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Coal Sector Returns and Oil Prices: Developed and Emerging Countries

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ABSTRACT

This paper examines the effect of oil price on coal sector stock returns. A multifactor market model is used to estimate the expected excess returns to the coal sector. A 1% increase in oil price return has a statistically significant positive impact on coal sector returns of between 0.06% and 0.20%. A 1% increase in coal price raises the return of coal sector returns by between 0.22% and 0.30%. Increased volatility in oil price return significantly reduces coal sector return. Participants in energy markets may perceive oil price as being determined globally and as providing information on demand for energy overall. Understanding the variables that affect the behaviour of the stock prices in the coal is of importance to market participants and policy makers, and is helpful in developing efficient hedging policies to deal with changes in energy prices.

Keywords: Coal Sector Return, Oil Price, Coal Price
JEL Classifications: G15, O13, Q4

1. INTRODUCTION

The literature examining the effect of oil price on stock prices has paid particularly close attention to the effect on the stock prices of oil and gas companies. Sadorsky (2001) and Boyer and Filion (2007) find that positive oil price shocks significantly raise stocks returns for Canadian oil and gas companies, and El-Sharif et al. (2005) and Mohanty and Nandha (2011) find a similar result for U.K. and U.S. oil and gas companies, respectively. Dayanandan and Donker (2011) report that oil price increases have a positive and statistically significant impact on the accounting profits of oil and gas companies in North America. Ramos and Veiga (2011) analyse the returns of the oil and gas sector in 34 countries and find that sector returns largely depend on market portfolio and oil price returns. With regard to quantitative impact, these studies find that a 1% increase in oil price raises returns in the oil and gas sector by between 0.14% and 0.30%.

This paper examines the effect of energy prices on coal sector stock returns. In contrast to work identifying the effect of energy prices on the stock returns of oil and gas companies, relatively little similar work has appeared on the coal sector despite the importance of coal as a source of energy. In recent years coal provides over 23% of global primary energy needs (compared to 36% for oil), fuels 39% of the world's electricity industry, and provides almost 70% of the energy for global steel production (Statistical Review of World Energy [2009]).

We examine panel data on 17 country level coal sector stock indices and evaluate risk factors significant in determining return in the coal sector. A 1% increase in coal price raises coal sector returns by between 0.22% and 0.30%. A 1% increase in oil price return raises coal sector returns by between 0.06% and 0.20%. These results are robust across developed, emerging and differing groups of Asia-Pacific and Pacific countries. The coefficients of coal price return and oil price return are positive and statistically significant in regressions for coal sector returns in both developed and emerging markets. The exposure of coal sector return to coal price return is greater than that to oil price return for both developed and emerging markets. Increased volatility in coal and oil price return significantly reduces coal sector return. Crude oil price developments may have influence on coal sector stocks since oil price is perceived as reflecting global demand for energy.

Market return, interest rate premium, foreign exchange rate risk, and coal price returns are statistically significant in determining the excess coal sector stock returns. A multifactor market model is used to estimate the expected excess returns to the coal sector. Currency depreciation has a negative impact on the return of coal companies, a result similar to that found by comparable country studies for oil and gas companies. Understanding the variables that affect the behaviour of the stock prices of coal companies is important to market participants and policy makers, and helpful to developing efficient hedging policies to deal with energy price shocks.

The remainder of the paper is organized as follows. Section 2 describes the data and the methodology. Section 3 discusses the regression equations and energy price variables. Section 4 presents the results of the research and section 5 concludes the study.

2. DATA AND METHODOLOGY

We obtain monthly returns for coal sector indices based on the Datastream industry classification, created by FTSE and Dow Jones. We find 17 (U.S. dollar) indices of coal sector available at country level for 14 Asia Pacific countries and for three other countries. The 17 countries Australia, Canada, Chile, China, Hong Kong, India, Indonesia, Japan, New Zealand, Poland, Philippines, Russia, Singapore, Spain, Thailand, U.K., and U.S. Data are monthly and range from January 1999 to December 2010, comprising 144 monthly observations. The excess return series for coal sector is given by natural log difference of current month's closing price from previous month's closing price minus the monthly return on short run government bond for the corresponding country. Return data are converted to U.S. dollar returns to ensure conformity of the return data across countries. Data of all variables are from Datastream.

2.1. Methodology

An arbitrage pricing theory approach is taken to investigate the interaction between stock returns and energy prices. Sadorsky (2001), Boyer and Filion (2007), and Nandha and Faff (2008) have previously used a multifactor market model to study the impact of oil prices on stock returns. To identify important determinants of coal industry stock returns we apply a multi-factor arbitrage pricing theory model to panel data. The following international factor model will be used to link priced risk factors to required rates of return in assets in the coal sector:

$$r_{i,t}=a_i+\sum_{j=1}^{k}\beta_j F_{j,i,t}+\varepsilon_{i,t}, i=1,2...l \quad (1)$$

where $r_{i,t}$ represents the excess return of the coal sector of country i at time t, β_j is the factor loading or systematic risk for risk factor j, and $F_{j,i,t}$ is the risk factor j, for country i at time t. The variable $\varepsilon_{i,t}$ is a random error term. k is the number of risk factors and l is the number of countries. The model is estimated assuming fixed effects using ordinary least squares and random effects panels using generalized least squares (GLS) method. Hausman test results are obtained for all specifications with the null hypothesis of no correlation between country effects and the explanatory variables (i.e. the random effects model is the null hypothesis).

