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Risk factors in oil and gas industry returns: International evidence

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ABSTRACT

The recent boom in oil prices has attracted many investors to oil companies in search of both returns and diversification benefits. This analysis of the risk factors of investing in the oil and gas industry in 34 countries finds evidence that oil price is a globally priced factor for the oil industry. The oil and gas sector in developed countries responds more strongly to oil price changes than in emerging markets. Oil and gas industry returns also respond asymmetrically to changes in oil prices; oil price rises have a greater impact than oil price drops. There is no parallel to the asymmetry of oil price changes in other industries related to commodities. If there is any asymmetry, it is in the opposite direction from oil. Negative commodity price changes have a greater impact than positive ones. The results seem to indicate that the oil and gas industry is distinguished by a pass-through effect.

1. Introduction

World dependence on energy has grown steadily in the last decades. Thriving economies such as China and India are quickly becoming large oil consumers. China actually doubled its consumption between 1996 and 2006. Major oil exporting countries have become developed countries, and countries that were once net exporters like Indonesia are now net importers.

Not surprisingly, oil gains have attracted the attention of investors and oil-related funds have gained importance in financial markets around the world. Fig. 1 shows the steady increase since the early 1980s in the number of mutual funds and exchange traded funds that invest in oil and in energy companies. According to LIPPER Hindsight, in 2008 there were 379 mutual funds and 26 exchange-traded funds benchmarked to the FTSE oil and gas industry index.

Investors in the oil and gas industry closely follow oil price fluctuations because “corporate managers and investors care about the exposure firms have to interest rates, exchange rates and commodity prices” (Tufano, 1998, p. 1015). Values change with oil prices because “oil price fluctuations directly affect revenues, profits, investments and cash flows” (Boyer and Filion, 2007, p. 433).

The difficulty is that the overall effect of oil price changes may not be easy to understand, as firm effects run in different directions. Look first at an increase in oil prices. If oil is a major input, operating costs increase. The overall effect on cash flows, however, will depend on the elasticity of demand, i.e., how much demand is depressed, and whether firms can pass oil price hikes on to customers. If firms can pass through prices to consumers, the increase in revenues can offset costs, increasing profits.

Another not insignificant effect is the impact of rising oil prices on inflation. Because oil is an input for almost all goods and services, rising oil prices create price pressure on the economy, setting the discount rate soaring and reducing the present value of cash flows.

A variety of empirical evidence indicates that oil price changes have a positive effect on oil and gas industry returns (see Boyer and Filion, 2007; Faff and Brailsford, 1999; Nandha and Faff, 2008; Oberndorfer, 2009; Sadorsky, 2001). This means that soaring oil prices increase the discounted value of cash flows of oil firms, assuming oil demand is not too depressed and firms can easily pass oil price increases on to customers.

Our work makes several contributions to the literature. First, we investigate whether the oil and gas industry has a factor exposure to

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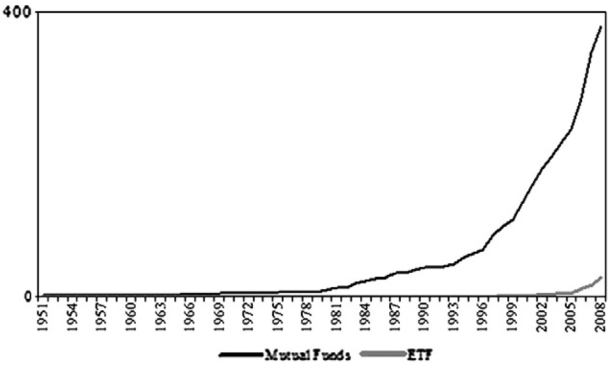

Fig. 1. Number of mutual funds and exchange traded funds (ETF) investing in oil and gas industry (FTSE classification).
Source: LIPPER.

oil price changes in a sample of 34 countries. We use a multifactor panel model that measures the impact of several risk factors and allows simultaneous exploration of the cross sectional and time series features of the data.

Second, the large sample of countries allows analysis of the impact of oil price changes in emerging markets. Evidence on the risk exposure of the oil and gas industry has come from only a few developed countries (with the exception of Nandha and Faff (2008)).[1] The size of the sample let us see the differences between industries in emerging countries and developed countries. As Basher and Sadorsky (2006, p. 226) note "emerging economies tend to be more energy intensive than more advanced economies and are therefore more exposed to higher oil prices".

Third, we expand the literature by examining the asymmetric effects of oil price changes in the oil and gas industry worldwide. Mork (1989) and Mork et al. (1994) find that oil price hikes have a negative impact on gross domestic product (GDP), but oil price drops do not necessarily lead to a positive impact on output and certainly not to an impact of the same degree. Several authors analyzing asymmetric effects on stock market indexes find mixed results (e.g., Basher and Sadorsky, 2006; Cong et al., 2008; Park and Ratti, 2008; Sadorsky, 2008), but the evidence is scarce for the oil and gas industry.

The fourth contribution relates to methodology. A major strength of our work is that we take advantage of more refined ways of measuring the nonlinear impact of oil price changes; most of the related studies use the traditional dummy variable approach; i.e., they differentiate positive from negative changes (e.g., Basher and Sadorsky, 2006; Nandha and Faff, 2008; Sadorsky, 2008). We follow closely Hamilton (1996), who proposes the net oil price increase (*NOPI*), a measure that compares the current price of oil with the previous reference value. *NOPI* better, although not perfectly, captures the exogenous component of price variation. Oil price changes are also measured taking into account oil price volatility. Lee et al. (1995) and Hamilton (1996) observe that turbulence in oil prices mitigates the marginal effect of any given oil price change. Therefore, oil price fluctuations are likely to have more of an impact in environments where oil prices have been stable.

[1] Nandha and Faff (2008) is the closest work to ours as they investigate whether oil price risk is global. There are, however, significant differences. First, we do not use global industry indices. Global indices require that country returns be market weighted. Thus results on risk factors might be determined by countries that have a large weight in the index, such as the U.S. and other developed countries. Our work instead, captures the cross-sectional variation of the 34 countries of our sample. Second, the analysis of oil price changes takes into account oil price volatility, because price changes are likely to have less of an impact when there is high turbulence of oil prices (see Lee et al., 1995).

Finally, we compare the asymmetric effects of oil price changes in oil and gas industry returns with effects in other commodities and industries. This question is important because many investors look for a commodity company to diversify portfolios. Are commodity investors exposed to the same kind of risks? or is the oil and gas industry a special case? Little is known about this issue, and we believe our study provides new insights.

Our evidence supports four major conclusions: oil and gas industry returns around the world follow oil price changes. Oil industry stock returns increase with oil price hikes and drop with price declines. The impact of oil price fluctuations is significant even in very volatile price periods. Oil price volatility is also positively associated with gas and oil industry returns. While the oil and gas industry shows exposure to the world market portfolio, local market indices have greater explanatory power, consistent with models of partial segmentation.

Oil industry returns respond asymmetrically to oil price fluctuations; that is, oil price hikes impact industry returns more than oil price reductions. This result is stronger statistically if the asymmetry measure takes into account exogenous variations in oil prices.

There are differences moreover between industries in developed and in emerging markets. Oil price risk in industries in developed countries is more strongly priced than in industries in emerging countries. The asymmetric effects of oil price changes are also stronger for industries in developed countries. The level of asymmetry is greater, if the asymmetric effects are measured using exogenous variations in oil prices. In this case, asymmetric effects are also found in industries in emerging markets.

Finally, it is notable that we cannot find that other commodity price changes have the same asymmetric effects on industry returns as oil price changes. In fact, if there is any asymmetry, it is different from the asymmetry of oil price changes for oil and gas industry returns. Price drops impact industry returns more than price increases. Results are robust to changes in the proxy for oil prices and commodities, to different asymmetry measures and to time dummies.

The conclusions of our analysis are therefore helpful in understanding the role of oil price changes in the oil and gas industry returns. They also have implications for investment and risk management decisions.

The paper is organized as follows: Section 2 reviews the literature. Section 3 describes the methodology and data. Section 4 presents the empirical results on oil risk factors. First, we report the results of the baseline regression; then, we disentangle differences in the sensitivity between industries in developed and in emerging markets. Section 5 and section 6 examine asymmetric effects on oil and gas industry returns and several other industries, using different measures of asymmetry. Section 7 shows the robustness analysis, and Section 8 concludes.

2. Literature review

The determinants of stock market returns are an important issue in financial economics. The literature has tried for long to find factors that explain the returns of securities. Given the weak empirical support for the market portfolio, studies have looked for additional economic or financial variables that could explain stock market returns (see Fama and French, 1992). The relation of oil with business cycles and industrial production (see Hamilton, 1983; Kim and Loungani, 1992) make it a natural candidate as highlighted in the growing number of studies that examine the relation between oil price changes and stock markets (see, e.g., Basher and Sadorsky, 2006; Chen et al., 1986; Cong et al., 2008; Driesprong et al., 2008; Ferson and Harvey, 1994a,b; Hammoudeh and Li, 2004; Huang et al., 1996; Jones and Kaul, 1996; Papapetrou, 2001; Park and Ratti, 2008; Sadorsky, 2008).

The first results were not supportive of oil as a significant factor in financial markets. Huang et al. (1996), Chen et al. (1986) and Ferson and Harvey (1994b) 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 oil price risk in stock markets. Jones and Kaul (1996), however, 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 their economies. More recently, Driesprong et al. (2008) find some predictive power in oil returns.

With the growing interest in oil stocks, a number of authors have investigated drivers of oil and gas industry returns, such as the market portfolio, interest and currency rates and naturally oil prices. Faff and Brailsford (1999) document a positive and significant impact of oil prices on Australian oil and gas industry equity returns. Sadorsky (2001) finds that the rises of the stock market index and oil prices have a positive effect on Canadian oil companies' returns, while increases in interest rates and exchange rates have a negative effect. El-Sharif et al. (2005) find a significantly positive impact of oil prices on oil and gas returns in the U.K. Boyer and Filion (2007) find a positive association between stock returns of 105 Canadian oil and gas companies and appreciation in oil and gas prices. They also document that Canadian energy stocks returns are positively correlated with the Canadian stock market return, crude oil and natural gas prices, growth in internal cash flows and proven reserves, and negatively correlated with interest rates. Park and Ratti (2008) also indicate that oil price rises have a positive impact on equity returns of oil and gas industries of 13 European countries. Finally, Oberndorfer (2009) finds that oil price hikes lead to an appreciation in gas stocks in European countries.

A common aspect of these studies is that they focus on oil and gas stocks in developed markets, but, as Basher and Sadorsky (2006, p. 226) argue, “emerging economies tend to be more energy intensive than more advanced economies and are therefore more exposed to higher oil prices. Consequently oil price changes are likely to have greater impact on profits and stock prices of emerging economies.”

Other researchers analyze the asymmetric effects of oil price changes. Mork (1989) and Mork et al. (1994) find that oil price hikes have a negative impact on GDP, but that falls in oil prices do not necessarily have a positive impact on output or an impact of the same degree. More recent work examines whether these asymmetric effects pertain to stock market returns (e.g., Basher and Sadorsky, 2006; Cong et al., 2008; Park and Ratti, 2008; Sadorsky, 2008). The evidence is conflicting. Basher and Sadorsky (2006) find asymmetric effects, while Park and Ratti (2008), Nandha and Faff (2008) and Cong et al. (2008) do not. The evidence for the oil and gas industry is scarce. Cong et al. (2008) use Chinese stock data, and Nandha and Faff (2008) use global industry indices. The analysis has been undertaken using both multifactor models (Basher and Sadorsky, 2006; Nandha and Faff, 2008; Sadorsky, 2008), and vector autoregressive models (Cong et al., 2008; Park and Ratti, 2008; Sadorsky, 1999).

3. Data and methodology

This section describes the methodology and data used to make inferences about the importance of oil prices as a global factor.

We collect monthly returns for oil industry indices based on Datastream industry classification. Datastream has recently adopted the Industry Classification Benchmark (ICB) for a range of its global data products and services. The first level corresponds to the market index, which is then decomposed into four levels: industries, super-sectors, sectors and subsectors.

We use oil and gas industry indices, one of 19 supersector indices. Datastream indices are weighted by market capitalization, and provide extensive coverage of each country's total market capitalization.

For data availability reasons, our final sample covers oil and gas indices from 34 countries from May 1998 through December 2009, for a total of 140 monthly observations. These 34 countries have complete data for the time period. As is customary in the financial literature, returns are computed as $r_{i,t} = 100 \times [\ln(I_{i,t}) - \ln(I_{i,t-1})]$, where $I_{i,t}$ is the price index of industry i at time t. Returns are expressed in U.S. dollars and excess returns are computed using the one-month Eurodollar interest rate. The choice of the U.S. dollar as the reference currency is justified by the fact that oil price is determined in U.S. dollars in international markets.

We follow the literature that uses international factor models to examine the impact of systematic factors on stock returns (see Ferson and Harvey, 1994b; Jin and Jorion, 2006; Karolyi and Stulz, 2003; Tufano, 1998). The model is as follows

$$r_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_k F_{k,t} + u_{i,t} \tag{1}$$

where $r_{i,t}$ is the excess return of the oil and gas industry of country i at time t. β_k are the coefficients of $r_{i,t}$ on K risk factors, $F_{k,t}$ with $k = 1,...,K$. The α_i is the intercept. 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. α_i thus captures the effects of those variables that are peculiar to the ith country and that are constant over time. $u_{i,t}$, the error term, represents the nonsystematic excess return relative to the factors. According to Ferson and Harvey (1994b), factor regressions provide information about the usefulness of global factors in controlling for the risks of international investments.

Table 1 reports summary statistics for industry indices by country. Most industries have positive excess returns during the period. Only 7 out of 34 have negative excess returns. Volatility is lower in the U.S.

Table 1
Oil and gas industry returns—summary statistics. This table reports summary statistics of the oil and gas industry (Level 2 of ICB Classification) monthly returns by country. The sample period runs from 1998:05 through 2009:12. By column, we report the mean, the standard deviation (SD), the kurtosis, the skewness, the Jarque–Bera statistics and their p-values. The returns are the first differences of the logarithm of prices in percentage.

