of Integrated Oil Companies includes the Super Majors, Regional Companies (US, Europe) and National Companies. An issue which seems to be particularly relevant in examining the behaviour of the share value of a single oil company is the selection of the different variables that could affect its dynamics. In this respect, we analyze time series data on stock prices of several companies of different

business volumes and targeted markets and from several countries, together with the oil prices, relevant stock market indexes and exchange rates.

The typical approach to measuring the exposure of a company to different risk factors is to estimate a single regression using changes of market share as dependent variables and changes in the factors of interest as independent variables, eventually controlling for other effects. Conversely, in this paper we focus on the long-run determinants of the market value of each company using multivariate cointegration techniques and vector error correction models (VECM).

The paper is organized as follows. Section 2 contains a brief review of the previous works on risk factors in oil returns. The data set is described in Section 3. Section 4 is dedicated to modeling the determinants of long-run dynamics in the value of oil companies. Section 5 concludes.

2. Previous works

Very few attempts have been made to analyze the factors affecting oil company stocks and their relations. Some deal with the time series properties of the US exchange rate and oil prices, while others refer specifically to the exposure of firms to various risk factors. These studies examine several companies and periods, taking into consideration different risk factors, and focus on the short run impacts or long run exposure.

The sensitivity of London quoted oil company stocks to oil prices is investigated by Manning (1991). The estimation period ranges from January 1986 to June 1988 and the frequency of the data is weekly. A cointegration procedure is adopted to assess market efficiency. The absence of cointegrating relations between oil company stock values, market index values and oil prices is established, in accordance with the efficient market hypothesis. The estimated short-run dynamic models support the hypothesis of positive oil price effects on the returns of oil companies, and the magnitude of the estimated coefficients is larger for the firms involved in exploration than for integrated oil companies. Some evidence of lagged effects of oil price changes is found. However, significant lagged terms are viewed as reflecting transaction costs and the peculiarities of the oil market more than market inefficiency.

The existence of a possible link between oil prices and the US exchange rate is examined by Amano and van Norden (1998). Monthly data for the period 1972(2)-1993(1) and a VECM approach are considered, and the two non-stationary variables are shown to be cointegrated. Moreover, the long-run level of the exchange rate seems to adjust to the price of oil, but not vice-versa. Specifically, a one percent increase in the commodity price would lead to a 0.51 percent appreciation of the dollar in the long run.

Sadorsky (2001) examines Canadian oil and gas industry stock returns over the period 1983(4)-1999(4). Using monthly data and a multifactor market model, which includes returns on market index, oil price, interest rate and exchange rate, he finds that stock price returns are sensitive to all these factors. Stock price returns show a positive

relationship with the market and oil price factors, and a negative relationship with the interest rate and exchange rate returns.

In the context of the literature suggesting that exchange rates are non-stationary and affected by oil price changes, Click (2001) considers whether there is long run exposure of oil companies to exchange rate and oil price changes. Data are monthly and cover the period 1979(7)-1999(7). Using the nine largest oil companies (as for 1999) and the cointegration technique, a multi-factor model containing the S&P 500 index, exchange rates and oil prices is found to dominate the single-factor CAPM model in eight of nine cases. Furthermore, it is shown that models should include exchange rates and oil prices simultaneously in order to avoid omitted variable bias.

To summarize, Manning (1991) considers weekly data for the period 1986-1988, verifies the absence of cointegrating relations between oil stocks, oil prices and the market index, and finds positive short run effects of oil price changes on stocks of London-quoted oil companies. The two more recent contributions use monthly data for a period that includes the 80s and 90s. Sadorsky (2001) employs a short run dynamic model and finds significant impacts of the market index, oil prices, interest rates and exchange rates on Canadian oil companies. Click (2001) commences with the non-stationarity of exchange rates established by Amano and van Norden (1998), and uses a VECM approach. His study seems to be unique in investigating long run exposures of the world's major (as for 1999) oil companies.