2.2. The Risk Factors

In this paper we will estimate different versions of Equation 1 with various risk factors. In the basic model the risk factors are taken to be market return, the foreign exchange return, an interest rate differential, and coal and oil price returns. These variables affect future investment opportunities and consumption and are perceived as key variables in inter-temporal asset-pricing models. Global stock return and a benchmark market return of each country are used alternatively as measures of market exposure of coal sector returns. Using global market index to measure market exposure of sector returns avoids possible distorted results due to the lack of diversification of the stock markets of some countries. The excess return series for each market index is given by natural log difference of current month's closing price from previous month's closing price minus the monthly return on short run government bond for the corresponding country.

A short term interest rate differential is utilized as a risk factor. The interest rate differential is defined as the 3 months government bond for each country and the 3 months U.S. Treasury bill rate. A higher interest rate differential indicates a less liquid monetary environment. Foreign exchange risk is measured by the monthly logarithmic difference of the U.S. dollar price of foreign currency. A fall in the foreign exchange variable indicates a devaluation of the local currency against U.S. dollar.

The price of oil is the West Texas Intermediate (WTI) crude oil futures price contract. WTI crude oil futures price contracts is the most widely traded oil futures contract and serves as a standard in the oil market. The price of coal is ICE Global Newcastle futures contract in U.S. dollar per metric tonne. This is the leading price benchmark for seaborne thermal coal in the Asia-Pacific region. Oil and coal price returns are given by the log difference in the monthly data for oil and coal prices.

2.3. Summary Statistics

Tables 1 and 2 present summary statistics of coal sector returns and excess stock returns by country. In Table 1 Australia, China, Indonesia, and Thailand have relatively high coal sector excess returns over 1999-2010. In Table 2, the emerging markets have relatively high excess stock returns compared to the developed stock markets. From Tables 1 and 2 it is evident that returns in the coal sector of a country are higher than the local market excess stock return. The coal sector returns exhibit kurtosis of more than three in all markets except India. As evidenced by the Jarque-Bera (JB) statistics, both coal sector returns and local stock markets returns are not normally distributed. However, the models to be estimated are linear and normality is not presumed in order to obtain consistent estimates.

Table 3 presents summary statistics on oil price returns, and coal returns. Oil price returns are higher than the coal price returns by factor of about 65%. The standard deviation (SD) of oil price returns is also higher than that for coal price returns, but in the monthly data only by a proportion of about 8.8%. Oil returns are negatively skewed and coal returns are positively skewed. The JB statistics imply that the null hypothesis that oil price returns are

Table 1: Summary statistics: Coal sector returns

	Dependent variable					
Country	**Mean**	**SD**	**Kurtosis**	**Skewness**	**JB**	***P* value**
Australia	0.0211	0.1006	5.6380	−0.3756	45.14	0.0000
Canada	0.0135	0.2816	7.0958	−0.7525	110.2572	0.0000
Chile	0.0158	0.2953	62.7240	6.5619	2243.18	0.0000
China	0.0242	0.1418	4.7187	−0.0746	17.8578	0.0000
Hong Kong	−0.0116	0.2844	5.3912	−1.0207	15.6516	0.0004
India	0.0080	0.0626	2.6554	−0.2052	0.0837	0.9590
Indonesia	0.0239	0.2311	6.4659	0.4132	24.3326	0.0000
Japan	−0.0005	0.1699	4.8130	0.7737	34.0764	0.0000
New Zealand	0.0015	0.0253	4.3816	0.5088	4.9077	0.0860
Philippines	0.0126	0.2321	4.7973	0.6948	30.9671	0.0000
Poland	0.0222	0.0941	2.9097	0.5020	0.6774	0.7127
Russia	0.0192	0.2342	4.9022	−0.9502	14.4594	0.0007
Singapore	0.0328	0.2068	3.8280	−0.3065	2.1229	0.3460
Spain	0.0005	0.0790	6.1979	0.8786	65.4522	0.0000
Thailand	0.0247	0.1337	5.5019	−0.7915	52.5921	0.0000
U.K.	0.0032	0.1766	18.1058	−1.9064	1456.35	0.0000
U.S.	0.0137	0.1376	5.1317	−0.9507	48.9580	0.0000

Summary statistics of the coal sector monthly excess returns are reported by country over 1999:01 through 2010:12. Mean, SD, kurtosis, skewness, and JB statistics and *P* values are reported in each column. Return is the first difference of the logarithm of coal sector price in U.S. dollars minus a short-term interest rate. SD: Standard deviation, JB: Jarque-Bera

Table 2: Summary statistics: Market returns

	Independent variable					
	Mean	**SD**	**Kurtosis**	**Skewness**	**JB**	***P* value**
r_{wm}	0.0022	0.0539	4.9842	−0.7852	38.4167	0.0000
r_{lm}						
Australia	0.0065	0.0681	5.2655	−0.7670	44.9035	0.0000
Canada	0.0084	0.0661	5.8545	−0.8932	68.0339	0.0000
Chile	0.0110	0.0589	5.2043	−0.5144	35.5056	0.0000
China	0.0160	0.0948	3.6116	−0.0321	2.2692	0.3216
Hong Kong	0.0061	0.0678	3.5371	−0.1296	2.1339	0.3440
India	0.0133	0.1041	3.8844	−0.3518	7.6628	0.0217
Indonesia	0.0111	0.2058	10.3124	0.1861	321.6554	0.0000
Japan	0.0007	0.0554	3.2144	−0.0631	0.3714	0.8305
New Zealand	0.0037	0.0644	3.8119	−0.6411	13.8175	0.0010
Philippines	0.0095	0.0640	4.7661	−0.3109	21.0353	0.0000
Poland	0.0067	0.1022	4.4188	−0.6137	21.1178	0.0000
Russia	0.0227	0.1193	4.6641	−0.4063	20.5763	0.0000
Singapore	0.0100	0.0764	4.6815	−0.2982	19.1000	0.0001
Spain	0.0011	0.0683	4.7838	−0.6516	29.2800	0.0000
Thailand	0.0079	0.0970	4.1966	−0.1289	8.9907	0.0112
U.K.	0.0003	0.0563	5.4545	−0.5253	42.7704	0.0000
U.S.	0.0003	0.0521	4.6841	−0.7494	30.4968	0.0000