Dependent variable						
Country	Mean	SD	Kurtosis	Skewness	Jarque–Bera	p-value
Argentina	−0.66	12.10	7.20	0.07	97.93	0.000
Australia	0.92	9.02	5.83	−0.98	66.19	0.000
Austria	0.49	10.19	5.16	−0.84	41.42	0.000
Belgium	0.98	8.13	5.50	−0.28	36.13	0.000
Brazil	1.68	13.34	4.91	−0.65	29.26	0.000
Canada	0.73	8.37	4.88	−0.60	27.29	0.000
Chile	0.62	7.20	5.54	−0.51	41.29	0.000
China	0.61	13.31	6.17	0.55	62.08	0.000
Czech Rep.	0.84	10.24	5.20	−0.64	35.85	0.000
Denmark	1.68	16.62	6.07	−1.16	82.83	0.000
France	0.29	6.73	4.72	−0.21	17.02	0.000
Greece	−0.01	10.62	5.43	0.36	35.21	0.000
Hong Kong	0.57	12.03	3.89	−0.18	4.77	0.092
Hungary	0.49	12.04	5.66	−1.00	61.42	0.000
India	0.45	11.70	5.05	−0.26	24.39	0.000
Ireland	−0.02	13.77	4.80	−0.57	24.83	0.000
Israel	0.81	10.08	3.71	−0.03	2.58	0.275
Italy	0.20	6.49	4.22	−0.70	18.89	0.000
Japan	0.01	8.44	3.48	−0.35	3.86	0.145
Malaysia	0.24	9.17	11.34	−1.05	414.89	0.000
Netherlands	0.14	8.34	6.59	−1.07	97.56	0.000
New Zealand	1.14	9.50	3.79	−0.39	6.66	0.036
Norway	0.37	9.01	5.23	−0.87	44.28	0.000
Philippines	−0.70	14.12	4.71	0.46	20.54	0.000
Poland	0.73	10.41	3.36	−0.15	1.11	0.574
Romania	−1.24	14.05	7.46	−1.13	139.53	0.000
Singapore	0.85	14.71	11.87	−0.65	451.21	0.000
South Africa	0.78	10.31	4.24	−0.71	19.71	0.000
Spain	−0.01	7.30	8.70	−1.69	246.61	0.000
Sri Lanka	0.52	9.37	4.66	0.47	19.94	0.000
Thailand	0.71	11.93	5.19	0.08	26.18	0.000
Turkey	−0.50	16.31	4.13	−0.47	11.61	0.003
U.K.	0.11	6.52	3.43	−0.03	0.87	0.649
U.S.	0.26	6.08	3.70	−0.26	3.98	0.137

Table 2
Independent variables—summary statistics. This table reports the summary statistics of the independent variables. Explanatory variables are the world market return (*WORLD*), the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), the difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*), the oil price return (*OIL*) and the volatility of oil price (*VOL_OIL*). The sample period ranges from 1998:05 through 2009:12. By column, we report the mean, the standard deviation (SD), the kurtosis, the skewness, the Jarque–Bera statistics and their *p*-values.

Country	Mean	SD	Kurtosis	Skewness	Jarque–Bera	*p*-value
Independent variable						
WORLD	−0.08	5.20	5.70	−1.14	69.68	0.000
LOCAL						
Argentina	−0.64	9.85	4.64	−0.70	25.54	0.000
Australia	0.39	6.57	6.72	−1.15	106.88	0.000
Austria	0.15	7.24	12.94	−2.06	652.29	0.000
Belgium	−0.15	6.70	11.57	−1.93	497.57	0.000
Brazil	0.68	12.10	4.78	−0.86	34.12	0.000
Canada	0.34	6.65	7.07	−1.25	5.85	0.054
Chile	0.40	6.53	7.06	−1.15	121.79	0.000
China	1.02	10.84	4.41	0.02	10.61	0.005
Czech Rep.	0.99	8.64	5.09	−0.88	160.20	0.000
Denmark	0.21	6.35	7.66	−1.31	157.21	0.000
France	0.02	6.20	4.64	−0.88	32.17	0.000
Greece	−0.26	8.89	5.63	−0.98	59.87	0.000
Hong Kong	0.24	7.36	3.90	−0.10	4.38	0.112
Hungary	0.10	10.28	8.84	−1.62	250.14	0.000
India	0.82	10.12	4.51	−0.57	19.66	0.000
Ireland	−0.53	7.04	5.43	−1.08	58.99	0.000
Israel	0.41	7.13	3.64	−0.62	10.76	0.005
Italy	−0.27	6.50	4.93	−0.68	30.61	0.000
Japan	−0.22	5.66	2.92	−0.01	0.09	0.958
Malaysia	0.26	8.47	6.55	−0.28	71.41	0.000
Netherlands	−0.30	6.93	9.83	−1.84	337.76	0.000
New Zealand	0.00	6.55	3.84	−0.75	16.35	0.000
Norway	0.24	8.48	8.02	−1.62	200.75	0.000
Philippines	−0.13	8.61	6.98	−0.06	87.97	0.000
Poland	0.14	10.53	5.12	−0.96	45.43	0.000
Romania	−0.34	14.47	5.25	−0.77	40.95	0.000
Singapore	0.32	7.73	5.57	−0.62	44.92	0.000
South Africa	0.27	9.45	6.96	−1.39	130.88	0.000
Spain	0.03	6.25	5.17	−0.94	45.86	0.000
Sri Lanka	0.10	8.38	3.98	0.20	41.44	0.000
Thailand	0.21	11.32	4.63	−0.29	16.29	0.000
Turkey	0.17	16.44	4.44	−0.46	15.80	0.000
U.K.	−0.31	5.02	6.08	−0.86	69.00	0.000
U.S.	−0.24	5.00	4.26	−0.86	25.33	0.000
CURRENCY						
Argentina	−0.95	6.38	60.56	−6.98	19865.00	0.000
Australia	0.23	3.79	5.88	−0.87	62.97	0.000
Austria	0.20	2.97	4.31	−0.10	9.33	0.009
Belgium	0.20	2.95	4.35	−0.12	9.94	0.007
Brazil	−0.30	7.00	28.35	−3.60	3928.40	0.000
Canada	0.22	2.68	7.08	−0.58	100.06	0.000
Chile	−0.08	3.34	9.66	−1.37	121.79	0.000
China	0.14	0.35	12.91	2.84	739.49	0.000
Czech Rep.	0.42	3.73	3.39	−0.39	4.14	0.127
Denmark	0.20	2.95	4.32	−0.11	9.45	0.009
France	0.19	2.96	4.32	−0.12	9.49	0.009
Greece	0.21	2.98	4.23	−0.12	8.31	0.016
Hong Kong	0.00	0.15	14.05	1.59	736.98	0.000
Hungary	0.08	3.87	8.82	−1.43	235.14	0.000
India	−0.11	1.62	6.77	−0.45	83.57	0.000
Ireland	0.18	2.96	4.31	−0.12	9.38	0.009
Israel	−0.02	2.52	5.30	−0.64	38.20	0.000
Italy	0.19	2.97	4.31	−0.11	9.33	0.009
Japan	0.26	3.27	6.37	0.68	73.33	0.000
Malaysia	0.06	1.49	19.96	1.10	1650.30	0.000
Netherlands	0.19	2.97	4.31	−0.11	9.28	0.010
New Zealand	0.19	3.87	5.10	−0.41	27.91	0.000
Norway	0.18	3.10	5.25	−0.56	34.73	0.000
Philippines	−0.10	2.21	6.97	−0.59	95.35	0.000
Poland	0.12	3.86	5.25	−0.92	47.01	0.000
Romania	−0.91	3.51	6.72	−0.80	91.39	0.000
Singapore	0.09	1.67	4.64	−0.18	15.12	0.001
South Africa	−0.27	5.08	3.40	−0.47	5.76	0.056
Spain	0.19	2.96	4.31	−0.11	9.34	0.009
Sri Lanka	−0.42	1.46	10.53	−0.78	331.49	0.000
Thailand	0.10	2.40	4.56	−0.11	13.34	0.001

Table 2 (*continued*)

Country	Mean	SD	Kurtosis	Skewness	Jarque–Bera	*p*-value
Independent variable						
CURRENCY						
Turkey	−1.28	5.48	13.86	−2.09	763.08	0.000
U.K.	−0.02	2.50	5.77	−0.37	45.24	0.000
U.S.	1.00	0.00	–	–	–	–
INT_RATE_DIFF						
Argentina	1.06	1.81	17.32	3.65	1459.30	0.000
Australia	0.16	0.14	1.78	0.00	9.01	0.011
Austria	−0.03	0.13	1.48	−0.02	13.89	0.001
Belgium	−0.03	0.13	1.48	−0.02	13.85	0.001
Brazil	1.15	0.47	5.75	1.39	81.24	0.000
Canada	0.00	0.07	2.29	0.49	8.57	0.014
Chile	−0.25	0.15	1.59	0.03	11.87	0.003
China	0.01	0.14	2.45	−0.33	3.44	0.179
Czech Rep.	0.04	0.21	6.12	1.29	92.70	0.000
Denmark	−0.01	0.13	1.86	0.14	8.52	0.014
France	−0.03	0.13	1.48	−0.02	13.85	0.001
Greece	0.09	0.20	3.83	1.00	26.94	0.000
Hong Kong	−0.01	0.11	41.79	5.08	8874.30	0.000
Hungary	0.56	0.27	2.06	0.02	5.42	0.067
India	0.32	0.12	3.30	0.39	3.44	0.179
Ireland	−0.02	0.13	1.55	−0.16	13.33	0.001
Israel	0.24	0.21	2.27	0.56	10.58	0.005
Italy	−0.03	0.12	1.58	−0.09	12.39	0.002
Japan	−0.27	0.16	1.67	0.07	10.75	0.005
Malaysia	−0.01	0.16	2.69	−0.02	0.87	0.648
Netherlands	−0.03	0.13	1.47	−0.02	14.08	0.001
New Zealand	0.23	0.16	2.40	−0.49	7.73	0.021
Norway	0.12	0.19	1.97	0.14	6.85	0.033
Philippines	–	–	–	–	–	–
Poland	0.46	0.40	2.06	0.35	8.32	0.016
Romania	–	–	–	–	–	–
Singapore	−0.15	0.11	2.23	−0.48	8.84	0.012
South Africa	0.53	0.23	2.06	0.33	7.44	0.024
Spain	−0.03	0.13	1.54	−0.04	12.87	0.002
Sri Lanka	–	–	–	–	–	–
Thailand	0.01	0.23	23.09	3.85	2634.80	0.000
Turkey	1.59	0.95	3.93	1.44	32.56	0.000
U.K.	0.10	0.10	1.64	0.04	11.26	0.004
U.S.	–	–	–	–	–	–
OIL	1.20	10.68	4.77	−0.74	29.59	0.000
VOL_OIL	9.87	3.96	5.22	1.22	60.61	0.000

and U.K. oil industries, 6.08% and 6.52%, respectively, and higher in countries like Denmark and Turkey, over 16%. All industries have kurtosis values higher than three. Note also that the distribution of excess returns of oil and gas industries is negatively skewed for the great majority of countries. Consequently, the Jarque–Bera test rejects the assumption of Gaussian returns for almost all countries, except for Hong Kong, Israel, Japan, Poland, the U.K. and the U.S.

Our choice of global risk factors is based on theoretical and empirical work in the field. We include the market portfolio, currency and interest rates and oil prices.

3.1. Market portfolio

Use of the market portfolio in factor models is supported by the theoretical work of Sharpe (1964) and Merton (1973). Extension to an international setting warrants use of a world market portfolio (see Adler and Dumas, 1983; Stulz, 1981).

Datastream provides a world market index computed by weighting all country index returns. The variable *WORLD* is the logarithmic changes in the world market portfolio index in excess of a short-term interest rate, the one-month Eurodollar interest rate as in Ferson and Harvey (1994a). This proxy of the market portfolio has been tested empirically by authors such as Ferson and Harvey (1994b), Basher and Sadorsky (2006) and Nandha and Faff (2008). Ferson and Harvey (1994b) note that while it is by far the most important factor, it does not provide a good explanation of cross-sectional differences in average returns.

Partial-segmentation models suggest, alternatively, that partial segmentation may be more appropriate for less developed countries (see Errunza and Losq, 1985). These models suggest that both local and world factors should influence equilibrium asset returns. Therefore, given that our sample includes a broad range of countries, we test the local market portfolio as a factor too (see Boyer and Filion, 2007; El-Sharif et al., 2005; Faff and Brailsford, 1999; Sadorsky, 2001).

LOCAL is the local market portfolio return, computed as the logarithmic changes in the local market portfolio excess returns. Returns are in excess of the same short-term interest rate, the one-month Eurodollar interest rate.

Table 2 presents descriptive statistics for the independent variables. They are worth a brief comment. First, *WORLD* excess returns are negative for the period. Standard deviations for *LOCAL* range from 5.00% for the U.S. to 16.44% for Turkey. The kurtosis is higher than three in all countries, except Japan, and distributions of local market returns are negatively skewed.

3.2. Currency rates

Currency rate changes, a primary risk in foreign international investment, are a relevant factor for the oil industry because oil is priced in U.S. dollars in international markets.[2] Thus, we test whether oil industry returns show some sensitivity to changes in currency rates against the U.S. dollar.

The empirical evidence on the impact of currency fluctuations on gas and oil industries is mixed. Both Sadorsky (2001) and Boyer and Filion (2007) find that currency rates have a significant impact on stock price returns in the Canadian oil and gas industry, mainly because currency appreciation leads to industry return increases. El-Sharif et al. (2005), however, do not find this effect is statistically significant for U.K. oil companies.

The variable *CURRENCY* is defined as the logarithmic changes in currency rates against the U.S. dollar. A positive change in the rate means an appreciation of the foreign currency with respect to the U.S. dollar.

The currency panel of Table 2 presents descriptive statistics on currency rates. Most currencies have appreciated against the U.S. dollar. Volatility is highest for Brazil and Argentina, with values of over 6%. Exchange rate variability is lower on average than the volatility of oil industry and local stock market returns. Since kurtosis is higher than three and there is negative skewness, the Jarque–Bera test leads us to reject the null of Gaussian returns for almost all currency returns.

3.3. Interest rates

Interest rates are a typical factor given their relation to macroeconomic conditions. Evidence on the importance of interest rate changes for the oil and gas industry returns is mixed. Sadorsky (2001) and Boyer and Filion (2007) show that interest rates have a significant impact on stock returns in the Canadian oil and gas industry. The term premium, the difference between the three-month and one-month interest rate positively impacts industry returns. El-Sharif et al. (2005) and Oberndorfer (2009), however, do not find statistical significance.

In our international setting we cannot use interest rates directly because they are expressed in local currencies. Instead we use a factor that represents the interest rate differential in relation to the common currency, the U.S. dollar.[3] The factor $INT\_RATE\_DIFF_i$ is defined as the difference between the interest rate of country i and the U.S. interest rate, $r_i - r_{US}$, where r_i is the three-month interest rate of the particular country and r_{US} is the U.S. three-month interest rate.

The last panel of Table 2 presents statistics on the interest rate differentials. We have data for only 31 countries; 13 countries, most of them in the euro area, have lower interest rates than the U.S. The standard deviation of this variable is lower than for previous variables.

3.4. Oil prices

Oil is the major input for oil and gas companies as we observe in the introduction. Firm value should reflect its price changes. The oil factor (*OIL*) in the model specification is proxied by the logarithmic change in oil prices from the price index of London Brent Crude Oil priced in U.S. dollars per barrel (U$/BBL).[4] Brent crude 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.