3. Data description

With the aim of understanding the determinants of oil company stock price variations, as well as their short and long-run behavior, we analyze time series data on stock prices of several oil companies together with the relevant stock market indexes, exchange rates and crude oil prices.

In order to get an overview of the oil industry we investigate companies from several countries and with different business volumes and targeted markets (global or regional), namely: Bp (BP, UK), Chevron-Texaco (CH, US), Eni (ENI, Italy), Exxon-Mobil (EXX, US), Royal Dutch Shell (ROY, The Netherlands/UK), and Total-Fina-Elf (TOT, France). These series (STOCK) are closing prices quoted in the stock market of the country of origin of each company (see Graph 1).¹ For the selected Oil Companies the relevant stock indexes (MKT) are: FTSE (UK), Dow Jones (DJ, US), MIB30 (Italy), AEX (The Netherlands), and CAC40 (France) (see Graph 2).

Moreover, given the presence of companies from UK and countries belonging to the European Monetary Union, we consider the closing quotations of the exchange rates (ER)

¹ For ROY, we have considered the Dutch market.

of the US dollar against the British pound and the Euro (USD/GBP and USD/EUR) (see Graph 2).²

The selected crude oil prices are dated Brent for the spot series (SP) and futures Brent prices (FP) with three-month (FP3) and twelve-month (FP12) maturities (see Graph 3).³

The sample period ranges from 23 January 1998 to 4 April 2003, and the frequency of observations is weekly. All prices are log-transformed and expressed in local currencies, with the only exception of crude prices, which are denominated in USD per barrel.

4. Modelling the determinants of long-run dynamics in oil company stock values

We consider each company separately and analyze, with a cointegrated VAR model (VECM), the existence of long-run relations and short-run effects among the market value of the company, the difference between FP12 and SP (SPREAD), and the relevant stock market index and exchange rate, the latter being only for non-US companies.

Augmented Dickey-Fuller (ADF) statistics are used to investigate the time series properties of the data. All variables are integrated of order one, or $I(1)$, most of them with intercept but no trend (see Table 1). Although individually non-stationary, these series

² Reuters is the main source for Company stock values, market indexes and exchange rates

³ Spot and futures prices of Brent are from Platt's. FP12 have been used in the long-run analysis, while FP3 have been selected in the short-run model. Considering that using different oil marker, such as WTI for the US companies does not affect the overall results a common oil price market has been adopted.

may still form one or more linear combinations which are stationary, or $I(0)$. In this case, there are one or more long-run equilibrium relationships among the variables entering the VAR specification, which are said to be cointegrated.

Following Johansen and Juselius (1990), the starting point of our cointegration analysis is a VAR specification for the $nx1$ vector of $I(1)$ variables X_t :

$$X_t = \mu_0 + \mu_1 t + A_1 X_{t-1} + \dots + A_p X_{t-p} + u_t \quad (1)$$

where μ_0 is a $nx1$ vector of constants, t is a deterministic trend, μ_1 is a $nx1$ vector of deterministic linear trend coefficients, and u_t is a $nx1$ i.i.d. Gaussian error vector.

If we write equation (1) as:

$$\Delta X_t = \mu_0 + \mu_1 t + \Pi X_{t-p} + \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{p-1} \Delta X_{t-p+1} + \varepsilon_t \quad (2)$$

where $\Gamma_i = -(\mathbf{I}_n - A_1 - \dots - A_i)$, $i=1, \dots, p-1$, and $\Pi = -(\mathbf{I}_n - A_1 - \dots - A_p)$, we obtain the VECM representation of the original VAR system (see, among others, Charemza and Deadman, 1992).

If cointegration among the variables X_t is present, model (2) includes both long-run and short-run stationary components. The maximum likelihood method proposed by Johansen (1990) tests the presence of cointegration at the system's level by determining

the rank of the long-run matrix, Π . If $\text{rank}(\Pi) = r$, with $0 < r < n$, the matrix Π can be decomposed as $\Pi = \lambda\beta'$, where λ is a $n \times r$ matrix of adjustment parameters and β is a $n \times r$ matrix containing the r cointegrating relations among the variables in X_t . The Johansen approach enables estimation of the parameters β , and to test for the number of $I(0)$ linear combinations among the X_t variables.