This table reports summary statistics of global stock market excess return (r_{wm}) and local stock market excess return (r_{lm}) over 1999:01 through 2010:12. Mean, SD, kurtosis, skewness, and (JB) statistics and *P* values are reported in each column. Return is the first difference of the logarithm of coal sector price in U.S. dollars minus a short-term interest rate. SD: Standard deviation, JB: Jarque-Bera

Table 3: Summary statistics on oil and coal prices

	Independent variable					
	Mean	**SD**	**Kurtosis**	**Skewness**	**JB**	***P* value**
r_o	0.0107	0.0954	4.5885	−0.5885	13.8361	0.0000
r_c	0.0065	0.0877	3.4522	0.2508	2.7362	0.2546

Summary statistics for oil price return, r_o, and coal price return, r_c are reported for 1999:01 through 2010:12. Oil price return in the log difference in 1-month future price of WTI, and coal price return is log difference in ICE Global Newcastle futures price of coal. Mean, SD, kurtosis, kewness, and JB statistics and *P* values are reported in each column. SD: Standard deviation, JB: Jarque-Bera, WTI: West Texas Intermediate

normally distributed is rejected and that the null hypothesis that coal price returns are normally distributed is not rejected.

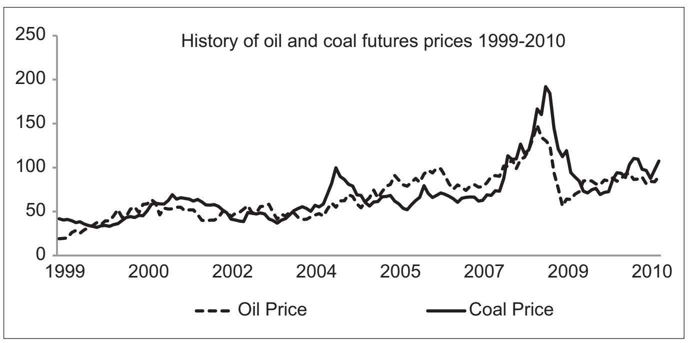
Figure 1 displays coal price and oil price from January 1999 to December 2010. The energy prices do tend to track one another. Figure 1 reveals that there were upward jumps in prices from 2007.

That continued until the Global financial crisis (GFC) in September-October, 2008. During the GFC there were significant drops in oil and coal prices, with the drop in oil price occurring earlier than the drop in coal price. In the monthly data, oil price peeked in July 2008 and coal price peeked in September 2008. Prices started recovering in late 2009, with the recovery in oil price starting earlier than that in coal prices. Movement in prices between oil and coal will diverge depending on circumstances that impact relative inventories of coal and oil available to users.

Coal price achieved a local peak in July 2004. During this period power generation companies experience low coal reserves during severe power shortages in China, the world's largest producer of coal. Figure 2 displays coal price return and oil price return from January 1999 to December 2010. Both the oil and coal price return series exhibit large swings in the monthly data. The Figure 2 suggests that the timing of these swings may not be that strongly related.

The correlation matrix of variables is provided in Table 4. Coal and oil price returns have a positive co-movement and correlation coefficient of 0.22. The highest correlation (0.66) is between local stock market excess return and global stock market excess return. These two variables will not appear simultaneously in the same regression. It is likely that overall, multicollinearity is not a problem in estimating linear regression models with these variables.

Figure 1: Oil and coal futures prices in U.S. dollars. Source: Oil price is monthly West Texas Intermediate crude oil futures price in U.S. dollars per barrel. Coal price return is monthly ICE Global Newcastle futures coal price in U.S. dollar per metric tonne. Data are from Datastream



3. ARBITRAGE PRICING REGRESSIONS AND OIL PRICE VARIABLES

3.1. The Basic Regression

In the basic model the risk factors are taken to be market return, the foreign exchange return, an interest rate differential, and coal and oil price returns. The basic model is given by:

$$r_{i,t} = \alpha + \beta_{wm} r_{wm,t} + \beta_{in} i_{i,t} + \beta_{fx} fx_{i,t} + \beta_c r_c + \beta_o r_{o,t} + \mu_{i,t}, i = 1, 2 \ldots l \tag{2}$$

Where $r_{i,t}$ represents the excess return of the coal sector of country i at time t, $r_{wm,t}$ represents the global market excess return at time t, $i_{i,t}$ is the interest rate difference between the short-term interest rate of country and 3 months U.S. T-bill rate, $fx_{i,t}$ is the foreign exchange return (log difference in U.S. dollar price local currency) of country i, $r_{c,t}$ is the coal price return, $r_{o,t}$ is the oil price return, α is a constant, and $\mu_{i,t}$ is an error term. An alternative to the basic model will substitute local market excess return ($r_{lm,t}$) in Equation 2 for global market excess return.