We also analyze the exposure to oil volatility. Oil volatility creates an environment of uncertainty that is likely to affect firm value.[5] Lee et al. (1995) note that price fluctuations are likely to have greater impact on environments where oil prices have been stable, as so they recommend taking into account oil price variability when studying oil price fluctuations.

VOL_OIL is the oil volatility obtained directly from the data by applying a moving average to the squared residuals

$$VOL\_OIL_t = \left[(m+1)^{-1} \sum_{j=0}^{m} \hat{\epsilon}_{t-j}^2\right]^{0.5}, \tag{2}$$

with $t = 0,\ldots, n-m-1$ and $m = 4$, obtaining by fitting an AR(1) model to oil returns, $OIL_t = c + \phi_1 OIL_{t-1} + \varepsilon_t$ (see Gallant and Tauchen, 1998). The volatility is computed from the innovations that are not explained by past oil changes. This method of estimation is typically used when the first two conditional moments are evaluated (see Bansal and Zhou, 2002; Doran and Ronn, 2008; Durham, 2003).

The next-to-last line in Table 2 (continued) presents summary statistics for oil crude prices. The monthly mean is 1.20% and volatility 10.68%. This volatility figure is higher than that in many equity stock markets and currencies.

Fig. 2 depicts the oil prices since 1950. Prices were quite stable for some 20 years, and did not represent a risk for oil companies. The first jump in oil prices occurred in 1973, when prices reached $3/BBL. In 1980–1981, the political revolution in Iran and then the war with Iraq made oil prices jump to almost $40/BBL. Prices peaked again in 1990 with the invasion of Kuwait by Iraq, and then dropped. After that, price of oil did not fluctuate very much until around 2002. The $40/BBL was reached again only in October 2004. Then started a dramatic price escalation. Oil prices passed $50/BBL in 2005 and $100/BBL in

[2] The Solnik (1974) model advocates that exchange rate risks should be priced in the absence of purchasing power parity. Adler and Dumas (1983) also present theoretical support for pricing exchange rate risks in a global setting. Dumas and Solnik (1995) and De Santis and Gerard (1998) find that currency risk is priced in a conditional setting for aggregate market returns.

[3] We follow the approach used in macroeconomics to test the uncovered interest rate parity (UIP), a well-known relation on the market efficiency of the foreign exchange market. Briefly, the UIP states that the foreign exchange gains from borrowing in one currency, exchanging that currency for another currency and investing in funds in the second currency, while simultaneously purchasing futures contracts to reconvert the currency at the end of the holding period, must be offset by the opportunity costs of holding funds in the first currency (the interest rate differential). Empirical tests for the UIP are based on logarithm returns using the equality $s_{t+k} - s_t = r_{LOCAL,t} - r_{FX,t}$, where s_t is the exchange rate of a country in the sample expressed in the foreign currency at time t, and $r_{LOCAL,t}$ and $r_{FX,t}$ are the nominal interest rates for domestic and foreign exchange rates, respectively.

[4] As tests of several sources of oil prices reveal high correlation (around 0.95), we use the price index of London Brent Crude Oil in the primary analysis.

[5] We thank a referee who commented that oil volatility creates a market environment prone to speculative trading. Cong et al. (2008) and Sadorsky (2008) make a similar point on the rise in oil price volatility and increasing speculative activity.

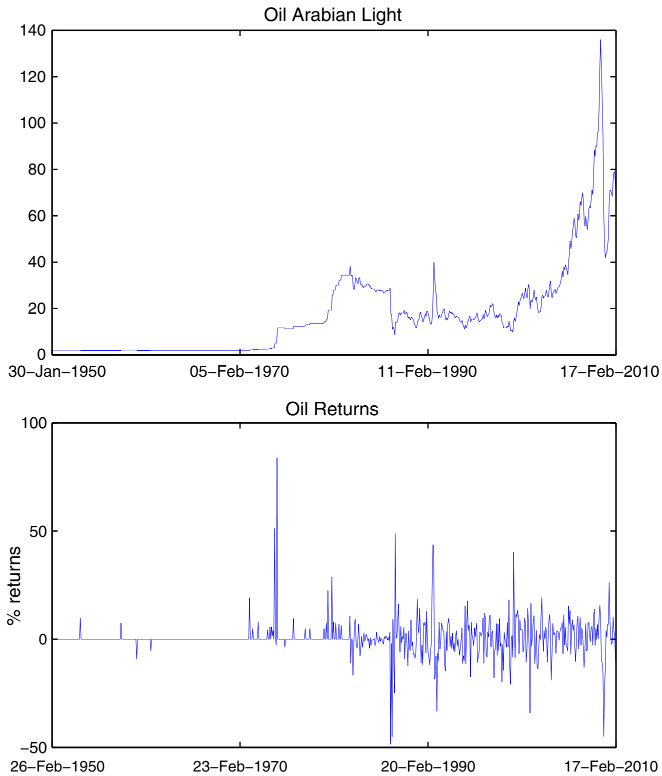

Fig. 2. Oil prices in U.S. dollars (first panel) and oil returns in percentage (second panel). Source: Bloomberg.

2007 to reach almost $150/BBL in July 2008. As many countries entered economic recession, prices continued to slide until the end of 2008, to increase again during 2009. The value in December 2009 was again close to $80/BBL.

The second graph in Fig. 2 depicts the variations in oil prices. It confirms the analysis of the first graph. Oil prices were stable until 1973. Then we see the first oil price jumps. After the 1980s, oil prices begin to fluctuate, registering booms and peaks.

Table 3 presents correlations among independent variables. There are large correlations between *WORLD* and *LOCAL*, around 0.72, and between *LOCAL* and *CURRENCY*, around 0.55. We pay special attention to these correlations. The others are not high and are not likely to cause multicollinearity.

4. Oil and gas industry risk factors

First we describe results regarding risk factors in the oil and gas industry around the world. Then we analyze whether there are differences in risk factors between industries in developed and emerging markets.

Table 3
Correlations-independent variables. This table reports the correlation among independent variables. Explanatory variables are the world market return (*WORLD*), the country market return (*LOCAL*), log price returns (*OIL*), currency variations against the U.S. dollar (*CURRENCY*), volatility of oil price (*VOL_OIL*) and the difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). The sample period runs from 1998:05 through 2009:12.

	WORLD	*LOCAL*	*OIL*	*CURRENCY*	*VOL_OIL*	*INT_RATE_DIFF*
WORLD	1.00					
LOCAL	0.72	1.00				
OIL	0.22	0.21	1.00			
CURRENCY	0.35	0.55	0.12	1.00		
VOL_OIL	0.13	−0.10	−0.16	0.11	1.00	
INT_RATE_DIFF	0.02	−0.01	−0.02	0.08	0.04	1.00

4.1. Oil price risk

Here we analyze whether oil price fluctuations affect oil and gas industry returns in a sample of 34 countries. Industry returns $r_{i,t}$ are regressed on the set of factors shown in Eq. (3).

$$r_{i,t} = \alpha_i + \beta_{MP} \cdot MP_t + \beta_{CURR} \cdot CURRENCY_{i,t} + \beta_{OIL} \cdot OIL_t + \beta_{VOL\_OIL} \cdot VOL\_OIL_t + \beta_{INT\_RATE} \cdot INT\_RATE\_DIFF_{i,t} + u_{i,t}, \tag{3}$$

where *MP* denotes the market portfolio, proxied either by the world market portfolio (*WORLD*) or by the country market portfolio (*LOCAL*). α_i accounts for possible heterogeneity among gas and oil industries, and $u_{i,t}$ is the error term at time t. Because of the structure of the data, we estimate Eq. (3) as a panel. One advantage of this approach is that it enhances the quality and quantity of data and allows us to study the dynamics of the variable of interest with a relatively short time series. Moreover, the intercepts can differ according to the country for capturing cross-sectional heterogeneity.

We estimate fixed effects (using ordinary least squares estimation method) and random effects panels (using generalized least squares estimation method). The advantage of the former is that it can account for the fact that the country effects may be correlated with the explanatory variables. To choose between the two specifications we run a Hausman test for all specifications (the null hypothesis is the nonexistence of correlation). According to the test results we cannot reject the hypothesis of no correlation at any significance level in all cases. This evidence suggests that the random effects specifications are more appropriate than the fixed effects models, so we present those results in the text.

Table 4 presents the estimation results of Eq. (3). Column (1) shows that the variables *WORLD*, *CURRENCY* and *OIL* are statistically significant at standard levels of significance. The market portfolio is statistically significant and explains part of the variability. The sign of the coefficient of the variable *CURRENCY* indicates positive industry returns due to appreciation of the local currency against the U.S. dollar in line with the results of Sadorsky (2001) and Boyer and Filion (2007). The coefficient of *OIL* is positive. This means that oil and gas sector returns respond positively to oil price hikes and negatively to oil price drops.

Oil is always statistically significant in the various specifications whether we add *VOL_OIL*, column (2) or *INT_RATE_DIFF*, column (3). The positive coefficient of *VOL_OIL* indicates that industry returns increase with growing uncertainty on oil prices. The variable *INT_RATE_DIFF* is statistically significant. The last estimation (4) represents a horse race including all variables. The results show that all variables are still statistically significant. The R^2 of the estimations ranges between 0.33 and 0.37.

Columns (5)–(8) use *LOCAL* as the market portfolio. *LOCAL* is statistically significant at standard levels of confidence, and the value of its coefficient is slightly higher than the coefficient of the variable *WORLD*. Both *OIL* and *VOL_OIL* remain statistically significant. An important difference is that *CURRENCY* and *INT_RATE_DIFF* are statistically significant only at weak levels of confidence.

The results in Table 4 let us conclude which market portfolio seems more relevant. The R^2 increases substantially in columns (5)–(8) to around 0.56. This seems to suggest that although the world market portfolio has some explanatory power, the importance of the local market portfolio is stronger, consistent with the argument of partial-segmentation models and the findings of Ferson and Harvey (1994b).[6]

[6] Ferson and Harvey (1994b) find that world market betas provide a poor explanation of average returns across countries, and Stulz (1981) and Adler and Dumas (1983) prove the validity of the model only in a setting with no exchange rate risk and a constant opportunity set.

Table 4
Risk factors in oil and gas industry. This table reports random effects panel regression estimations (Eq. (3)) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the world market return (*WORLD*), the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), log price returns (*OIL*), volatility of oil price (*VOL_OIL*) and difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). *t*-statistics robust to heteroscedasticity are in parentheses, and errors are clustered by country.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WORLD	0.780	0.787	0.788	0.796				
	(23.837)	(15.507)	(15.307)	(15.284)				
LOCAL					0.870	0.870	0.875	0.876
					(25.226)	(25.384)	(22.702)	(22.710)
CURRENCY	0.873	0.885	0.813	0.822	0.114	0.123	0.089	0.097
	(18.416)	(12.360)	(11.148)	(11.226)	(1.762)	(1.910)	(1.233)	(1.342)
OIL	0.156	0.162	0.168	0.175	0.124	0.128	0.139	0.144
	(10.886)	(7.998)	(9.203)	(9.312)	(6.838)	(7.032)	(8.328)	(8.499)
VOL_OIL		0.138		0.126		0.083		0.086
		(4.943)		(4.817)		(4.520)		(4.081)
INT_RATE_DIFF			0.473	0.447			0.130	0.112
			(2.081)	(1.994)			(0.691)	(0.603)
Constant	0.275	−1.091	0.272	−0.975	0.158	−0.669	0.209	−0.642
	(2.113)	(4.258)	(2.588)	(3.976)	(2.069)	(3.499)	(2.658)	(3.113)
Observations	4760	4760	4221	4221	4760	4760	4221	4221
Countries	34	34	31	31	34	34	31	31
R^2	0.335	0.338	0.367	0.369	0.563	0.564	0.551	0.552

The increase in R^2 when *LOCAL* is taken as a proxy for the market portfolio improves the model's goodness of fit, suggesting that *LOCAL* is a factor that captures most of the cross-sectional variation.

4.2. Developed countries vs. emerging markets

So far the evidence on the importance of oil price changes for the oil and gas industry has come from industries in developed markets (e.g., Boyer and Filion, 2007; El-Sharif et al., 2005; Faff and Brailsford, 1999; Sadorsky, 2001). Our large sample of countries allows us to analyze developed and emerging markets separately to see whether there are differences between the two groups.

We would expect some differences as it is conventional wisdom that emerging markets may not be fully integrated into the global economy. For instance, Carrieri and Majerbi (2006) argue that the empirical evidence suggests that expected returns of emerging markets are likely to be affected more by local than by global risk factors. Second, according to Basher and Sadorsky (2006, p. 226) “emerging economies tend to be more energy intensive than more advanced economies and are therefore more exposed to higher oil prices. Consequently oil price changes are likely to have greater impact on profits and stock prices of emerging economies.”

To discern whether there is a difference in oil price risk exposure of industries in developed and emerging markets, we divide our sample into two groups following the MSCI classification of developed and emerging markets and rerun Eq. (3). The analysis is conducted in a similar way, first using *WORLD* as a proxy for the market portfolio, and then using *LOCAL*.

Table 5 presents the results, distinguishing developed countries (Panel A) from emerging markets (Panel B).

The estimation results of regression (3) in columns (1)–(3) show that both subsamples have exposure to the world market portfolio but the coefficient is higher for industries in developed markets, which is quite consistent with the fact that these countries are more integrated with the world market. The opposite happens with *CURRENCY*, whose coefficient is higher for emerging markets than for developed markets.

Our particular interest is in *OIL* with a statistically significant and positive coefficient, that is higher in developed markets. The coefficient of *VOL _OIL* however, although positive for both samples, is higher in emerging markets. *INT _RATE _DIFF* is not statistically significant at standard levels of significance. The R^2 of developed and emerging markets is quite similar, ranging between 0.3 and 0.4.