With the number r of cointegrating relationships determined, the following version of model (2) can be estimated by OLS:

$$\Delta X_t = \mu_0 + \mu_1 t + \lambda \text{ecm}_{t-p} + \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{p-1} \Delta X_{t-p+1} + \varepsilon_t \quad (3)$$

where $\text{ecm}_{t-p} \equiv \hat{\beta}' X_{t-p}$ is the $r \times 1$ vector of long-run equilibria among the X_t variables.

Testing the significance of the estimated parameters λ in system (3) determines which variables can be considered as (weakly) exogenous (see Urbain, 1992). Specifically, the dependent variables of equations where the coefficients λ are not statistically significant can be treated as exogenous.

Using the Johansen cointegration procedure outlined in the previous section, there is one cointegrating relation in all six company-specific systems. Table 2⁴ reports the trace tests and the coefficients of the long-run relationships among the stock prices of the

⁴ All models are estimated using the econometric software EViews 4.1.

company, the spread between FP12 and SP, the market index and the exchange rate. Since all variables are log-transformed, we can interpret the coefficients β_i , $i=1,\dots,4$, as long-run elasticities.

If the estimated value of the parameter β_2 is positive, an increase in the ratio between future and spot prices (i.e. upward expectations of crude oil price) corresponds to an increase in the company market value. Intuitively, we expect this situation to hold for a company which is focused on upstream activities. Conversely, a company whose business is mainly downstream could be penalized by a future increase in oil prices, if it is not able to transfer the rise in oil prices to the price of refined products. This result is linked to the speed of price adjustments to the oil price increase.

Since these oil companies are among the world's largest enterprises, and their business encompasses both upstream and downstream activities in several energy sectors, the sign of the β_2 coefficient cannot be determined *a priori*. The estimated parameters are positive in the case of CH, EXX and ENI, and negative for BP, ROY and TOT.

Economic theory suggests that the coefficients β_3 (long-run elasticities of the oil stock value with respect to the stock market index) should be positive. The explanation of the estimated negative elasticities for ENI and ROY relies on specific market circumstances. In the case of ENI (see Graph 1), during the whole 1999 and the beginning of 2000 the oil stock value has decreased since it is still affected by the plunge in crude prices which characterizes the 1998 and the beginning of 1999, while the stock market index is

increasing, as it is drawn by speculative stocks. After the end of the high-tech stocks bubble, the market enters a downward trending phase. The ENI stock is probably seen as a “shelter”, and tends to rise, as it is positively influenced by high crude oil prices. In the case of ROY (Graph 1), the negative correlation is more evident in the first part of the sample, where the price of crude oil records its minimum average level.

All the estimated β_4 parameters are negative. Since the transaction currency in oil markets is USD, the stock value of a non-US company is expected to decrease when the dollar appreciates relative to the local currency.

The estimated adjustment coefficients in VECM representations are reported in Table 3. In all the estimated models, the significance of the estimated parameters λ_i , $i=1,\dots,4$, indicates that one or two variables can be considered to be weakly exogenous in the VECM. In particular, the market index seems to be endogenous for those companies (ENI, ROY, TOT) whose capitalization, compared with the stock market, is larger. The spread variable is found to be endogenous for BP, EXX, CH and ROY. Loading estimates, which correspond to the exchange rate equations, are not significant, confirming its expected exogeneity. The autoregressive structure of the estimated models seems to be statistically adequate, since the null hypothesis of no residual autocorrelation is never rejected (as in the LM tests Table 3). The forecast capacity of the models is verified by the Mean Absolute Percentage Error computed on the last 8 weeks of the sample, reported at the bottom of the table.

5. Conclusion

This paper addresses how to empirically determine the sign and magnitude of different variables affecting oil stock prices. We adopt a company-specific approach, and focus on long-run determinants of the market value of each company using multivariate cointegration techniques and vector error correction models.