In Equation 2, the returns $r_{i,t}$, $r_{wm,t}$, $r_{lm,t}$, $r_{c,t}$ and $r_{o,t}$ are expressed as U.S. dollar returns. A test of the null hypothesis that the exchange

Figure 2: Oil and coal futures price returns. Source: Oil price return is monthly logarithmic change in West Texas Intermediate crude oil futures price in U.S. dollars per barrel. Coal price return is monthly logarithmic change in ICE Global Newcastle futures coal price in U.S. dollar per metric tonne. Data are from Datastream

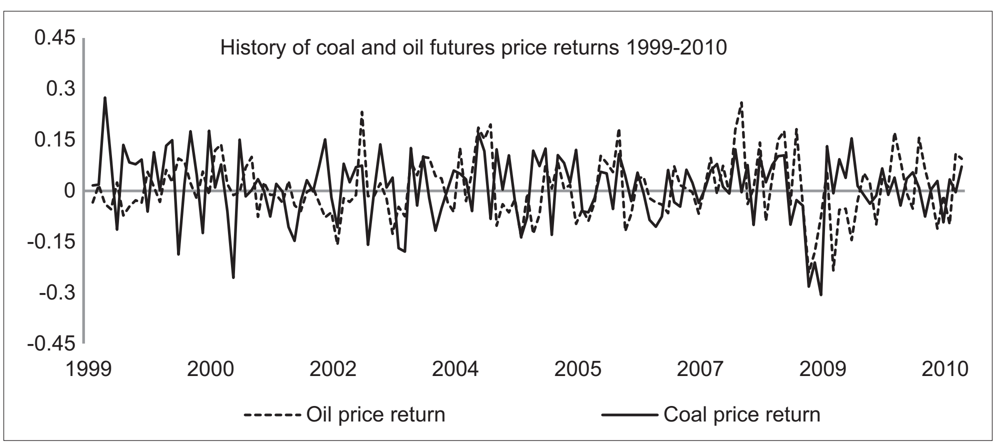


Table 4: Correlation matrix of the variables

	World market return	Local market return	Foreign exchange rate return	Interest rate difference	Coal price return	Oil price return	Coal price return volatility	Oil price return volatility
World market	1.0000							
Local market	0.6562	1.0000						
Foreign exchange	0.3599	0.4197	1.0000					
Interest rate difference	−0.0795	−0.0494	−0.0344	1.0000				
Coal return	−0.0636	−0.0777	0.0073	−0.0687	1.0000			
Oil return	−0.0734	−0.0842	−0.1214	−0.0494	0.2209	1.0000		
Coal volatility	−0.0654	−0.0280	−0.0845	0.0876	0.0143	−0.1906	1.0000	
Oil volatility	−0.1262	−0.0861	0.0156	0.0520	−0.0426	0.1791	−0.3094	1.0000

rate has no influence on local currency returns in the coal sector other than through the impacts on local currency denominated market (either global or local), coal and oil returns is provided by testing Ho:β_{wm}+β_{fx}+β_c+β_o=1 (or Ho: β_{lm}+β_{fx}+β_c+β_o=1). If the null hypothesis is not rejected, upon substitution, Equation 2 becomes (the superscript L indicates local currency-denominated returns):

$$r^{L}_{i,t} = \alpha + \beta_{wm} r^{L}_{wm,t} + \beta_{in} i_{in,t} + \beta_{c} r^{L}_{c,t} + \beta_{o} r^{L}_{o,t} + \mu_{i,t}, \tag{2}$$

$$i = 1, 2 \ldots l,$$

with the foreign exchange term removed, since $r^{L}_{z,t} \equiv r_{z,t} - fx_{i,t}$, z=i, wm, lm, c,o.

3.2. Energy Price Volatility

Sadorsky (1999) identifies oil price shocks and oil price volatility as playing an important role in explaining U.S. real stock returns. Aydogan and Berk (2015) report that oil price changes significantly and rationally affect the Turkish stock market. Park and Ratti (2008) state that increased volatility in energy prices causes greater uncertainty about product demand and future returns on investment, and affects the present value of future dividends.

Oil and coal return volatilities are measured as the moving average of the squared residuals obtained from AR(1) regressions for oil and coal price returns. The AR(1) regression equations are given by:

$$r_{o,t} = c_{o} + \varphi_{o} r_{o,t-1} + \varepsilon_{o,t} \tag{3a}$$

$$r_{c,t} = c_{c} + \varphi_{c} r_{c,t-1} + \varepsilon_{c,t} \tag{3b}$$

The measure of oil and coal price return volatility is given by the residuals from equations (3a) and (3b), $\hat{\varepsilon}_{o,t}$ and $\hat{\varepsilon}_{c,t}$:

$$\sigma_{k,t} = \left[\left(m+1\right)^{-1} \sum_{j=0}^{m} \hat{\varepsilon}^{2}_{k,t-j} \right]^{0.5}, k = o, c \tag{4}$$

with t = 0 ..., n-m-1 and m=4. Volatility in oil and coal price returns is based on innovations that are not explained by past oil and coal price changes. Volatility has been measured in this way by Gallant and Tauchen (1998).

An arbitrage pricing model that captures the effects of energy price volatility is given by:

$$\begin{aligned} r_{i,t} &= \alpha + \beta_{wm} r_{wm,t} + \beta_{in} i_{i,t} + \beta_{fx} fx_{i,t} + \beta_{c} r_{c} + \\ &\beta_{o} r_{o,t} + \beta_{coalvol} \sigma_{c,t} + \beta_{oilvol} \sigma_{o,t} + \mu_{i,t}, i = 1, 2 \ldots l \end{aligned} \tag{5}$$

where volatility in coal and oil price returns is given by $\sigma_{c,t}$ and $\sigma_{o,t}$, respectively.

4. RESULTS

The international factor model equations for excess coal sector returns in section 3 are estimated as a panel. We estimate fixed effects using ordinary least squares and random effects panels using GLS method. Fixed effects method is advantageous if the country effects are correlated with the explanatory variables. Hausman test results are obtained for all specifications with the null hypothesis of no correlation (the random effects model is the null hypothesis). The test results for the equations show that the null hypothesis cannot be rejected in all cases. In what follows only results for random effect panels are reported.[1] Data on coal sector, global and local market returns are winsorized at the 1st percentile and 99th percentile to deal with the outliers. It turns out that this procedure does not greatly affect results.