Columns (4)–(6) use *LOCAL* as a proxy for the market portfolio. First, we observe that both subsamples are exposed to changes in the local market portfolio. Second, currency fluctuations and interest rate differentials are not statistically significant at standard levels of significance as in Table 4. Second, the variable *OIL* is a priced factor,

Table 5
Risk factors in oil and gas industry: developed vs. emerging markets. This table reports random effects panel regression estimations (Eq. (3)) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the world market return (*WORLD*), the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), oil price returns (*OIL*), volatility of oil price (*VOL_OIL*) and difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). *t*-statistics robust to heteroscedasticity are in parentheses, and errors are clustered by country.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Developed countries						
WORLD	0.810	0.817	0.817			
	(10.675)	(10.664)	(10.959)			
LOCAL				0.888	0.891	0.892
				(12.410)	(12.448)	(12.594)
CURRENCY	0.586	0.594	0.594	0.062	0.069	0.067
	(7.138)	(7.366)	(7.572)	(0.691)	(0.786)	(0.779)
OIL	0.193	0.198	0.198	0.172	0.177	0.177
	(10.422)	(10.217)	(10.283)	(11.554)	(11.500)	(11.540)
VOL_OIL		0.110	0.110		0.097	0.097
		(3.280)	(3.181)		(3.688)	(3.506)
INT_RATE_DIFF			0.080			0.300
			(0.063)			(0.251)
Constant	0.185	−0.911	−0.910	0.280	−0.689	−0.685
	(1.484)	(2.847)	(2.793)	(2.687)	(2.786)	(2.687)
Observations	2520	2520	2520	2520	2520	2520
Countries	18	18	18	18	18	18
R^2	0.346	0.348	0.348	0.462	0.463	0.463
Panel B: Emerging markets						
WORLD	0.766	0.775	0.784			
	(11.238)	(11.372)	(12.198)			
LOCAL				0.866	0.865	0.869
				(21.980)	(22.150)	(20.873)
CURRENCY	1.042	1.059	0.988	0.132	0.141	0.114
	(10.114)	(10.004)	(9.726)	(1.463)	(1.561)	(1.045)
OIL	0.118	0.126	0.142	0.069	0.072	0.093
	(3.370)	(3.562)	(3.989)	(2.385)	(2.531)	(3.101)
VOL_OIL		0.172	0.151		0.068	0.068
		(3.876)	(3.665)		(2.527)	(1.969)
INT_RATE_DIFF			0.462			0.209
			(1.773)			(1.097)
Constant	0.480	−1.226	−0.996	0.040	−0.638	−0.577
	(3.996)	(2.964)	(2.576)	(0.347)	(2.104)	(1.530)
Observations	2240	2240	1701	2240	2240	1701
Countries	16	16	13	16	16	13
R^2	0.337	0.340	0.404	0.650	0.651	0.666

but the coefficient of *OIL* is two times higher in the developed countries sample (Panel A) than in the emerging markets sample (Panel B). Third, oil volatility is priced and has a positive coefficient.

Comparing the models, using *LOCAL* as a proxy for the market portfolio, the R^2 of the models increases sharply, particularly for emerging markets. As expected, they are less integrated with the world market, and the local market has great explanatory power.

To gauge whether the differences in sensitivities of *OIL* and *VOL_OIL* are statistically different, we test the null that coefficients are equal for industries in developed and emerging markets, a hypothesis rejected at standard levels of confidence.[7]

To sum this up, oil and gas industry returns in developed and emerging markets follow the price of oil and oil price risk is strongly priced in developed countries. Results are robust whether we use *WORLD* or *LOCAL* as the market portfolio and controlling for the variability of oil prices.

Given the large differences in the R^2, from now on we present only results with the factor LOCAL in order to save space.

5. Asymmetric effects of oil price changes

Some research has found an asymmetric impact of oil price changes on the macroeconomy. That is oil price hikes have a negative impact on gross domestic product, but drops in oil price do not necessarily have a positive impact on output and not of the same degree (see Mork, 1989; Mork et al., 1994). There is, however, contradictory evidence of asymmetry effects of oil prices in financial markets. Basher and Sadorsky (2006) find that oil price changes produce asymmetric effects while Park and Ratti (2008), Nandha and Faff (2008) and Cong et al. (2008) do not find this.

To investigate whether there are asymmetric effects of oil for oil and gas industry returns, we define measures of nonlinear variation of oil prices. Then we test asymmetry in all industries. Finally, we disentangle differences in industries in emerging and developed markets.

5.1. Nonlinear oil price measures

To test for asymmetric effects of oil price variation, we need to define nonlinear measures of oil price changes. The traditional approach is based on a dummy variable that differentiates positive from negative oil price changes and multiplies the variable oil price changes, which is equivalent to the following variables:

$$OILP_t = \max[0, \ln(oil_t) - \ln(oil_{t-1})]$$

$$OILN_t = \min[0, \ln(oil_t) - \ln(oil_{t-1})],$$

where oil_t is the price of oil at time t and the $OILP_t$ ($OILN_t$) is the positive (negative) oil price change at time t. *OILP* (*OILN*) assumes positive values each time variations are positive (negative) and zero otherwise.

A second measure is proposed by Hamilton (1996). He argues that if one wants to measure how unsettling an increase in the price of oil is likely to be for the spending decisions of consumers and firms, it is more appropriate to compare the current price of oil with its value over the last year rather than during the previous month alone. Net Oil Price Increase (*NOPI*) is defined as

$$NOPI_t = \max(0, \ln(oil_t) - \ln[\max(oil_{t-1}, \ \ldots, oil_{t-12})]),$$

where $NOPI_t$ is the net price increase at time t. *NOPI* can be interpreted as the amount by which the log oil price exceeds its maximum value over the last year. Note that in a period of consistent oil price escalation, *NOPI* would be low, but if prices soar sharply *NOPI* is high. An advantage of *NOPI* is that it is a better measure to extract the exogenous component of oil price fluctuations (see Kilian, 2008). Similarly we define Net Oil Price Decline (*NOPD*) as $NOPD_t = \min(0, \ln(oil_t) - \ln[\max(oil_{t-1},\ldots, oil_{t-12})])$, where $NOPD_t$ is the net price decline at time t. *NOPD* is negative when the oil price is below its peak value over the last year.[8]

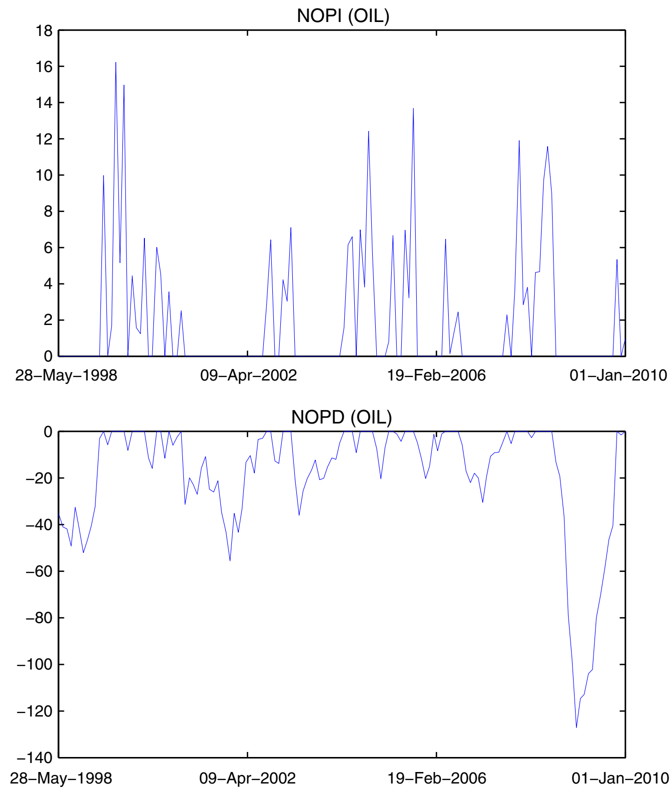

Fig. 3. Net oil price increase (first panel) and net oil price decline (second panel).

Fig. 3 graphs *NOPI* and *NOPD* for the sample period (see Hamilton, 2003, for a longer-period analysis of *NOPI*). We see episodes of peaking prices that seem to cluster in some periods. *NOPD* also shows some peaks and slumps, and we can see the dramatic fall of oil prices during 2009.

5.2. Asymmetry results

To examine the asymmetric effects of oil price fluctuations, we rewrite the factor model to include the nonlinear measures of oil price changes: *OILP*, *OILN*, *NOPI* and *NOPD* (besides the other factors LOCAL, CURRENCY and *INT_RATE_DIFF*). First, we see whether exposure to rises in oil price is different from the exposure to oil price drops. If the coefficients of *OILP* and *OILN* are similar, then the contention of asymmetry has no support. Following Basher and Sadorsky (2006), Nandha and Faff (2008) and Sadorsky (2008), we include *OILP* and *OILN* in a model to help test these effects:

$$\begin{aligned} r_{i,t} = \alpha_i &+ \beta_{LOCAL} \cdot LOCAL_{i,t} + \beta_{CURR} \cdot CURRENCY_{i,t} + \beta_{OILP} \cdot OILP_t \\ &+ \beta_{OILN} \cdot OILN_t + \beta_{VOL\_OIL} \cdot VOL\_OIL_t + \beta_{INT\_RATE} \cdot INT\_RATE\_DIFF_{i,t} + u_{i,t}. \end{aligned} \quad (4)$$

[7] For the hypothesis that the coefficient of oil is equal for developed and emerging markets, the test statistic is 6.54 and the p-value is 0.0104. For the hypothesis that the coefficient of volatility of oil is equal for developed and emerging markets the test statistic is 2.66 and the p-value is 0.1087. More details on the test are available from the authors upon request.

[8] These measures have been frequently used to measure the impact of oil on macroeconomic variables and more recently stock market indices (see, e.g. Aloui and Jammazi, 2009; Cobo-Reyes and Quirós, 2005; Cologni and Manera, 2008; Cong et al., 2008; Cuñado and Garcia, 2003; Park and Ratti, 2008).

Table 6 provides the estimation results for the complete Eq. (4) for all samples. The coefficients of *LOCAL* and *CURRENCY* have similar values as in the previous estimations, so we will skip over them and focus on the asymmetry results. Columns (1)–(3) show that *OILP* and *OILN* are positive and statistically significant; thus industry returns are shown to follow both positive and negative price fluctuations, although coefficients are higher for positive changes than for negative ones. Oil volatility affects industry returns but only at a 10% significance level.

Next we use the measures introduced by Hamilton (1996), *NOPI* and *NOPD*, to try to capture the exogenous component of oil price variations:

$$r_{i,t} = \alpha_i + \beta_{LOCAL} \cdot LOCAL_{i,t} + \beta_{CURR} \cdot CURRENCY_{i,t} + \beta_{NOPI} \cdot NOPI_t + \beta_{NOPD} \cdot NOPD_t + \beta_{VOL\_OIL} \cdot VOL\_OIL_t + \beta_{INT\_RATE} \cdot INT\_RATE\_DIFF_{i,t} + u_{i,t}. \quad (5)$$

Columns (4)–(6) of Table 6 present the impact of changes in oil prices. Here, the results on asymmetry are dramatic. The coefficients representing price increases are from 10 to 20 times higher than the coefficients representing price declines. Differences are mitigated slightly when we consider oil volatility, which has a statistically significant coefficient. This confirms Lee et al. (1995) and Hamilton (1996) in that turbulence in oil prices reduces the marginal effect of any given price change. Nevertheless, results are consistent with the evidence that positive price fluctuations have more of an impact than negative ones.

To analyze the statistical reliance of the gap coefficient, we test for asymmetric responses of oil and gas industry excess returns to oil price changes using two tests. Test 1 defines a null hypothesis of symmetry, i.e., tests whether coefficients of positive and negative variations are equal, $H_0: \beta_{OILP} = \beta_{OILN}$ *or* $H_0: \beta_{NOPI} = \beta_{NOPD}$. Rejection of the null hypothesis indicates statistical support for asymmetric responses. Nonrejection could be due to both coefficients being equal to zero, i.e., there is no sensitivity to the oil factor. Test 2 checks this explanation. It analyzes the joint hypothesis that both coefficients are equal to zero, $H_0: \beta_{OILP} = \beta_{OILN} = 0$ or $H_0: \beta_{NOPI} = \beta_{NOPD} = 0$.

The last rows in Table 6 show rejection of the null hypothesis of Test 1 at standard levels of significance for columns (1) and (3) and at a 10% confidence level for column (2). Also, the equality of the coefficients of *NOPI* and *NOPD* is always rejected at standard levels of statistical significance.

If we base our interpretation of the results on discounted cash flow method, the intuition is that the increase in the present value of future cash flows is proportionally greater when oil prices soar than the drop is when oil prices fall. This indicates either that demand is not sufficiently depressed by price spikes or firms in this industry have considerable market power. According to Kilian (2009), both effects together can make firms pass through price increases to customers, which could explain why positive changes in oil prices influence oil and gas returns more than negative changes.

Table 6
Asymmetric effects of oil price changes. This table reports random effects panel regression estimations (Eqs. (4) and (5)) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), positive oil price changes (*OILP*), negative oil price changes (*OILN*), net oil price increase (*NOPI*) and net oil price decline (*NOPD*), volatility of oil price (*VOL_OIL*) and difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). Test 1 tests the null hypothesis $H_0: \beta_{OILP} = \beta_{OILN}$ or $H_0: \beta_{NOPI} = \beta_{NOPD}$. Test 2 tests the null $H_0: \beta_{OILP} = 0, \beta_{OILN} = 0$ *or* $\beta_{NOPI} = 0, \beta_{NOPD} = 0$. *t*-statistics robust to heteroscedasticity are in parentheses and errors are clustered by country.

	(1)	(2)	(3)	(4)	(5)	(6)
LOCAL	0.873	0.872	0.879	0.900	0.900	0.917
	(25.514)	(25.615)	(23.170)	(24.858)	(24.968)	(22.637)
CURRENCY	0.109	0.115	0.087	0.103	0.116	0.084
	(1.657)	(1.761)	(1.201)	(1.552)	(1.753)	(1.135)
OILP	0.187	0.175	0.196			
	(6.124)	(5.216)	(6.002)			
OILN	0.070	0.085	0.096			
	(3.014)	(3.115)	(3.638)			
NOPI				0.227	0.210	0.214
				(5.801)	(5.303)	(5.041)
NOPD				0.004	0.016	0.022
				(1.301)	(3.294)	(4.567)
VOL_OIL		0.048	0.048		0.122	0.146
		(1.838)	(1.770)		(4.236)	(4.489)
INT_RATE_DIFF			0.102			0.153
			(0.546)			(0.745)
Constant	−0.338	−0.708	−0.686	−0.036	−0.991	−1.057
	(1.773)	(3.661)	(3.271)	(0.278)	(4.420)	(4.194)
Observations	4760	4760	4221	4760	4760	4221
Countries	34	34	31	34	34	31
R^2	0.564	0.565	0.553	0.555	0.556	0.541
Test 1	8.520	3.420	4.170			
p-value	(0.004)	(0.064)	(0.041)			
Test 2	49.890	50.040	72.850			
p-value	(0.000)	(0.000)	(0.000)			
Test 1				30.900	22.160	18.870
p-value				(0.000)	(0.000)	(0.000)
Test 2				42.040	52.410	67.300
p-value				(0.000)	(0.000)	(0.000)

5.3. Developed and emerging markets

What can we say about differences between developed and emerging markets? Table 7 shows the estimation results but separately for developed countries (Panel A) and emerging markets (Panel B). Columns (1)–(3) show results of estimation of Eq. (4). *OILP* and *OILN* (positive and negative price changes) are statistically significant for developed markets, but for emerging markets only *OILP* is statistically significant. Thus industries in developed markets react both to positive and negative changes of oil prices, while in emerging markets they react only to positive changes. In both subsamples, the coefficients are higher for positive variations than for negative variations. In developed markets, *OILP* is about twice as high as *OILN*. *VOL_OIL* is not statistically significant for developed markets.