The long-run relationships among the stock price of the company, the spread between spot and future oil price, the relevant stock market index and the exchange rate are analyzed. This assessment is particularly important for its environmental implications, since O&G related companies will have to deal with a major issue in the next decade, namely the prospect of policies to contrast global warming. This issue is likely to affect companies' sales, operating costs, asset values, and shareholder values.

The main results of the paper can be summarized as follows.

First, an increase in the ratio between future and spot prices corresponds to an increase in the company market value. Intuitively, we expect this situation to hold for a company which is focused on upstream activities. Conversely, a company whose business is mainly downstream could be penalized by a future increase in oil prices, if it is not able to transfer the rise in oil prices to the price of refined products. This result is linked to the speed of price adjustments to the oil price increase. Since these oil

companies are among the world's largest enterprises, and their business encompasses both upstream and downstream activities in several energy sectors, the sign of this effect cannot be determined *a priori*. It is positive in the case of CH, EXX and ENI, and negative for BP, ROY and TOT.

Second, economic theory suggests that the long-run elasticities of the oil stock value with respect to the stock market index should be positive. The explanation of the estimated negative elasticities for ENI and ROY relies on market circumstances which are specific to these companies.

Third, since the transaction currency in oil markets is USD, the stock value of a non-US company decreases when the dollar appreciates relative to the local currency.

Fourth, in all the estimated models the significance of the estimated adjustment coefficients indicates that one or two variables can be considered to be weakly exogenous in the VECM. In particular, the market index seems to be endogenous for those companies (ENI, ROY, TOT) whose capitalization, compared with the stock market, is larger. The spread variable is found to be endogenous for BP, EXX, CH and ROY, whereas the exchange rate is exogenous for all companies.

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Table 1. ADF unit root tests

<i>Series</i>	<i>Lag length</i>	<i>ADF</i>
BP (no trend)	0	-2.51
Δ BP (no trend)	0	-17.71 ^{**}
CH (trend)	0	-2.93
Δ CH (no trend)	0	-17.92 ^{**}
ENI (no trend)	3	-1.71
Δ ENI (no trend)	2	-12.88 ^{**}
EXX (no trend)	1	-3.34 [*]
Δ EXX (no trend)	0	-21.09 ^{**}
ROY (no trend)	0	-1.61
Δ ROY (no trend)	0	-17.62 ^{**}
TOT (no trend)	0	-2.51
Δ TOT (no trend)	0	-18.88 ^{**}
USD/EUR (no trend)	0	-1.31
Δ USD/EUR (no trend)	0	-16.86 ^{**}
USD/GBP (no trend)	0	-1.83
Δ USD/GBP (no trend)	0	-16.60 ^{**}
SPREAD (trend)	0	-2.76
Δ SPREAD (no trend)	0	-16.18 ^{**}
AEX (trend)	0	-1.25
Δ AEX (no trend)	0	-15.14 ^{**}
FTSE (trend)	0	-2.11
Δ FTSE (no trend)	0	-16.24 ^{**}
MIB30 (trend)	0	-1.90
Δ MIB30 (no trend)	0	-14.78 ^{**}
DJ (trend)	0	-2.57
Δ DJ (no trend)	0	-17.57 ^{**}
CAC40 (trend)	0	-1.43
Δ CAC40(no trend)	0	-16.00 ^{**}

Notes to Table 1: all price series are in logs; the data frequency is weekly; the sample period begins on 23 January, 1998 and ends on 4 April, 2003; ADF is the calculated t test for the null hypothesis of a unit root in the series from the Augmented Dickey-Fuller regression. *Lag length* is the order of the augmentation needed to eliminate any autocorrelation in the residuals of the ADF regression; * (**) indicates significance at 5% (1%) on the basis of the critical values given in MacKinnon (1996).