Results from estimating Equation 2 are reported in Table 5. Two sets of results are reported: in panel A with global stock market index return as market return; and in panel B with local benchmark stock index return as the market return. In column 1 of Table 5 results are reported for all countries in the sample. To address the issue of whether risk factors in coal sector returns differ between developed and emerging countries, estimation of coal sector returns in developed and in emerging countries are reported in columns 2 and 3, respectively. Developed and emerging markets are identified according to Morgan Stanley Capital International classification.

Results for sub-groups of Asia-Pacific and Pacific of countries are reported in columns 4-7. Four sub-groups are considered. Asia-Pacific1 countries are Australia, Canada, Chile, China, Hong Kong, India, Indonesia, Japan, New Zealand, Philippines, Russia, Singapore, Thailand and U.S. Pacific1 countries are Australia, Canada, Chile, China, Hong Kong, Indonesia, Japan, New Zealand, Philippines and Singapore. Asia-Pacific 2 countries are Asia-Pacific 1 countries excluding Russia and the U.S. Pacific 2 countries are Pacific1 countries excluding China and Hong Kong.

4.1. Market, Exchange Rate and Interest Rate Risk

In all regressions in Table 5 the Wald test statistic for panel data indicates the models are statistically significant. In Table 5, the coefficient of global market index return, β_{wm} , in panel A and the coefficient of global market index return,, in panel B are statistically different from zero at 1% level of confidence. Since in each column, the estimate of β_{lw} is less than β_{wm} it appears that coal sector returns are more sensitive to systematic risk in the global economy than to systematic risk in the local economy. Thus, it is concluded that coal sector returns are strongly influenced by global market developments.

The estimate of the coefficient of foreign exchange rate risk (a rise indicates an appreciation of the local currency) is positive and statistically significant at the 1% level in all regressions in Table 5. The appreciation of the local currency against the U.S. dollar generates positive coal industry returns, results similar to the findings of Sadorsky (2001), Boyer and Filion (2007), and Ramos and Veiga (2011) for oil and gas sector returns. A test of the null hypothesis that the exchange rate has no influence on local currency returns in the coal sector other than through the impacts on local currency denominated market, coal and oil returns (Ho: β_{wm}+β_{fx}+β_c+β_o=1) is not rejected in all regressions in Table 5. Thus, the hypothesis that the true relationship determining

1 The fixed effect results and Hausman test results are available upon request.

Table 5: Coal sector returns for different groups of countries

Variables	1	2	3	4	5	6	7
	Full sample	Developed	Emerging	Asia-Pacific[1]	Asia-Pacific[2]	Pacific[1]	Pacific[2]
Panel A							
Constant	0.1650***	0.1582**	0.1741***	0.1498**	0.1751***	0.1513***	0.1684***
	(0.0625)	(0.0815)	(0.0741)	(0.0752)	(0.0551)	(0.0452)	(0.0447)
r_{wm}	0.8638***	1.1001***	0.7354***	1.0432***	0.8874***	0.9452***	0.9573***
	(0.1547)	(0.1910)	(0.1474)	(0.1785)	(0.1891)	(0.1525)	(0.2150)
f_x	0.4321***	0.4871***	0.5474***	0.4258***	0.4987***	0.3952***	0.4235**
	(0.1925)	(0.2010)	(0.2010)	(0.1987)	(0.1874)	(0.2014)	(0.2090)
i	−0.3768	−0.1618	−0.0154	−0.1941*	−0.0987	−0.2014	−0.1118
	(0.2910)	(0.1241)	(0.1024)	(0.1132)	(0.0856)	(0.1293)	(0.0987)
r_o	0.1256***	0.0612**	0.0754***	0.0834**	0.0971***	0.0925***	0.1025***
	(0.0425)	(0.0309)	(0.0310)	(0.0380)	(0.0298)	(0.0350)	(0.0289)
r_c	0.2890***	0.2219***	0.2651***	0.2180***	0.2515***	0.2421***	0.2987***
	(0.0680)	(0.0914)	(0.0698)	(0.0825)	(0.0791)	(0.0920)	(0.0474)
Wald χ^2	140.36	214.10	114.37	224.10	184.21	190.20	175.21
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.1817	0.1587	0.1021	0.1710	0.1874	0.1982	0.1692
χ^2 test: $\beta_{wm}+\beta_{fx}+\beta_c+\beta_o=1$							
	4.01	5.96	5.56	6.20	4.01	4.89	5.19
	(0.405)	(0.114)	(0.135)	(0.102)	(0.260)	(0.180)	(0.158)
Panel B							
Constant	0.1689***	0.2014**	0.1914**	0.1479**	0.1821***	0.1415***	0.1897***
	(0.0654)	(0.0921)	(0.0952)	(0.0752)	(0.0624)	(0.0474)	(0.0503)
r_{ln}	0.5311***	0.9874***	0.4825***	0.6051***	0.5959***	0.5941***	0.5785***
	(0.0874)	(0.1541)	(0.0741)	(0.1025)	(0.1751)	(0.1012)	(0.1954)
f_{xi}	0.4546***	0.2587*	0.3687**	0.4021**	0.4874***	0.3852***	0.4354**
	(0.2101)	(0.1478)	(0.1756)	(0.1975)	(0.1984)	(0.2062)	(0.2117)
i_l	−0.4594**	−0.3021***	−0.0541	−0.2052*	−0.1025	−0.2214*	−0.1285
	(0.2263)	(0.1124)	(0.1974)	(0.1078)	(0.0765)	(0.1285)	(0.0887)
r_o	0.2033***	0.0874**	0.1895***	0.0874***	0.0920***	0.0895***	0.1014***
	(0.0347)	(0.0470)	(0.0410)	(0.0299)	(0.0301)	(0.0350)	(0.0251)
r_c	0.1689***	0.2203***	0.1474***	0.2211***	0.2458***	0.2335***	0.2884***
	(0.0654)	(0.0889)	(0.0477)	(0.0901)	(0.0758)	(0.0852)	(0.0521)
Wald χ^2	117.20	184.10	115.17	152.10	161.21	159.20	165.21
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.1142	0.1610	0.1008	0.1524	0.1628	0.1658	0.1705
χ^2 test: $\beta_{lm}+\beta_{fx}+\beta_c+\beta_o=1$							
	5.21 (0.2663)	3.98 (0.263)	3.12 (0.373)	4.72 (0.194)	5.21 (0.157)	4.57 (0.261)	6.24 (0.110)