Columns (4)–(6) use *NOPI* and *NOPD* to test asymmetric reactions. While again values are statistically significant in developed markets, *NOPD* is not in emerging markets. Once the evidence suggests that negative variations have no impact on industry returns in emerging markets.

The last rows in Panel A of Table 7 show rejection of the null of $H_0: \beta_{OILP} = \beta_{OILN}$ for model (1) at standard levels of significance, but only at weak levels for models (2) and (3) in developed markets. For emerging markets, the difference between the coefficients is not statistically significant.

The equality of *NOPI* and *NOPD* coefficients ($H_0: \beta_{NOPI} = \beta_{NONI}$) tends to be rejected both in developing and emerging markets, although in column (6) equality is not rejected.

Overall, the results confirm the asymmetric effects of oil price fluctuations in oil and gas industry returns in developed markets according to either measure of asymmetry. For emerging markets, although coefficients are higher for positive variations than for negative ones, only *OILP* and *NOPI* are statistically significant. This means that oil price drops do not impact industry returns in emerging markets.

6. Asymmetric effects of commodity price changes

We have documented that oil price fluctuations have asymmetric effects on oil and gas industry returns. That is, price spikes impact industry returns more than price drops. Does the relation between oil and the oil industry have parallels in other industries? Do other commodity-driven industries have this pass-through effect?

Table 7
Asymmetric effects of oil price changes: developed countries vs. emerging markets. This table reports random effects panel regression estimations (Eqs. (4) and (5)) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), positive oil price changes (*OILP*), negative oil price changes (*OILN*), net oil price increase (*NOPI*) and net oil price decline (*NOPD*), volatility of oil price (*VOL_OIL*) and difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). Test 1 tests the null hypothesis $H_0: \beta_{OILP} = \beta_{OILN}$ or $H_0: \beta_{NOPI} = \beta_{NOPD}$. Test 2 tests the null $H_0: \beta_{OILP} = 0, \beta_{OILN} = 0$ or $\beta_{NOPI} = 0, \beta_{NOPD} = 0$. *t*-statistics robust to heteroscedasticity are in parentheses, and errors are clustered by country.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Developed countries						
LOCAL	0.896	0.896	0.897	0.945	0.951	0.952
	(12.820)	(12.831)	(12.975)	(13.071)	(13.146)	(13.322)
CURRENCY	0.044	0.052	0.051	0.052	0.068	0.065
	(0.497)	(0.596)	(0.589)	(0.588)	(0.789)	(0.764)
OILP	0.249	0.235	0.235			
	(7.372)	(6.317)	(6.315)			
OILN	0.108	0.124	0.124			
	(3.690)	(3.423)	(3.428)			
NOPI				0.291	0.267	0.266
				(5.941)	(5.424)	(5.351)
NOPD				0.009	0.025	0.026
				(1.887)	(3.524)	(3.653)
VOL_OIL		0.055	0.054		0.163	0.166
		(1.527)	(1.494)		(4.014)	(4.218)
INT_RATE_DIFF			0.256			0.603
			(0.213)			(0.514)
Constant	−0.316	−0.735	−0.730	0.120	−1.157	−1.161
	(1.270)	(2.929)	(2.822)	(0.723)	(3.909)	(3.887)
Observations	2520	2520	2520	2520	2520	2520
Countries	18	18	18	18	18	18
R^2	0.464	0.464	0.464	0.442	0.444	0.445
Test 1	6.520	2.790	2.760	29.480	20.890	19.980
p-value	(0.011)	(0.095)	(0.097)	(0.000)	(0.000)	(0.000)
Test 2	138.430	137.780	138.710	82.680	79.160	86.730
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Panel B: Emerging markets						
LOCAL	0.867	0.866	0.871	0.880	0.879	0.893
	(22.081)	(22.119)	(20.996)	(21.543)	(21.665)	(19.759)
CURRENCY	0.132	0.137	0.109	0.124	0.133	0.100
	(1.452)	(1.501)	(0.999)	(1.338)	(1.437)	(0.877)
OILP	0.121	0.111	0.137			
	(2.544)	(2.061)	(2.405)			
OILN	0.025	0.037	0.053			
	(0.778)	(1.019)	(1.495)			
NOPI				0.157	0.146	0.136
				(2.693)	(2.421)	(1.876)
NOPD				−0.001	0.007	0.018
				(0.319)	(1.127)	(3.013)
VOL_OIL		0.040	0.036		0.083	0.120
		(0.954)	(0.808)		(2.057)	(2.257)
INT_RATE_DIFF			0.205			0.236
			(1.071)			(1.140)
Constant	−0.366	−0.670	−0.618	−0.196	−0.844	−0.928
	(1.235)	(2.209)	(1.616)	(0.986)	(2.476)	(1.992)
Observations	2240	2240	1701	2240	2240	1701
Countries	16	16	13	16	16	13
R^2	0.651	0.651	0.667	0.648	0.649	0.663
Test 1	2.950	1.080	1.340	7.250	4.990	2.560
p-value	(0.086)	(0.298)	(0.248)	(0.007)	(0.026)	(0.110)
Test 2	6.840	6.450	9.590	7.260	9.560	15.520
p-value	(0.033)	(0.040)	(0.008)	(0.027)	(0.008)	(0.000)

These questions are important because demand for commodity companies, such as oil stocks or gold stocks has increased as investors become aware of their diversification benefits and inflation-hedging properties. There has been no clear answer to the questions: Are investors exposed to the same kind of risks? or is the oil and gas industry a special case?

Works on commodity price risk are scarce. Gold is the only commodity to receive extensive study in the academic literature (see Blose and Shieh, 1995; Faff and Chan, 1998; Jin and Jorion, 2006; Khoo, 1994; Louden, 1993; MacDonald and Solnik, 1977; Martin and Keown, 1977; Stone, 1974; Tufano, 1998). Authors usually analyze the impact of gold price variations on the value of gold mines or a gold company index, and tend to find a positive relation between them.

Two relevant exceptions in the commodity price risk literature are Sadorsky and Henriques (2001) and Oberndorfer (2009). Sadorsky and Henriques (2001) study the impact of commodity prices on the Canadian paper and forest product industry returns. They use a Canadian commodity spot price index that includes metals, minerals and forest products and find that industry returns tend to follow the price of this index. Oberndorfer (2009) analyzes the impact of changes in oil, coal and natural gas prices on stock returns of utility companies of the Eurozone. He finds that the prices of oil and coal have a negative effect and the price of natural gas a positive but not statistically significant effect.

We believe commodity price analysis is important because comparison with other industries might help us understand why there are asymmetric effects in the oil and gas industry. Kilian (2009) suggests inelasticity of energy demand, similar market structure and the limited supply of the main input are possible drivers of the asymmetric effects. If we were to find asymmetric effects of commodity price changes in other industries, we could rule out explanations like inelasticity of demand for energy. But if we find similar effects in industries with similar market structures, the explanation of market structure as allowing cartel behavior would gain support.

We thus analyze a set of industries whose activity is largely dependent on a commodity, as in the oil and gas industry. We aim to see whether commodity price changes are a risk factor and whether there are asymmetric effects as in the oil industry for this set of comparable industries.

6.1. Data

We describe selection of industries, the commodities and the available statistics. All the industries are directly dependent on commodities, so they are likely to be subject to commodity price risk.

6.1.1. Industries

Industries selected are supersectors from Datastream Industry Classification Benchmarks (ICB) decomposition to keep the analysis as comparable as possible. The supersectors selected are: Chemicals (1300), Basic Resources (1700), Food and Beverage (3500) and Utilities (7500). These industries depend heavily on commodities and therefore are likely to be exposed to commodity price risk. They also have some similarities to and differences from the oil and gas industry.

6.1.1.1. Basic resources. The basic resources industry shares many similarities with the oil and gas industry. First, the main input is a non-renewable natural resource. As Hong and Sarkar (2008, p. 1286) state "commodity price risk is nevertheless important for companies in natural resources industries." Second, the natural resources business is capital-intensive requiring large scale of investments to operate. Third, it also requires large up-front investments with significant lead times, i.e., there is usually an enormous lead time between the initial discovery of a resource and the time it comes to market. Sadorsky (2001, p. 18) notes that "natural resources companies are dealing with a depleting resource base. In order to remain in business natural extraction companies are continuously searching for low cost natural resources to exploit their depleting asset base." Fourth, raw materials are rather homogenous. Thus, product differentiation is not possible, and companies need to minimize costs to increase profits.

As for market structure, Plourde and Watkins (1998) document that firms vary from very small to very large, and several organizations engage in cartel-like behavior. Notwithstanding, the same authors note that the industrial structure for gold and silver is quite competitive with many small firms while other metal industries range from oligopolist to monopolistic.

6.1.1.2. Food and beverage. The food and beverage industry uses agricultural commodities in production. Unlike oil, agricultural commodities are renewable commodities, and the industry does not usually necessitate up-front investments or excessive lead times. The industry tends to be competitive. Production is geographically widespread with many small producers but also large production examples such as coffee in Brazil, or cocoa in Ivory Coast.

One salient feature of this sector is that prices of some agricultural commodities like rice, sugar and wheat are artificially supported by government subsidies in many countries in order to keep food prices low.

6.1.1.3. Chemicals. The chemical industry uses several raw materials like crude oil or metals, transforming them into a variety of articles used in other industrial products like automobiles, construction items or household goods. Chemical industry revenues are therefore dependent on business cycles; in other words, the demand is not inelastic.

Like the oil industry, the chemical industry is capital-intensive, requiring large scale of investments to operate. Further, the industry is quite concentrated, with barriers to entry due to high front-up costs as well as technology patents.

In terms of market structure, the chemical industry includes large, medium and small companies around the world. Product differentiation might exist depending on the value added compared to the input for a product.

6.1.1.4. Utilities. The utilities industry includes companies whose revenues come from the administration of public services such as water and electricity. In many countries, these companies are state-owned, but they have been frequently privatized following the argument that private ownership increases efficiency. Yet anecdotal evidence shows that even if utilities become privately owned, they tend to remain monopolies or oligopolies, because the infrastructure is very expensive to build or maintain.[9]

Other important similarities with the oil industry include: the inelasticity of the consumption of electricity or water, the homogeneity of the product and finally the large scale of investments necessary to operate.

6.1.2. Commodities

The next step is to select a set of representative commodities that might proxy for commodity price risk. The best choice seems the basket of components of the Standard & Poor's Goldman Sachs Commodity Index (S&P GSCI). The index represents several categories of commodities: energy, industrial metals, precious metals, agriculture and livestock. These commodities are chosen because they are economically important and are widely followed by investors.

Table 8 presents the list of 21 commodities and the benchmark used. Prices of commodities are taken from Datastream. We use the known benchmarks for some commodities but in other cases the S&P GSCI price index, widely followed by investors.[10]

6.1.2.1. Energy. Energy is important for all industries, but our focus is on the risk exposure of the sector utilities. Energy commodities selected are: natural gas, oil and coal as in Oberndorfer (2009).[11] We took prices from known indices. Given that natural gas is less storable than oil, and its price can vary across countries, we choose the price given by the S&P 500 GSCI Natural Gas Price Index. For coal we use the Global Insight Coal Index Basis 6000 Price Index.

Table 8
Commodity benchmark.

Commodity	Benchmark
Energy	
Natural gas	S&P GSCI Natural Gas Spot Price Index
Coal	Global Insight Coal Index Basis 6000 Price Index
Industrial metals	
Aluminum	LME-Aluminium 99.7% Cash U$/MT—A.M. Official
Copper	LME-Copper, Grade A Cash U$/MT—A.M. Official
Lead	LME-Lead Cash U$/MT—A.M. Official
Nickel	LME-Nickel Cash U$/MT—A.M. Official
Zinc	LME-SHG Zinc 99.995% Cash U$/MT—A.M. Official
Precious metals	
Gold	Gold Bullion LBM U$/Troy Ounce
Silver	Silver Fix LBM Cash Cents/Troy ounce
Agriculture and livestock commodities	
Cocoa	S&P GSCI Cocoa Index Spot Price Index
Coffee	S&P GSCI Coffee Spot Price Index
Corn	S&P GSCI Corn Spot Price Index
Livestock	S&P GSCI Livestock Spot Price Index
Soybeans	S&P GSCI Soybeans Spot Price Index
Wheat	S&P GSCI Wheat(CBOT) Spot Price Index
Chemicals	
Benzene	Benzene, US Gulf Spot FOB Barges $/gal
Ethylene	Ethylene, Eur Spot FD NWE Pipe E/MT
Naphtha	Naphtha Far East CFR Japan, 2Half, $/MT
Propylene	Propylene (P), Spot CIF NWE E/MT
PTA	PTA, Contract FD NWE E/MT
PVC	PVC, Domestic UK £/MT

6.1.2.2. Industrial metals. Industry metal price fluctuations are a risk for the basic resources sector. Industry metals are aluminum, copper, lead, nickel and zinc. Like oil, industrial metals are consumed by many industries. Metal prices are usually determined competitively on exchanges like the London Metal Exchange (LME), and common benchmarks are taken from there.

6.1.2.3. Precious metals. Precious metals are gold and silver. Usually the demand for precious metals prices is less dependent on economic activity. We use the common benchmarks for these two metals, the Gold Bullion from the London Bullion Market (LBM) U$/troy ounce and the Silver Fix from the LBM Cash Cents/troy ounce.

6.1.2.4. Agriculture and livestock commodities. For agriculture commodities and livestock, we use the S&P GSCI prices for cocoa, coffee, corn, livestock, soybeans, and wheat.

6.1.2.5. Chemical products. Chemical products are not included in the S&P GSCI but we decide to include them, given our particular interest in the chemical industry. Many of the representative chemical products are subproducts of crude oil. For instance, crude oil is separated into components like ethylene and propylene. These two products are necessary to produce plastics for several industries such as automobile, information technology, construction, household goods and toys.

We select chemicals like propylene, benzenedicarboxylic acid (PTA) and polyvinyl chloride (PVC), and some subproducts of oil like benzene, ethylene, and naphtha. They represent the majority of the output of the industry. Benchmarks are as indicated by Datastream.

[9] See Oberndorfer (2009) for a more detailed description of the European utilities case.

[10] According to some figures of 2007, the GSCI has an estimated $60 billion in institutional investor funds tracking it. See www2.goldmansachs.com/our-firm/…/2007-02-06.html.

[11] Older data from electricity prices are available only for the U.S. For Europe, prices start in 2005 and 2007. (See Oberndorfer, 2009, for a similar problem).