Table 2. Long-run estimated coefficients and cointegration tests

Estimate	BP	CH	ENI	EXX	ROY	TOT
$\hat{\beta}_0$	-2.46	-4.95	7.33	-5.08	7.33	5.27
$\hat{\beta}_1$	-	-	-	0.001 ^{***} (0.00)	-0.004 ^{***} (0.001)	-
$\hat{\beta}_2$	-0.39 ^{***} (0.09)	0.49 ^{***} (0.09)	0.22 [*] (0.11)	0.30 ^{***} (0.10)	-0.65 ^{***} (0.14)	-0.25 ^{***} (0.07)
$\hat{\beta}_3$	0.55 ^{***} (0.08)	1.02 ^{***} (0.13)	-0.46 ^{***} (0.07)	0.94 ^{***} (0.08)	-0.47 ^{***} (0.17)	-0.05 ^{***} (0.05)
$\hat{\beta}_4$	-1.39 ^{***} (0.23)	-	-1.42 ^{***} (0.19)	-	-3.07 ^{***} (0.40)	-1.74 ^{***} (0.13)
n	0	1	1	1	0	0
Trace test	27.96 ^{**}	34.11 ^{**}	49.51 ^{**}	47.63 ^{**}	70.82 ^{***}	61.21 ^{***}

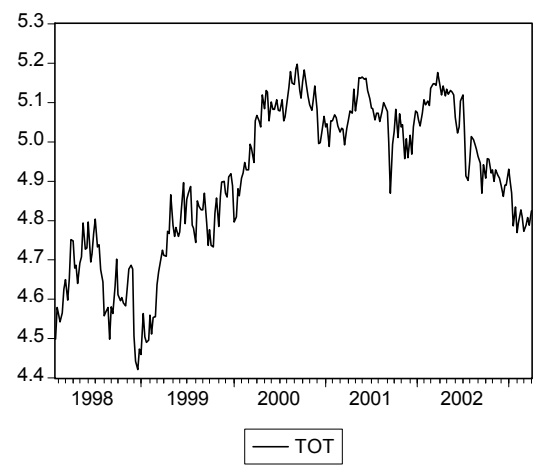
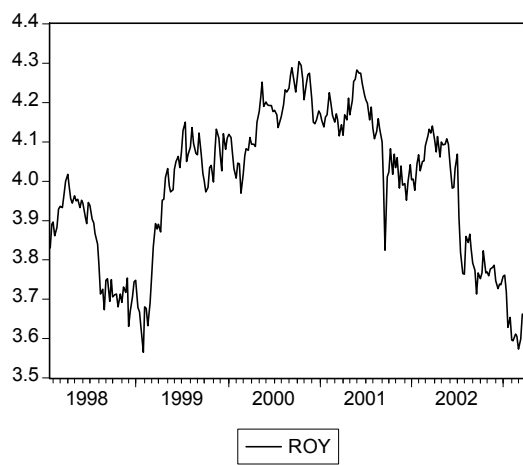