The reports estimates of Equation 2: $r_{i,j}=\alpha+\beta_{rm}r_{wm,t}+\beta_{in}i_{i,t}+\beta_{fx}fx_{i,t}+\beta_c r_c+\beta_o r_o+\mu_{i,t}$

local currency returns in the coal sector is given by Equation 2' is not rejected.[2]

The estimate of the coefficient of the interest rate difference is negative and mostly not statistically significant in Table 5. Tighter liquidity in a country tends to lower returns in the coal sector. This is consistent with monetary tightening signalling macroeconomic slowdown with a dampening future demand for energy. In addition, the coal sector is capital intensive and higher interest rates increase the cost of carrying debt and of financing investment with negative implications for coal sector returns.

The dependent variable is the monthly excess returns of the coal industry indices in U.S. dollars. Explanatory variables include the global market return (r_{wm}) or local market return (r_{lm}), the log difference in the U.S. dollar price of local currency (*fx*), difference between the local interest rate and the U.S. interest rate (*i*), coal price return (r_c), oil price return (r_o). Country groups are the following. Developed countries are Australia, Canada, Hong Kong, Japan, New Zealand, Singapore, Spain, U.K. and U.S. Emerging countries are Chile, China, India, Indonesia, Poland, Philippines, Russia and Thailand. Asia-Pacific[1] countries are Australia, Canada, Chile, China, Hong Kong, India, Indonesia, Japan, New Zealand, Philippines, Russia, Singapore, Thailand and U.S. Asia-Pacific[2] countries are Asia-Pacific[1] countries excluding Russia and the U.S. Pacific[1] countries are Australia, Canada, Chile, China, Hong Kong, Indonesia, Japan, New Zealand, Philippines and Singapore. Pacific[2] countries are Pacific[1] countries excluding China and Hong Kong. The standard errors robust to heteroskedasticity appear in parentheses below parameter estimates, and errors are clustered by country. P-value appears below test results. Statistical significance at 1%, 5% and 10% levels of confidence is indicated by ***, ** and *, respectively.

2 Faff and Brailsford (1999) report a similar outcome for most Australian sectors including the oil and gas sector, in that in an equation with all returns expressed in local currency the exchange is not statistically significant.

4.2. Coal and Oil Price Returns

The coal price return is statistically significant at 1% level in determining excess return in the coal sector in all the regressions in Table 5. A 1% increase in coal price return raises the coal company returns by between 0.147% and 0.299%. The results are consistent with and analogous to findings that oil price returns are positively associated with the returns of oil and gas companies. Sadorsky (2001) and Boyer and Filion (2007), for example, find that a 1% increase in oil price raises the return of Canadian oil and gas companies by about 0.300%. Mohanty and Nandha (2011) report that a 1% increase in oil price raises return in the U.S. oil and gas sector by between 0.207% and 0.378% depending on time period. Ramos and Veiga (2011) report a smaller effect (about 0.144%) of oil price returns on returns in the oil and gas sector worldwide.

Oil price return is statistically significant at 1% (5%) level in determining excess return in the coal sector in 12 (2) regressions in Table 5. A 1% increase in oil price return raises coal sector returns by between 0.061% and 0.203%. Oil prices may have a sizeable impact on coal sector stock even coal price returns are included in the regression. Participants in the energy markets may perceive oil price as being determined globally and as reflecting future global demand for energy overall more efficiently than does coal price. For this reason crude oil price developments have influence on coal sector stocks. Bachmeier and Griffin (2006) conclude from examination of five crude oils that the world oil market is a single integrated economic market, but the coal market is not, and that a primary global energy market overall is only existent in the long run. Humphreys and Welham (2000) observe that the coal industry by the 1990s had started to emerge as a global industry. Ekawan and Duchêne (2006) observe that the spot market had become much more important over time for trade in coal in the Atlantic region, with the fraction of spot market trade rising from 14% in 1983 to 80% of the total in 2003. It is noted by Ekawan et al. (2006) that spot markets have also become much more important for trade in coal in the Pacific region. Warell (2006) find that the market is globally integrated for coal. Li (2010) provides a review of the growth in an international market in steam coal and concludes that progress toward a fully developed spot market is well advanced. Li et al. (2010) find a stable long run cointegrating relationship between price series for coal in Europe and Japan that is supportive of a globally integrated market for coal.

4.3. Coal and Oil Price Return Volatilities

Results from estimating Equation 5, in which the SDs of coal and oil price return volatilities appear, are reported in Table 6. The coefficient of coal return volatility is negative in all regressions in Table 6, but is not statistically significant in 6 out of 7 regressions and statistically significant at the 10% level in 1 regression (in column 2).

Oil price return volatility has a negative statistically significant effect at the 1%, 5% and 10% level on coal sector returns in 2, 4 and 1 regressions, respectively. An increase in oil price return volatility by its mean value decreases coal sector returns by 13.04% (9.93%).[3] This result is in line with that reported by Park and Ratti (2008) and Sadorsky (1999) that increased volatility in oil price reduces stock price returns measured by a general index. The sensitivity of coal sector return to oil price return volatility and not to coal price return volatility reinforces the observation that participants in the coal sector market pay attention to oil price developments.