6.1.3. Statistics on commodities

Table 9 shows the summary statistics for the commodities. All index prices of commodities are in U.S. dollars, and returns are computed much as for oil returns. All commodities have positive mean returns during the time period. The highest returns are for lead and naphtha although they are lower than the mean return of oil, 1.2%.

We compute the level of volatility of each commodity using Eq. (2). Many commodities are subject to higher levels of volatility than oil, such as natural gas (17.85%), nickel (11.23%) and subproducts of oil such as benzene (16.05%), ethylene (11.58%) and naphtha (12.54%). Studies covering 1985–1994 have already found that oil return volatility approximates the volatility of commodities such as lead, nickel and zinc (see Plourde and Watkins, 1998). More recently, Olimb and Ødegård (2009) compared recent-period oil volatility with that for other commodities, concluding that oil volatility has not increased significantly while other commodities have become substantially more volatile.

6.2. Commodity price risk

Before we examine asymmetry in relation to commodity price fluctuations, we need to see whether the industries show commodity risk exposure. We use a multifactor model and estimate the sensitivity of the industries to commodity price fluctuations ($COMM_j$) and commodity price volatility (VOL_COMM_j) like section 5. We use the factors: *LOCAL*, *CURRENCY* and *INT_RATE_DIFF*, and also control for oil price changes, as some research concludes that oil prices are related to the price of other commodities (see e.g., Baffes, 2007; Akram, 2009). Table 10 describes the results. The panels analyze the different industries: basic resources, food and beverage, chemical industry and utilities. The effect of each commodity price fluctuation in each industry returns is reported by column. The header of each column identifies the selected commodity.

Panel A shows the results of the impact of metal price changes on basic resources returns. The coefficient of *LOCAL* is higher than 1, which means that industry returns tend to vary considerably with changes in local market. This result is consistent with previous results in gold stock literature such as Khoo (1994), Blose and Shieh (1995) and Faff and Chan (1998).

CURRENCY has a negative coefficient, meaning currency appreciation against the U.S. dollar has a negative effect on returns. Louden (1993) and Khoo (1994) also find that gold stocks are negatively related with exchange rates.

Interest rate differentials are statistically significant in most results. Oil price changes (*OIL*) positively impact basic resources industry returns.

The basic resources industry shows exposure to commodity price fluctuations. $COMM_j$ is statistically significant and has a positive coefficient for all metals. The volatility of commodities coefficient is negative for precious metals such as gold and silver, and positive for the others, but only the value for aluminium price volatility is statistically significant.

Panel B shows how price fluctuations in several agricultural commodities affect food and beverage industry returns. *LOCAL* has a coefficient of around 0.65 across the board. Thus, industry returns tend to fluctuate smoothly with local market portfolio returns. Coefficients are positive and statistically significant for *CURRENCY* variations as well as interest rates. Coefficients for *OIL* are negative but not statistically significant. The industry returns do not seem to react to the prices of agricultural goods, except for corn. VOL_COMM_j has a negative coefficient that is statistically significant only for coffee and livestock.

The results for the chemical industry are in Panel C. *LOCAL* has a coefficient around 0.89, lower than 1. Thus industry returns tend not to change so much with local market portfolio changes. *CURRENCY* as well as *INT_RATE_DIFF* do not seem to affect industry returns. *OIL* affects industry returns positively. The industry returns tend to follow the price of chemical goods, and commodity price volatility is likely to affect industry returns negatively, although values are not always statistically significant.

Panel D shows the estimation results for the commodity price exposure of utilities. *LOCAL* has a coefficient of 0.7, which is consistent with the idea that revenues change little with the economic cycle, given that the activity provides a public service to industrial and retail consumers. *CURRENCY* is statistically significant with a positive coefficient. The value of the coefficients is similar to the estimates presented in Oberndorfer (2009). *INT_RATE_DIFF* is statistically significant, with a negative coefficient. Utility returns follow *OIL* price fluctuations but inversely; in other words, oil price spikes impact industry returns negatively. The result for natural gas is statistically significant with a positive estimated coefficient, while the coefficient for coal is negative but not statistically significant.

The signs of the coefficients of the commodities are in line with Oberndorfer (2009)'s results. He also finds that oil and coal have negative estimated coefficients and natural gas has a positive estimated coefficient.

Briefly, basic resources, chemicals and utilities are subject to some commodity price risk while food and beverage is not.

6.3. Asymmetric effects of commodity price fluctuations

To study the asymmetric effects of commodity price changes, we compute measures of nonlinear variations of commodity prices as we did for oil. $COMMP_j$ has a positive value if commodity j has a price increase and 0 otherwise. $COMMN_j$ is a variable that assumes a negative value if prices of commodity j fall and 0 otherwise.

Similarly, the analogues of *NOPI* and *NOPD* for other commodities are net commodity price increase ($N\_COMM\_PI_j$) and net commodity price decline ($N\_COMM\_PD_j$) of commodity j:

$$N\_COMM\_PI_{j,t} = \max\left(0, \ln\left(comm_{j,t}\right) - \ln\left[\max\left(comm_{j,t-1}, \ldots, comm_{j,t-12}\right)\right]\right)$$

$$N\_COMM\_PD_{j,t} = \min\left(0, \ln\left(comm_{j,t}\right) - \ln\left[\max\left(comm_{j,t-1}, \ldots, comm_{j,t-12}\right)\right]\right), \quad (6)$$

Table 9

Commodity returns—summary statistics. This table reports the summary statistics of the commodities returns. Prices are in U.S. dollars. By column, we report the mean, the standard deviation (SD), the kurtosis, the skewness, the Jarque–Bera statistics and their *p*-values.

Commodity	Mean	SD	Kurtosis	Skewness	Jarque–Bera	*p*-value
Energy						
Natural gas	0.66	17.85	3.42	0.00	0.82	0.66
Coal	0.69	6.03	3.64	−0.05	2.08	0.35
Industry metals						
Aluminum	0.31	5.97	3.68	−0.11	2.53	0.28
Copper	0.98	8.50	9.75	−1.11	282.89	0.00
Lead	1.05	9.85	4.04	−0.28	7.41	0.02
Nickel	0.86	11.23	3.45	−0.39	4.35	0.11
Zinc	0.63	8.64	6.48	−0.63	75.93	0.00
Precious metals						
Gold	0.90	4.82	4.54	−0.04	12.65	0.00
Silver	0.72	8.18	5.86	−0.91	63.81	0.00
Agriculture and livestock commodities						
Cocoa	0.48	9.49	3.62	0.20	2.74	0.25
Coffee	0.02	9.65	3.34	0.37	3.71	0.16
Corn	0.35	8.15	3.37	−0.31	2.85	0.24
Livestock	0.12	4.69	3.92	−0.39	7.78	0.02
Soybeans	0.35	8.31	3.58	−0.45	6.20	0.05
Wheat	0.42	8.07	3.02	−0.01	0.01	1.00
Chemicals						
Benzene	0.98	16.05	12.80	−1.91	622.51	0.00
Ethylene	0.54	11.58	5.66	−0.41	42.74	0.00
Naphtha	1.09	12.54	18.81	−2.27	1526.90	0.00
Propylene	0.50	8.16	15.47	−1.84	951.57	0.00
PTA	0.20	7.05	12.38	−2.09	593.86	0.00
PVC	0.42	5.69	4.56	−0.54	19.55	0.00

Table 10

Commodity risk exposure: basic resources and food and beverage. This table reports random effects panel regression estimations (Eq. (1)) where the dependent variables are the monthly excess returns of basic resources (Panel A) and food and beverage (Panel B) in U.S. dollars from 1998:05 through 2009:12. Explanatory variables include country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), the difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*), oil price return (*OIL*), commodity price returns (*COMM_j*) and volatility of commodity prices (*VOL_COMM_j*). Commodities used are presented in the top of columns. *t*-statistics robust to heteroscedasticity are in parentheses and errors are clustered by country.

	Panel A: Basic resources							Panel B: Food and beverage					
	Precious metals		Industrial metals										
	Gold	Silver	Aluminum	Copper	Lead	Nickel	Zinc	Cocoa	Coffee	Corn	Livestock	Soybeans	Wheat
LOCAL	1.113	1.088	1.076	1.061	1.094	1.066	1.077	0.654	0.647	0.650	0.645	0.648	0.653
	(24.992)	(24.563)	(24.445)	(23.040)	(22.465)	(23.180)	(22.571)	(16.166)	(16.474)	(16.193)	(16.050)	(16.363)	(16.188)
CURRENCY	−0.213	−0.191	−0.126	−0.153	−0.125	−0.117	−0.134	0.199	0.208	0.197	0.207	0.202	0.197
	(3.163)	(2.918)	(1.715)	(2.181)	(1.626)	(1.579)	(1.851)	(2.169)	(2.325)	(2.172)	(2.314)	(2.237)	(2.168)
INT_RATE_DIFF	0.458	0.478	0.558	0.546	0.534	0.489	0.566	0.487	0.518	0.469	0.525	0.470	0.466
	(1.766)	(1.863)	(2.106)	(2.068)	(1.878)	(1.845)	(2.117)	(2.304)	(2.529)	(2.147)	(2.505)	(2.173)	(2.102)
OIL	0.120	0.111	0.117	0.073	0.137	0.127	0.126	−0.017	−0.013	−0.016	−0.019	−0.016	−0.017
	(5.121)	(5.105)	(5.157)	(3.562)	(5.752)	(5.490)	(5.329)	(1.628)	(1.228)	(1.530)	(1.790)	(1.578)	(1.745)
COMM_j	0.243	0.186	0.210	0.218	0.070	0.104	0.129	0.016	0.011	0.032	0.016	0.024	0.022
	(6.060)	(7.002)	(7.352)	(8.449)	(3.111)	(5.895)	(4.811)	(1.459)	(1.222)	(2.469)	(0.784)	(1.933)	(1.857)
VOL_COMM_j	−0.094	−0.037	0.204	0.051	0.012	0.014	0.062	−0.031	−0.166	0.015	−0.300	−0.031	0.027
	(1.602)	(1.391)	(4.001)	(1.728)	(0.425)	(0.356)	(1.912)	(1.151)	(3.871)	(0.775)	(3.222)	(1.479)	(0.982)
Constant	0.321	0.268	−1.034	−0.415	−0.078	−0.106	−0.456	0.382	1.595	0.002	1.460	0.358	−0.081
	(1.201)	(1.122)	(3.540)	(1.641)	(0.308)	(0.235)	(1.744)	(1.541)	(3.766)	(0.014)	(3.435)	(1.819)	(0.317)
Observations	3541	3541	3541	3541	3541	3541	3541	4081	4081	4081	4081	4081	4081
Countries	28	28	28	28	28	28	28	30	30	30	30	30	30
R^2	0.514	0.519	0.516	0.522	0.510	0.514	0.514	0.450	0.454	0.450	0.452	0.450	0.450

Commodity risk exposure: chemicals and utilities. This table reports random effects panel regression estimations (Eq. (1)) where the dependent variables are the monthly excess returns of Chemicals (Panel C) and Utilities (Panel D) in U.S. dollars from 1998:05 through 2009:12. Explanatory variables include country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), the difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*), oil price return (*OIL*), commodity price returns (*COMM_j*) and volatility of commodity prices (*VOL_COMM_j*). Commodities used are presented in the top of columns. *t*-statistics robust to heteroscedasticity are in parentheses and errors are clustered by country.

	Panel C: Chemicals						Panel D: Utilities	
	Benzene	Ethylene	Naphtha	Propylene	PTA	PVC	Natural gas	Coal
LOCAL	0.894	0.896	0.898	0.896	0.903	0.905	0.715	0.718
	(15.169)	(15.179)	(15.255)	(14.953)	(15.091)	(15.240)	(15.370)	(15.418)
CURRENCY	0.061	0.030	0.052	0.057	0.047	0.063	0.426	0.433
	(0.492)	(0.242)	(0.412)	(0.456)	(0.370)	(0.488)	(5.610)	(5.855)
INT_RATE_DIFF	0.425	0.408	0.435	0.450	0.455	0.404	−0.445	−0.462
	(1.464)	(1.438)	(1.580)	(1.664)	(1.668)	(1.425)	(4.195)	(4.255)
OIL	0.028	0.030	0.011	0.028	0.043	0.052	−0.044	−0.035
	(2.220)	(2.253)	(0.451)	(2.056)	(2.881)	(3.500)	(3.409)	(2.711)
COMM_j	0.029	0.074	0.035	0.095	0.056	0.003	0.015	−0.003
	(2.752)	(6.835)	(1.319)	(4.575)	(1.551)	(0.144)	(2.250)	(0.222)
VOL_COMM_j	−0.026	−0.065	−0.063	−0.104	−0.225	0.020	0.000	0.046
	(0.886)	(1.708)	(1.970)	(2.141)	(3.079)	(0.518)	(0.034)	(1.347)
Constant	0.419	0.658	0.718	0.663	1.056	−0.051	0.240	−0.011
	1.035	1.696	2.057	2.127	2.768	0.187	(0.949)	(0.046)
Observations	3501	3501	3501	3501	3501	3501	3558	3558
Countries	26	26	26	26	26	26	27	27
R^2	0.4637	0.4683	0.4639	0.4681	0.4649	0.462	0.5364	0.536

where $comm_{j,t}$ is the price of commodity j at time t, and $N\_COMM\_PI_{j,t}$ ($N\_COMM\_PD_{j,t}$) is the net commodity price increase (decline) of commodity j at time t.

Tables 11 and 12 present the results, following the same approach as for oil price changes. Returns of basic resources, food and beverage, chemicals and utilities are regressed on a set of variables, including the measures of nonlinear price changes of commodities presented above. To save space and because our focus is on asymmetry, we present only the estimates of the coefficients related to the asymmetric effects of commodities.

6.3.1. Basic resources

Panel A of Table 11 shows the estimation results for basic resources as the dependent variable. $COMMP_j$ and $COMMN_j$ are statistically significant and their coefficients are positive for almost all metals. This means that industry returns follow the price of metals. It is worth noting that the coefficient tends to be higher for $COMMN_j$ than for $COMMP_j$. That is, negative changes have a greater impact than positive ones (with the exception of silver); in other words, the asymmetric effects work in the opposite direction from the results for oil.

To validate the asymmetry statistically, we use the same null as in the oil analysis (Test 1). The null hypothesis tests the equality of the coefficients for positive and negative changes. The result shows that we cannot reject at standard levels of significance the null of symmetry for gold and silver. For industrial metals, the null is rejected for aluminum and copper because the asymmetry goes in the opposite direction of the oil results. Price drops have more of an impact on industry returns than price hikes.

Panel A of Table 12 uses $N\_COMM\_PI_j$ and $N\_COMM\_PD_j$ to capture asymmetric effects. The variables $N\_COMM\_PI_j$ and $N\_COMM\_PD_j$ for precious metals and industrial metals are statistically significant, but a striking aspect is that now price hikes have greater impacts than price drops, which is contrary to the results in Table 11 and in line with the results for oil. The null is rejected, however, for silver, aluminum and lead.