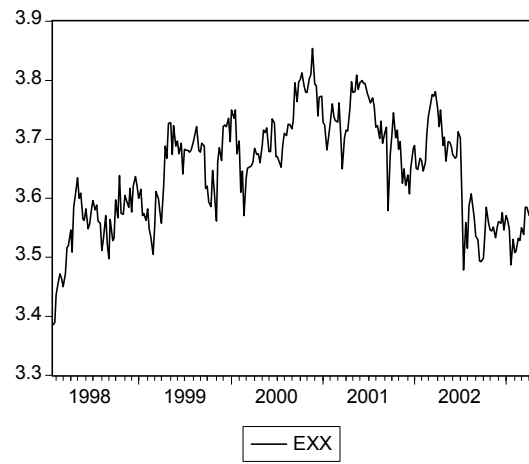
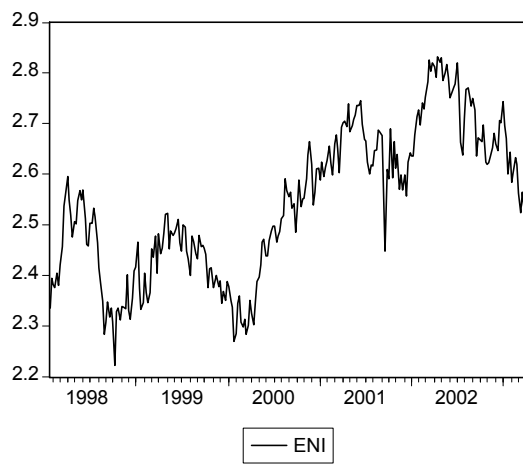
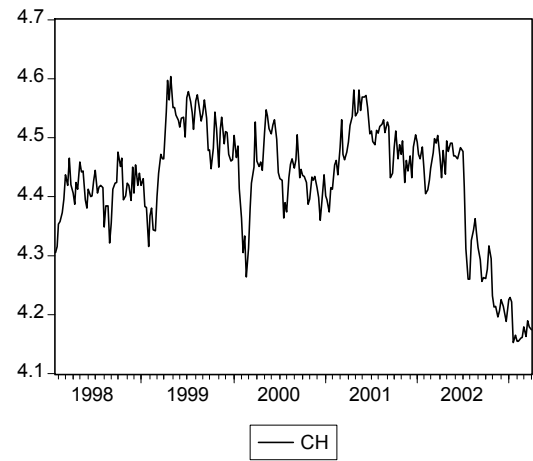
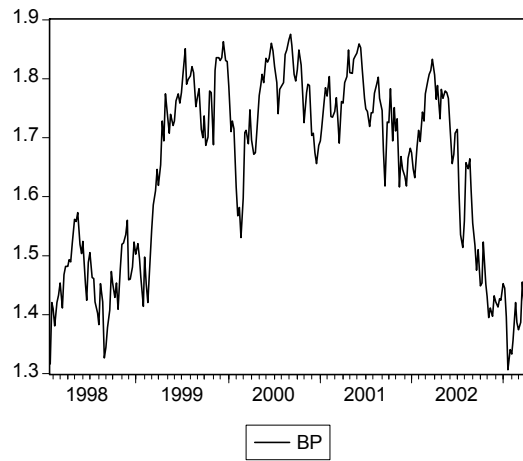
Notes to Table 2. $\hat{\beta}_i$, $i=0,...,4$ are the estimated coefficients of the cointegrating equation $STOCK_t^j = \beta_0 + \beta_1 t + \beta_2 SPREAD_t + \beta_3 MKT_t^j + \beta_4 ER_t^j$, associated with the VECM estimated for j -th company with $j=1,...,6$. Standard errors are reported in parentheses; * (**) [***] indicate significance at the 10% (5%) [1%] levels; n is the lag length of the VECM; the Trace test is the calculated statistic for the presence of at most r cointegrating relations provided by Johansen (1991). In the BP case, the reported value is relative to the max-eigenvalue test.