4.4. GFC

The sample period over January 1999 to December 2010 includes the GFC. To assess whether the effect of the distribution of oil price returns continues to have the same impact on coal sector returns pre and post GFC, we include a dummy variable in the Equation 5.

3 The mean of oil (coal) price return volatility defined in equation (4) is 0.0867 (0.0796). The product of the mean coefficient of oil (coal) price return volatility in Table (VI), -1.5041 (-1.1458), yielding -0.1304 (-0.0993).

Table 6: Coal sector return equations: Volatility in coal and oil returns

Variables	Full	Developed	Emerging	Asia-Pacific[1]	Asia-Pacific[2]	Pacific[1]	Pacific[2]
Constant	0.3010***	0.1983***	0.0987**	0.1593***	0.1352***	0.1325***	0.1352***
	(0.0874)	(0.0695)	(0.0449)	(0.0325)	(0.0347)	(0.0347)	(0.0347)
r_{wm}	0.7541***	1.3344***	0.8534***	1.0610***	1.1154***	1.1249***	0.8370***
	(0.1241)	(0.1140)	(0.1356)	(0.1132)	(0.1169)	(0.1313)	(0.1515)
f_x	0.6587***	0.6879***	0.4598***	0.3828***	0.4054***	0.3897***	0.5524***
	(0.2001)	(0.2010)	(0.1428)	(0.1201)	(0.1204)	(0.1029)	(0.1752)
i	−0.2784	−0.2785	−0.0937	−0.0773	−0.1524	−0.1239	−0.2231
	(0.2155)	(0.2777)	(0.2045)	(0.1690)	(0.1959)	(0.1354)	(0.2217)
r_o	0.1198***	0.1785**	0.0941***	0.0918***	0.1021***	0.1285***	0.1029***
	(0.0352)	(0.0723)	(0.0257)	(0.0288)	(0.0271)	(0.0374)	(0.0357)
r_c	0.2875***	0.2649***	0.2206***	0.1878***	0.2439***	0.2371***	0.2952***
	(0.0741)	(0.0702)	(0.0632)	(0.0689)	(0.0725)	(0.0695)	(0.0821)
σ_c	−1.1210	−0.6497*	−1.3500	−1.6363	−1.5531	−1.1859	−1.5531
	(0.7985)	(0.3609)	(0.1.2589)	(2.0589)	(1.1020)	(1.1223)	(1.1020)
σ_o	−1.5041***	−1.6003***	−1.2478**	−0.6958**	−1.2460**	−0.8692*	−1.2460**
	(0.4123)	(0.3981)	(0.6177)	(0.3163)	(0.5518)	(0.4852)	(0.5518)
Wald χ^2	339.52	235.54	118.63	284.02	339.52	213.58	155.57
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.1993	0.2448	0.1332	0.1958	0.1993	0.1805	0.1567

The reports estimates of Equation 5: $r_{i,t} = \alpha + \beta_{wm} r_{wm} + \beta_{in} i_{i,t} + \beta_{fx} fx_{i,t} + \beta_c r_{c,t} + \beta_o r_{o,t} + \beta_{coal}\sigma_{c,t} + \beta_{oil}\sigma_{o,t} + \mu_{i,t}$

Dummy variables with different timing will be considered in the regression equations to check the robustness of results. The equations to be estimated are given by:

$$r_{\mathrm{i,t}} = \alpha + \beta_{\mathrm{wm}} r_{\mathrm{wm,t}} + \beta_{\mathrm{in}} i_{\mathrm{i,t}} + \beta_{\mathrm{fx}} fx_{\mathrm{i,t}} + \beta_{\mathrm{c}} r_{\mathrm{c}} + \beta_{\mathrm{o}} r_{\mathrm{o,t}} + \beta_{\mathrm{coalvol}} \sigma_{\mathrm{c,t}} + \beta_{\mathrm{oilvol}} \sigma_{\mathrm{o,t}} + \lambda_{\mathrm{i1}} D_{\mathrm{1t}} + \lambda_{\mathrm{i2}} D_{\mathrm{2t}} + \mu_{\mathrm{i,t}}, 1 = 1, 2 \ldots l \quad (6)$$

where D_{kt} k=1,2 is a dummy variable defined as follows:

D_{1t} has value 1 on and after September, 2008 and 0 otherwise. Lehman Brothers filed for bankruptcy protection on 15 September 2008 and the stock market declined sharply.

D_{2t} has value 1 in September and November 2008 and 0 otherwise. The GFC appears to have stabilized by the end of November 2008 with dramatic action by the US Federal Reserve, including the pledge to purchase mortgage bonds guaranteed by Fannie Mae and Freddie Mac.

Results from estimating Equation 6 are reported in Table 7 for the world market index as market index. In Table 7 all coefficients of the dummy variable D_{2t} are negative and statistically significant, indicating that during the GFC returns for the coal sector declined even controlling for market returns. In the presence of D_{2t}, D_{1t} is not statistically significant in any of the regressions. This implies that the negative effect of the GFC on coal sector returns during and after September 2008 relative to returns before this date is confined to the September and November 2008 period.

The effect of oil price returns and volatility are unchanged by the inclusion of the dummy variable. A rise in oil price returns increases returns in the coal sector significantly, and a rise in oil price return volatility reduces returns in the coal sector significantly. Coal price return volatility remains statistically insignificant in explaining coal sector returns.

The dependent variable is the monthly excess returns of the coal industry indices in U.S. dollars. Explanatory variables include the global market return (r_{wm}) or local market return (r_{lm}), the log difference in the U.S. dollar price of local currency (fx) , difference between the local interest rate and the U.S. interest rate (i), coal price return (r_{c}), oil price return (r_{o}), volatility of coal returns (σ_{c}), volatility of oil returns (σ_{o}),

Country groups are the following:

Developed countries are Australia, Canada, Hong Kong, Japan, New Zealand, Singapore, Spain, U.K. and U.S.