Table 11
Asymmetric effects of commodity price changes. This table reports random effects panel regression estimations (Eq. (1)) for a variety of industries from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the reported industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), positive commodity price changes (*COMMP_j*), negative commodity price changes (*COMMN_j*), currency variations against the U.S. dollar (*CURRENCY*), oil price returns (OIL), volatility of commodity price (*VOL_COMM_j*) and the difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). Only coefficients *COMMP_j* and *COMMN_j* are presented. Test 1 tests the null hypothesis $H_0:\beta_{COMMP_j}=\beta_{COMMN_j}$. Test 2 tests the null $H_0:\beta_{COMMP_j}=0,\beta_{COMMN_j}=0$. *t*-statistics robust to heteroscedasticity are in parentheses, and errors are clustered by country.

	COMMP_j	*t*-value	*COMMN_j*	*t*-value	Test 1	*p*-value	Test 2	*p*-value	Observations	Countries	R^2
Panel A: Basic resources											
Gold	0.193	(3.528)	0.312	(3.745)	1.150	(0.284)	36.680	(0.000)	3541	28	0.515
Silver	0.256	(5.924)	0.128	(2.701)	2.980	(0.084)	60.290	(0.000)	3541	28	0.520
Aluminum	0.042	(0.708)	0.439	(6.377)	11.780	(0.001)	74.550	(0.000)	3541	28	0.518
Copper	0.120	(3.788)	0.326	(7.596)	14.250	(0.000)	74.660	(0.000)	3541	28	0.523
Lead	0.060	(1.735)	0.081	(1.535)	0.070	(0.785)	10.380	(0.006)	3541	28	0.510
Nickel	0.114	(3.588)	0.092	(3.381)	0.210	(0.645)	35.350	(0.000)	3541	28	0.514
Zinc	0.102	(3.307)	0.157	(3.630)	1.110	(0.292)	23.410	(0.000)	3541	28	0.514
Panel B: Food and beverage											
Cocoa	−0.059	(3.093)	0.107	(3.779)	15.630	(0.000)	15.720	(0.000)	4081	30	0.452
Coffee	−0.006	(0.438)	0.031	(1.520)	1.560	(0.211)	2.410	(0.300)	4081	30	0.454
Corn	−0.021	(0.852)	0.087	(4.214)	8.270	(0.004)	18.250	(0.000)	4081	30	0.451
Livestock	−0.060	(0.985)	0.086	(1.268)	1.420	(0.234)	1.610	(0.446)	4081	30	0.453
Soybeans	0.021	(0.942)	0.027	(1.103)	0.020	(0.884)	3.750	(0.153)	4081	30	0.450
Wheat	0.025	(1.300)	0.018	(0.758)	0.030	(0.857)	3.700	(0.158)	4081	30	0.450
Panel C: Chemicals											
Benzene	0.028	(1.249)	0.029	(1.202)	0.000	(0.998)	8.400	(0.015)	3501	26	0.464
Ethylene	0.037	(1.796)	0.113	(3.459)	2.340	(0.126)	56.350	(0.000)	3501	26	0.469
Naphtha	−0.007	(0.175)	0.053	(1.371)	0.980	(0.322)	1.910	(0.385)	3501	26	0.464
Propylene	0.023	(0.822)	0.151	(4.089)	6.030	(0.014)	21.330	(0.000)	3501	26	0.469
PTA	−0.040	(0.995)	0.026	(0.743)	1.260	(0.262)	1.280	(0.528)	3501	26	0.462
PVC	0.084	(1.774)	0.030	(0.352)	0.220	(0.639)	5.240	(0.073)	3501	26	0.465
Panel D: Utilities											
Natural gas	0.004	(0.356)	−0.007	(0.476)	2.480	(0.115)	8.650	(0.013)	3558	27	0.537
Coal	0.083	(1.697)	0.061	(1.851)	3.790	(0.052)	4.010	(0.135)	3558	27	0.537

6.3.2. Food and beverage

Panel B shows how price fluctuations of several agricultural commodities affect food and beverage industry returns. Again this industry tends not to react to commodity price changes. This is supported by Test 2 where the null of jointly statistical significance of the variables $COMMP_j$ and $COMMN_j$ tends to be not rejected. In the commodities where the asymmetry is statistically significant (like cocoa and corn) the effect works in the opposite direction of oil, and the estimates of the coefficients of $COMMN_j$ are higher than the estimates of the coefficients of $COMMP_j$. In fact, $COMMP_j$ presents several negative coefficients, meaning that price rises in agricultural commodities have negative effects on food and beverage industry returns.

Panel B of Table 12 uses $N\_COMM\_PI_j$ and $N\_COMM\_PD_j$. The previous results are confirmed; the food and beverage market tends not to react to price changes in agricultural commodities with the exception of price slumps in cocoa and wheat. When asymmetry exists, it works in the opposite direction of oil; in other words, food and beverage industry returns follow price drops but not price hikes.

6.3.3. Chemicals

The results for the chemical industry are in Panel C. Only negative changes in propylene and ethylene prices are statistically significant. Thus, we find evidence of asymmetric effects that go the opposite way from oil price changes. Coefficients for negative changes are larger than for positive changes. Statistically, inverse asymmetry is supported only for propylene.

In Table 12, Panel C, coefficients of $N\_COMM\_PI_j$ and $N\_COMM\_PD_j$ confirm the previous results. Industry returns tend not to respond to price rises except benzene and naphtha, which have negative signs. Price drops have a negative impact on industry returns, particularly raw materials coming from oil. This finding suggests that negative changes in commodity prices have a negative effect on industry returns. The tests on the null support the inverse asymmetry for benzene and naphtha.

6.3.4. Utilities

Panel D of Table 11 shows the results for utilities. Although coefficients of positive changes for natural gas and coal are larger than negative ones, there is no statistical support at standard levels of confidence. Industry returns react to rises in natural gas prices but not to price drops.

Table 12 uses $N\_COMM\_PI_j$ and $N\_COMM\_PD_j$. We find asymmetry for coal and natural gas, but at standard levels of confidence only for natural gas.

6.3.5. Summary

We conclude by noting that we cannot find that commodity price changes have the same universally asymmetric effects that oil price changes have in oil and gas industry returns. Using the traditional approach that distinguishes positive from negative changes, we find that some commodity price changes (aluminum, copper, cocoa, corn, ethylene and propylene) have asymmetric effects on industry returns but in the opposite direction from oil: price drops have more of an impact than price hikes.

Using net commodity price changes as in Hamilton (1996), commodity price changes of silver, aluminum, and natural gas present similar asymmetric effects to oil in basic resources and utility returns, respectively. This implies that outcomes can be different for nonlinear measures, as shown in the case of basic resources.

7. Robustness analysis

We examine the robustness of the results using different proxies for oil, commodities, different asymmetry measures and time dummies.

7.1. Oil and other commodity price proxies

One concern may be that our results could depend on the type of variable we use to proxy the oil and commodity prices. Therefore, we reestimate the models using different benchmarks. For oil we use the

Table 12

Asymmetric effects of net commodity price changes. This table reports random effects panel regression estimations (Eq. (1)) considering other industries from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the reported industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), net positive commodity price changes (*N_COMM_PI_j*), net negative commodity price changes (*N_COMM_PD_j*), currency variations against the U.S. dollar (*CURRENCY*), oil price returns (*OIL*), volatility of commodity price (*VOL_COMM_j*) and the difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). Only the coefficients of *N_COMM_PI_j* and *N_COMM_PD_j* are presented. Test 1 tests the null hypothesis $H_0: \beta_{N\_COMM\_PI_j} = \beta_{N\_COMM\_PD_j}$. Test 2 tests the null $H_0: \beta_{N\_COMM\_PI_j} = 0, \beta_{N\_COMM\_PD_j} = 0$. *t*-statistics robust to heteroscedasticity are in parentheses and errors, are clustered by country.

	N_COMM_PI_j	*t*-value	*N_COMM_PD_j*	*t*-value	Test 1	*p*-value	Test 2	*p*-value	Observations	Countries	R^2
Panel A: Basic resources											
Gold	0.277	(4.746)	0.123	(2.541)	2.620	(0.105)	67.250	(0.000)	3541	28	0.514
Silver	0.195	(4.011)	0.065	(3.482)	4.270	(0.039)	86.820	(0.000)	3541	28	0.514
Aluminum	0.214	(2.403)	0.002	(0.146)	4.850	(0.028)	8.910	(0.012)	3541	28	0.510
Copper	0.079	(1.401)	0.013	(0.988)	1.010	(0.314)	8.360	(0.015)	3541	28	0.509
Lead	0.113	(3.377)	0.019	(1.927)	6.420	(0.011)	19.430	(0.000)	3541	28	0.510
Nickel	0.045	(1.631)	0.003	(0.468)	1.920	(0.166)	3.330	(0.189)	3541	28	0.508
Zinc	0.012	(0.282)	0.031	(3.195)	0.160	(0.691)	13.360	(0.001)	3541	28	0.510
Panel B: Food and beverage											
Cocoa	−0.058	(1.957)	0.032	(4.423)	7.390	(0.007)	19.630	(0.000)	4081	30	0.452
Coffee	0.015	(0.606)	0.001	(0.230)	0.260	(0.609)	0.540	(0.762)	4081	30	0.453
Corn	−0.054	(1.382)	0.002	(0.311)	1.830	(0.177)	1.920	(0.382)	4081	30	0.450
Livestock	−0.006	(0.066)	−0.017	(1.307)	0.010	(0.918)	2.230	(0.328)	4081	30	0.452
Soybeans	0.049	(1.538)	−0.002	(0.240)	1.920	(0.166)	2.950	(0.229)	4081	30	0.450
Wheat	−0.012	(0.404)	0.017	(2.585)	0.810	(0.370)	6.710	(0.035)	4081	30	0.450
Panel C: Chemicals											
Benzene	−0.071	(3.122)	0.028	(4.229)	14.370	(0.000)	20.340	(0.000)	3501	26	0.465
Ethylene	0.073	(1.930)	0.019	(2.862)	1.700	(0.193)	21.470	(0.000)	3501	26	0.466
Naphtha	−0.086	(2.203)	0.033	(3.978)	7.670	(0.006)	16.380	(0.000)	3501	26	0.465
Propylene	0.014	(0.423)	0.027	(2.920)	0.120	(0.733)	12.380	(0.002)	3501	26	0.465
PTA	0.097	(1.414)	−0.007	(0.428)	1.760	(0.184)	2.160	(0.340)	3501	26	0.462
PVC	0.015	(0.212)	0.013	(1.005)	0.000	(0.984)	2.080	(0.353)	3501	26	0.465
Panel D: Utilities											
Natural gas	0.051	(3.207)	0.000	(0.020)	8.120	(0.004)	15.150	(0.001)	3558	27	0.537
Coal	0.012	(0.481)	0.008	(1.632)	0.020	(0.887)	3.440	(0.179)	3558	27	0.537

NYMEX-Light Crude Oil Continuous Settlement Price (U$/BBL). This price is for settlement of the NYMEX futures contract, the most widely traded futures contracts and it is also used as the benchmark to set oil product-related prices. The new explanatory variables are: oil futures returns *OIL*(*FUT*) and oil futures volatility *VOL_OIL*(*FUT*).

The results are unchanged for oil price risk. That is, oil risk is priced. Table 13 shows not only that the oil futures return variable is statistically significant but also that its coefficient is positive similar to the values in Tables 4 and 5. The volatility of oil futures is also statistically significant, and the other variable coefficients remain unchanged.

When we split the sample into developed and emerging markets, we see the same differences for the coefficients of the different markets, leading us to conclude that the results are not driven by choice of the oil proxy.

To check our results on asymmetry, we recompute the nonlinear measures of oil changes using oil futures returns. The new explanatory variables are *OIL*(*FUT*), *OILP*(*FUT*), *OILN*(*FUT*), *NOPI*(*FUT*) and *NOPD*(*FUT*).

Table 14 shows the estimation results of Eqs. (4) and (5) using oil futures returns instead of oil spot price returns. *OILP*(*FUT*), *OILN*(*FUT*), *NOPI*(*FUT*) and *NOPD*(*FUT*) are always statistically significant. The same differences between positive and negative changes are found using futures returns. Columns (1)–(3) show that positive changes are greater than negative changes (the coefficient of *OILP*(*FUT*) is higher than the coefficient of *OILN*(*FUT*)). The null hypothesis of Test 1, $H_0: \beta_{OILP(FUT)} = \beta_{OILN(FUT)}$, however, is rejected only at weak levels of significance.

In columns (4)–(6), note that the coefficients of *NOPI*(*FUT*) and *NOPD*(*FUT*) are slightly lower than those in Table 6, but the wide gap between them remains and the null of Test 1, $H_0: \beta_{NOPI(FUT)} = \beta_{NOPD(FUT)}$, is always rejected, supporting the asymmetry contention.

Further tests confirm the difference in oil price risk in developed and emerging markets. We observe also that changing commodity benchmarks has little impact on our findings.[12]

7.2. Scaled price changes

An alternative way to analyze asymmetry is to use a measure called scaled oil price increases (*SOPI*). According to Lee et al. (1995) what matters is how surprising an oil price increase is based on the observed changes. That is an unexpected oil price change will have less of an impact when conditional variances are high because much of the change in oil price will be regarded as transitory.

To calculate this measure, we estimate a GARCH(1, 1) model given by:

$$OIL_t = \mu + \sigma_t \epsilon_t$$
$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t_1}^2 + \beta_1 \sigma_{t-1}^2,$$

where $\varepsilon_t = \sigma_t \epsilon_t$ is the prediction error, $\sigma_t > 0$ is the conditional standard deviation of the underlying oil return (denoted volatility) and the innovation $\epsilon_t \sim NID(0,1)$. We impose the conditions $\alpha_0 > 0$, $\alpha_1 \geq 0$ and $\beta_1 \geq 0$ to guarantee that the conditional variance is positive and $\alpha_1 + \beta_1 < 1$ to assure it is stationary. Therefore, a measure that reflects the size and the variability of the unexpected oil shock might be defined for time t as $\hat{\varepsilon}_t^* = \frac{\hat{\varepsilon}_t}{\sigma_t}$ and consequently the *SOPI* is given by:

$$SOPI_t = \max(0, \hat{\varepsilon}_t^*).$$

In a similar manner, scaled oil price declines (*SOPD*) are defined at time t as $SOPD_t = \min(0, \hat{\varepsilon}_t^*)$. Therefore, oil price increases and declines are scaled by the oil conditional standard deviation. *SOPI* and *SOPD* will be high (in absolute value) when there are great price changes (in absolute value). We compute scaled price changes for oil (*SOPI* and *SOPD*) (see Hamilton, 2003; Park and Ratti, 2008) and for the other commodities ($S\_COMM\_PI_j$ and $S\_COMM\_PD_j$).