Table 3. VECM estimates (loadings) and diagnostic

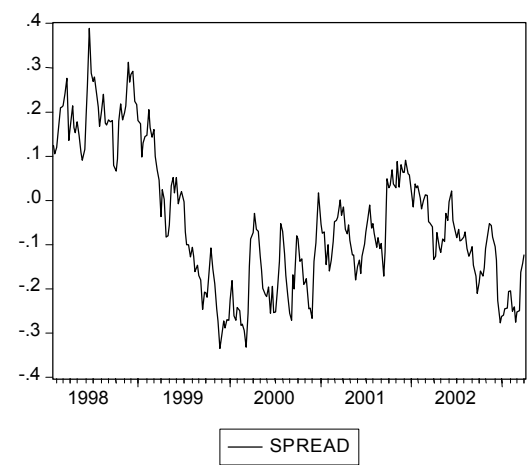
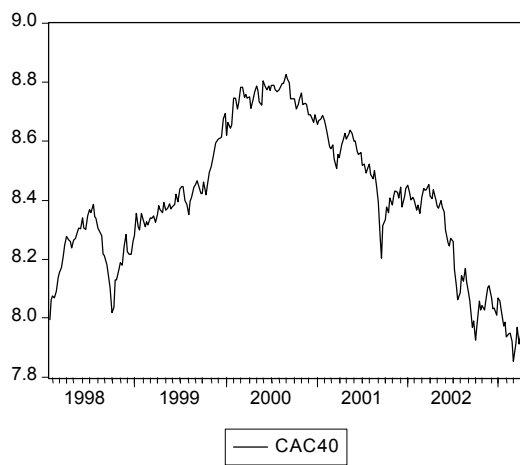
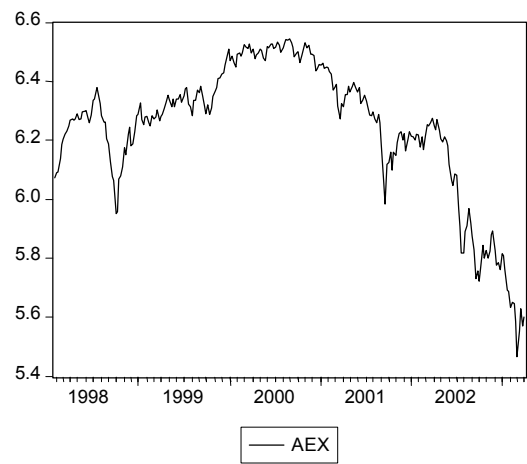
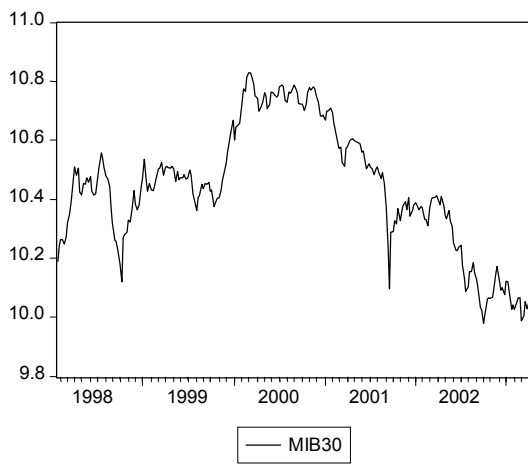
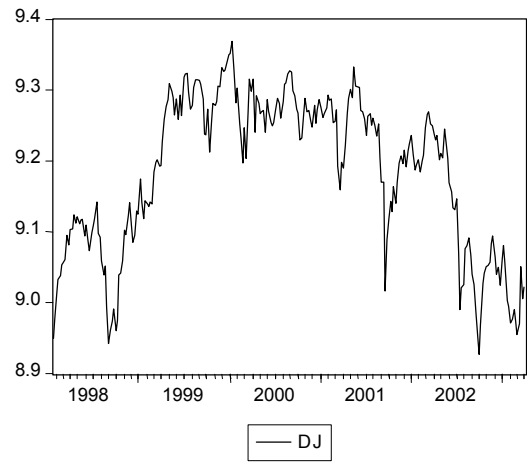
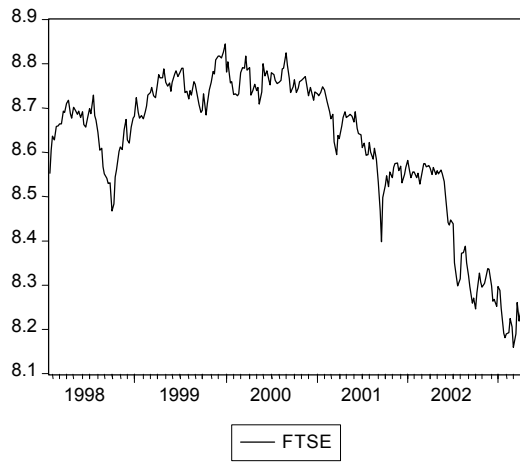
Estimate	BP	CH	ENI	EXX	ROY	TOT
$\hat{\lambda}_1$	-0.11 ^{**} (0.04)	-0.10 ^{**} (0.03)	-0.13 ^{**} (0.03)	-0.11 ^{**} (0.04)	-0.09 ^{**} (0.03)	-0.21 ^{**} (0.04)
$\hat{\lambda}_2$	-0.13 ^{**} (0.04)	0.11 ^{**} (0.04)	-0.02 (0.03)	0.18 ^{**} (0.05)	-0.09 ^{**} (0.03)	-0.08 (0.04)
$\hat{\lambda}_3$	-0.006 (0.02)	0.02 (0.03)	-0.12 ^{**} (0.03)	0.02 (0.03)	-0.06 ^{**} (0.02)	-0.10 ^{**} (0.03)
$\hat{\lambda}_4$	-0.004 (0.01)	-	0.005 (0.01)	-	-0.02 (0.01)	-0.01 (0.01)
Diagnostic	BP	CH	ENI	EXX	ROY	TOT
LM	10.76	5.56	20.28	7.24	12.16	19.48
R^2	0.04	0.05	0.12	0.09	0.04	0.09
$ \hat{\varepsilon}\hat{\varepsilon}' $	1.66e-13	1.32e-09	4.21e-13	1.14e-09	5.13e-13	4.81e-13
MAPE	3.18	0.54	1.25	1.18	0.81	0.40