Table 15 shows the estimation results. For the sake of space we present only the estimated coefficients related to the variables *SOPI* and *SOPD* and $S\_COMM\_PI_j$ and $S\_COMM\_PD_j$.

[12] Results are available upon request.

Table 13
Oil and gas industry: oil futures returns. This table reports random effects panel regression estimations (Eq. (3)) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), oil futures return (*OIL(FUT)*), volatility oil futures price (*VOL_OIL(FUT)*) and difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). *t*-statistics robust to heteroscedasticity are in parentheses and errors are clustered by country.

	Panel A: All countries		Panel B: Developed countries		Panel C: Emerging markets	
	(1)	(2)	(3)	(4)	(5)	(6)
LOCAL	0.870	0.870	0.890	0.890	0.870	0.870
	(25.520)	(22.600)	(12.410)	(12.550)	(22.220)	(20.640)
CURRENCY	0.110	0.080	0.040	0.030	0.130	0.110
	(1.650)	(1.110)	(0.400)	(0.380)	(1.460)	(0.970)
OIL(FUT)	0.120	0.140	0.170	0.170	0.060	0.080
	(6.620)	(7.560)	(11.530)	(11.630)	(2.280)	(2.480)
VOL_OIL(FUT)	0.070	0.070	0.100	0.100	0.030	0.020
	(2.620)	(2.280)	(2.530)	(2.560)	(0.950)	(0.410)
INT_RATE_DIFF		0.110		0.370		0.220
		(0.600)		(0.320)		(1.110)
Constant	−0.510	−0.460	−0.700	−0.700	−0.270	−0.080
	(2.010)	(1.660)	(2.020)	(2.060)	(0.720)	(0.160)
Observations	4760	4221	2520	2520	2240	1701
Countries	34	31	18	18	16	13

The asymmetric effects of oil price changes are confirmed using this measure (see Panel A of Table 15). The evidence is that price increases matter more than price drops, the *SOPI* coefficient is higher than the *SOPD* coefficient and $H_0: \beta_{SOPI} = \beta_{SOPD}$ is rejected at standard levels of significance.

Table 14
Asymmetric effects of oil futures returns. This table reports random effects panel regression estimations (Eqs. (4) and (5)) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), the positive oil futures price changes (*OILP (FUT)*), the negative oil futures price changes (*OILN (FUT)*), net oil futures price increase (*NOPI(FUT)*) and net oil futures price decline (*NOPD(FUT)*), volatility of oil futures price (*VOL_OIL (FUT)*) and difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). Test 1 tests the null hypothesis $H_0: \beta_{OILP(FUT)} = \beta_{OILN(FUT)}$ or $H_0: \beta_{NOPI(FUT)} = \beta_{NOPD(FUT)}$. Test 2 tests the null $H_0: \beta_{OILP(FUT)} = 0, \beta_{OILN(FUT)} = 0$ or $\beta_{NOPI(FUT)} = 0, \beta_{NOPD(FUT)} = 0$. *t*-statistics robust to heteroscedasticity are in parentheses, and errors are clustered by country.

	(1)	(2)	(3)	(4)	(5)	(6)
LOCAL	0.870	0.869	0.875	0.896	0.896	0.911
	(25.476)	(25.574)	(22.846)	(24.883)	(24.931)	(22.501)
CURRENCY	0.099	0.104	0.074	0.111	0.118	0.088
	(1.478)	(1.560)	(0.999)	(1.678)	(1.787)	(1.190)
OILP (FUT)	0.163	0.151	0.181			
	(5.003)	(4.282)	(5.381)			
OILN (FUT)	0.078	0.093	0.092			
	(3.295)	(3.315)	(3.218)			
NOPI (FUT)				0.172	0.159	0.164
				(4.032)	(3.581)	(3.412)
NOPD (FUT)				0.006	0.011	0.015
				(1.784)	(2.256)	(2.774)
VOL_OIL (FUT)		0.046	0.034		0.069	0.077
		(1.400)	(0.974)		(1.980)	(1.903)
INT_RATE_DIFF			0.110			0.141
			(0.582)			(0.680)
Constant	−0.187	−0.520	−0.477	0.113	−0.438	−0.402
	(1.029)	(2.052)	(1.713)	(0.814)	(1.688)	(1.374)
Observations	4760	4760	4221	4760	4760	4221
Countries	34	34	31	34	34	31
R^2	0.562	0.562	0.549	0.553	0.553	0.538
Test 1	3.810	1.270	3.110	13.890	9.800	8.530
p-value	(0.051)	(0.260)	(0.078)	(0.000)	(0.002)	(0.004)
Test 2	42.890	43.840	57.350	32.640	34.590	40.590
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 15 reports results testing the robustness of commodity price change results. Panel B presents the estimations for basic resources. The coefficient of $S\_COMM\_PI_j$ is lower than the coefficient of $S\_COMM\_PN_j$ for almost all commodities except for silver, lead and nickel, but Test 1 confirms asymmetric effects only for gold, aluminum and copper. As in Table 11, the asymmetry of commodities goes in opposite direction from oil asymmetry. Negative oil price changes have a greater impact on industry returns than positive changes.

Results are similar for food and beverage industry returns (Panel C). Cocoa, coffee and corn price changes have negative effects on industry returns. Chemical industry returns (Panel D) are also affected negatively by naphtha and propylene price variations. The results for cocoa, coffee or corn and propylene and naphtha show asymmetric effects but the asymmetry goes in the opposite direction from oil asymmetry. Price drops have more impact than price rises.

For utilities, although natural gas shows a higher coefficient for positive changes than negative ones (0.416 and 0.061, respectively), asymmetry is not supported statistically.

Overall, the results using scaled price changes confirm an asymmetric effect of oil price changes in oil and gas industry returns, which seems to represent a unique case. Although there are asymmetric effects for some commodities, they go in the opposite direction from oil price changes. Price drops have a greater impact than price rises.

7.3. Time dummies

A final test adds time dummies to the model for an augmented version of the original panel that allows the intercepts to vary over time. We introduce $t-1$ time dummies to see if there are possible shifts over time in excess returns in the level of the oil and gas industry. A joint significance test of the time dummy variables indicates rejection of the null hypothesis that they are jointly statistically insignificant at a 5% significance level.

Panel A of Table 16 shows the estimation results of Eq. (3) with time dummies. *OIL* is still statistically significant, but *VOL_OIL* is no longer a priced factor. All the remaining coefficients are similar to those in Table 4.

Finally, when we split the sample into developed and emerging markets, *OIL* is not statistically significant for emerging markets, although it is significant for industries in developed countries, which confirms differences across countries.[13]

The result that oil is a priced factor is therefore robust over different time periods.

8. Conclusion

Researchers have long sought to understand the factors that impact the equity returns of companies and markets. We contribute to the literature by studying the exposure of the oil and gas industry to a number of factors, particularly whether oil prices are a global factor.

The empirical evidence is that oil price has a positive impact on the market returns of the oil and gas industry around the world. Oil price risk is more important in developed country industries than in emerging markets. A striking aspect is that the oil and gas industry is strongly affected by local market returns, when companies operate their business in several countries.

We examine asymmetry in oil price fluctuations using two primary measures of asymmetry. The first distinguishes between positive and negative monthly changes, while the other compares oil changes to previous reference values. We find that oil industry returns react asymmetrically to oil price changes, that is, oil price hikes impact

[13] Results are available upon request.

Table 15
Asymmetric effects of scaled price changes: oil and other commodities. This table reports random effects panel regression estimations ($r_{i,t}=\alpha_i+\beta_{LOCAL}\cdot LOCAL_{i,t}+\beta_{CURR}\cdot CURRENCY_{i,t}+\beta_{S\_COMM\_PI}\cdot S\_COMM\_PI_{j,t}+\beta_{S\_COMM\_PD}\cdot S\_COMM\_PD_{j,t}+\beta_{INT_RATE}\cdot INT\_RATE\_DIFF_{i,t}+u_{i,t}$) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), Scaled Commodity Price Increases ($S\_COMM\_PI_j$) and Scaled Commodity Price Declines ($S\_COMM\_PD_j$) and the difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). Test 1 tests the null hypothesis $H_0:\beta_{S\_COMM\_PI_j}=\beta_{S\_COMM\_PD_j}$. Test 2 tests the null $H_0:\beta_{S\_COMM\_PI_j}=0,\beta_{S\_COMM\_PD_j}=0$. *t*-statistics robust to heteroscedasticity are in parentheses, and errors are clustered by country.

	SOPI	*t*-value	*SOPD*	*t*-value	Test 1	*p*-value	Test 2	*p*-value	Observations	Countries	R^2
Panel A: Oil and gas industry											
OIL	1.942	(6.100)	1.033	(3.960)	4.070	(0.044)	65.500	(0.000)	4221	31	0.554
	S_COMM_PI_j	*t*-value	*S_COMM_PD_j*	*t*-value	Test 1	*p*-value	Test 2	*p*-value	Observations	Countries	R^2
Panel B: Basic resources											
Gold	0.611	(3.189)	1.778	(5.176)	8.520	(0.004)	38.360	(0.000)	3541	28	0.514
Silver	1.543	(6.212)	1.061	(3.260)	1.260	(0.261)	53.740	(0.000)	3541	28	0.517
Aluminum	0.641	(2.048)	2.191	(6.762)	8.190	(0.004)	77.460	(0.000)	3541	28	0.517
Copper	1.003	(3.818)	2.787	(8.817)	23.690	(0.000)	81.810	(0.000)	3541	28	0.523
Lead	0.840	(2.641)	0.559	(1.268)	0.220	(0.636)	10.330	(0.006)	3541	28	0.510
Nickel	1.259	(4.113)	0.563	(2.384)	3.160	(0.076)	23.210	(0.000)	3541	28	0.513
Zinc	0.966	(3.389)	1.160	(3.439)	0.210	(0.645)	21.510	(0.000)	3541	28	0.513
Panel C: Food and beverage											
Cocoa	−0.374	(2.431)	0.833	(3.590)	12.870	(0.000)	13.430	(0.001)	4081	30	0.452
Coffee	−0.243	(1.617)	0.600	(2.295)	5.000	(0.025)	5.290	(0.071)	4081	30	0.450
Corn	−0.128	(0.711)	0.421	(3.249)	4.810	(0.028)	10.610	(0.005)	4081	30	0.450
Livestock	−0.447	(1.533)	0.539	(1.723)	2.900	(0.089)	3.000	(0.223)	4081	30	0.451
Soybeans	0.152	(0.930)	0.263	(1.520)	0.030	(0.857)	7.130	(0.028)	4081	30	0.450
Wheat	0.244	(1.647)	0.021	(0.111)	0.670	(0.413)	3.970	(0.138)	4081	30	0.450
Panel D: Chemicals											
Benzene	0.321	(1.168)	0.431	(1.493)	0.050	(0.824)	7.430	(0.024)	3501	26	0.463
Ethylene	0.437	(1.949)	1.188	(2.825)	1.510	(0.219)	49.910	(0.000)	3501	26	0.467
Naphtha	−0.692	(2.192)	0.685	(1.872)	6.990	(0.008)	7.160	(0.028)	3501	26	0.464
Propylene	−0.042	(0.213)	1.154	(4.069)	9.690	(0.002)	17.250	(0.000)	3501	26	0.466
PTA	0.100	(0.334)	0.577	(1.671)	0.630	(0.428)	0.670	(0.715)	3501	26	0.462
PVC	−0.208	(0.769)	0.087	(0.404)	0.730	(0.394)	4.670	(0.097)	3501	26	0.463
Panel E: Utilities											
Natural gas	0.416	(2.469)	0.061	(0.430)	2.670	(0.103)	6.230	(0.044)	3558	27	0.536
Coal	−0.116	(0.563)	0.119	(0.555)	0.530	(0.469)	0.530	(0.769)	3558	27	0.536

industry returns more than oil price drops according to both measures, but the results are stronger according to the second measure. We interpret the asymmetric effects as a sign that firms have the ability to pass their oil sensitivity on to customers through price changes.

Moreover, we also observe that the asymmetric effect is stronger for industries in developed countries than for industries in emerging markets. Using the traditional dummy approach that splits price changes into positive and negative, we are often able to reject the null of symmetry, but using the second asymmetry measure we also find asymmetric effects in emerging markets. This interpretation is consistent with the idea that emerging markets tend to react more to exogenous changes in oil prices.

Finally, we look at other commodity price changes to see if commodity-driven industries are affected similarly by asymmetric effects of oil price changes. When we find asymmetry, the asymmetry often goes in the opposite direction from oil. Negative changes have a greater impact than positive ones. According to net price change measures, in basic resources and utilities there are asymmetric effects similar to oil. Overall, however, the results seem to suggest that these asymmetric effects are unique features in the oil and gas industry, likely because of inelasticity of demand for energy, industry market structure and the limited supply of the primary industry input.

Our results have direct implications for investment in the oil and gas industry, as we identify several sources of variation in industry returns that are useful for controlling international risks of investments. Moreover, common investors can hedge against oil price increases by investing in these firms.

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Table 16
Risk factors in oil and gas industry (time dummies). This table reports random effects panel regression estimations (Eq. (3)) from 1998:05 through 2009:12. The dependent variable is the monthly excess returns of the oil and gas industry indices in U.S. dollars. Explanatory variables include the country market return (*LOCAL*), currency variations against the U.S. dollar (*CURRENCY*), oil price returns (*OIL*), volatility of oil price (*VOL_OIL*) and difference between the local interest rate and the U.S. interest rate (*INT_RATE_DIFF*). *t*-statistics robust to heteroscedasticity are in parentheses, and errors are clustered by country.

	Panel A: All countries		Panel B: Developed countries		Panel C: Emerging markets	
	(1)	(2)	(3)	(4)	(5)	(6)
LOCAL	0.860	0.870	0.890	0.890	0.880	0.900
	(21.510)	(20.790)	(12.000)	(12.010)	(19.120)	(17.700)
CURRENCY	0.070	0.030	−0.080	−0.080	0.100	0.060
	(0.920)	(0.400)	(0.680)	(0.680)	(1.050)	(0.500)
OIL	0.140	0.130	0.160	0.160	0.110	0.090
	(2.700)	(2.710)	(2.710)	(2.720)	(1.470)	(1.190)
VOL_OIL	0.080	0.120	0.180	0.180	−0.060	−0.060
	(0.790)	(1.120)	(1.720)	(1.800)	(0.420)	(0.270)
INT_RATE_DIFF		0.070		−0.190		0.140
		(0.360)		(0.140)		(0.700)
Constant	−1.240	−2.300	−4.080	−4.100	2.410	2.470
	(0.730)	(1.320)	(2.930)	(2.990)	(0.810)	(0.570)
Observations	4760	4221	2520	2520	2240	1701
Countries	34	31	18	18	16	13
R^2	0.600	0.590	0.540	0.540	0.680	0.700
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes

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