Notes to Table 3. $\hat{\lambda}_1, \hat{\lambda}_2, \hat{\lambda}_3$ and $\hat{\lambda}_4$ are the estimates of the long-run adjustment coefficients (loadings) of *STOCK*, *SPREAD*, *MKT* and *ER*, respectively. LM refers to the calculated value of the multivariate Lagrange Multiplier test for serial autocorrelation of order 2 in the residuals: under the null of no serial cointegration, it is distributed as χ^2 with k^2 degrees of freedom (where k = number of endogenous variables); R^2 is the R-squared of the first regression in the VECM representations; $|\hat{\varepsilon}\hat{\varepsilon}'|$ is the determinant of the covariance matrix of the VECM estimated residuals; *MAPE* is the Mean Absolute Percentage Error computed on the last 8 weeks of the sample; standard errors are reported in parentheses; * (**) indicates significance at the 5% (1%) level.

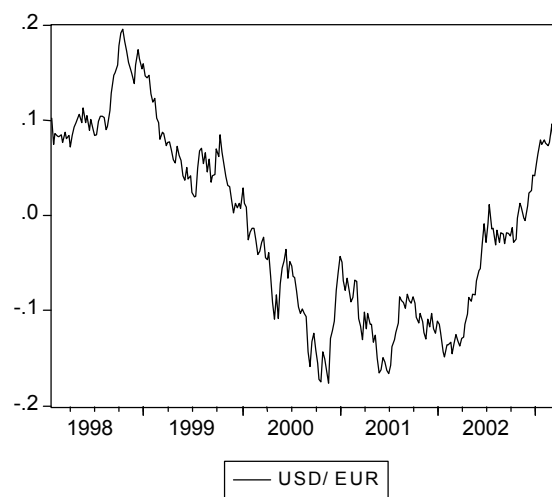
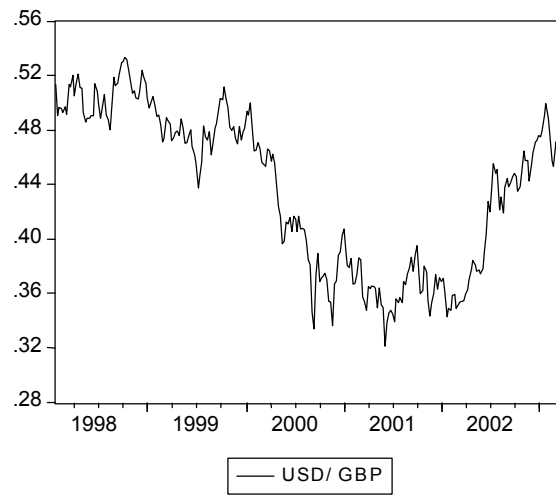
Graph 1. Oil company stock prices (actual values, logarithmic transformation)



Graph 2. Stock market indexes and spread (actual values, logarithmic transformation)



Graph 3. Exchange rates (actual values, logarithmic scale)



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