Emerging countries are Chile, China, India, Indonesia, Poland, Philippines, Russia and Thailand.

Asia-Pacific[1] countries are Australia, Canada, Chile, China, Hong Kong, India, Indonesia, Japan, New Zealand, Philippines, Russia, Singapore, Thailand and U.S.

Asia-Pacific[2] countries are Asia-Pacific[1] countries excluding Russia and the U.S.

Pacific[1] countries are Australia, Canada, Chile, China, Hong Kong, Indonesia, Japan, New Zealand, Philippines and Singapore.

Pacific[2] countries are Pacific[1] countries excluding China and Hong Kong.

Table 7: Coal sector return equations: Global financial crisis

Variables	Full	Developed	Emerging	Asia-Pacific[1]	Asia-Pacific[2]	Pacific[1]	Pacific[2]
Constant	0.1872***	0.2487***	0.1028**	0.1241**	0.1125**	0.1125**	0.1125**
	(0.0438)	(0.0871)	(0.0478)	(0.0620)	(0.0592)	(0.0592)	(0.0592)
r_{wm}	1.0098***	1.1675***	0.9063***	0.9357***	0.9887***	1.0030***	0.7619***
	(0.1004)	(0.1210)	(0.1427)	(0.1177)	(0.1214)	(0.1365)	(0.1567)
f_{x}	0.3918***	0.6115***	0.3514***	0.2953***	0.3789***	0.4239***	0.4987***
	(0.0956)	(0.1984)	(0.1235)	(0.0982)	(0.1129)	(0.1368)	(0.1432)
i	−0.1255	−0.3028	−0.0822	−0.1297	−0.2260	−0.1692	−0.2809
	(0.1061)	(0.2789)	(0.2047)	(0.1758)	(0.2020)	(0.1840)	(0.2287)
r_{o}	0.1304***	0.1836***	0.1069***	0.1012**	0.1037***	0.1494**	0.1045***
	(0.0469)	(0.0521)	(0.0311)	(0.0425)	(0.0321)	(0.0728)	(0.0399)
r_{c}	0.2688***	0.2259***	0.2433***	0.1637***	0.2398***	0.2498***	0.2933***
	(0.0657)	(0.0701)	(0.0599)	(0.0351)	(0.0549)	(0.0674)	(0.0855)
σ_{c}	−1.6182	−0.6126*	−1.2487	−1.3325	−1.2410	−1.3985	−1.3900
	(1.1854)	(0.3481)	(0.9584)	(0.9585)	(0.8690)	(1.0247)	(1.1359)
σ_{o}	−0.9069**	−1.5569***	−0.9541**	−0.4982*	−0.9722**	−0.9214**	−1.0120**
	(0.4160)	(0.4295)	(0.4632)	(0.2622)	(0.4761)	(0.5010)	(0.5361)
λ_1	−0.0103	−0.0198	−0.0051	−0.0024	−0.0049	−0.0052	−0.0086
	(0.0121)	(0.0148)	(0.0176)	(0.0138)	(0.0142)	(0.0159)	(0.0182)
λ_2	−0.1581***	−0.1641***	−0.1821***	−0.1433***	−0.1493***	−0.1427***	−0.0998**
	(0.0339)	(.0412)	(0.0501)	(0.0380)	(0.0395)	(0.0439)	(0.0508)
Wald χ^2	337.38	263.49	134.97	302.80	310.86	227.68	160.93
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.1981	0.2669	0.1492	0.2063	0.1855	0.1906	0.1617

The reports estimates of Equation 6: $r_{\mathrm{i,t}}=\alpha+\beta_{\mathrm{wm}}r_{\mathrm{wm}}+\beta_{\mathrm{in}}i_{\mathrm{i,t}}+\beta_{\mathrm{fx}}fx_{\mathrm{i,t}}+\beta_{\mathrm{c}}r_{\mathrm{c,t}}+\beta_{\mathrm{o}}r_{\mathrm{o,t}}+\beta_{\mathrm{coalvol}}\sigma_{\mathrm{c,t}}+\beta_{\mathrm{oilvol}}\sigma_{\mathrm{o,t}}+\lambda_1 D_{1,t}+\lambda_2 D_{2,t}+\mu_{\mathrm{i,t}}$

The standard errors robust to heteroskedasticity appear in parentheses below parameter estimates, and errors are clustered by country. P value appears below χ^2 test results. Statistical significance at 1%, 5% and 10% levels of confidence is indicated by ***, ** and *, respectively.

The dependent variable is the monthly excess returns of the coal industry indices in U.S. dollars. Explanatory variables include the global market return (r_{wm}) or local market return (r_{lm}), the log difference in the U.S. dollar price of local currency (f_x), difference between the local interest rate and the U.S. interest rate (i), coal price return (r_c), oil price return (r_o), volatility of coal returns (σ_c), volatility of oil returns (σ_o), D_1 is a dummy variable equal to 0 before September 2008 and equal to 1 on and after September 2008, with coefficient λ_1, and D_2 is a dummy variable equal to 0 before September 2008 and after November 2008 and equal to 1 during September and November 2008, with coefficient λ_2.

Country groups are the following:

Developed countries are Australia, Canada, Hong Kong, Japan, New Zealand, Singapore, Spain, U.K. and U.S.

Emerging countries are Chile, China, India, Indonesia, Poland, Philippines, Russia and Thailand.

Asia-Pacific[1] countries are Australia, Canada, Chile, China, Hong Kong, India, Indonesia, Japan, New Zealand, Philippines, Russia, Singapore, Thailand and U.S.

Asia-Pacific[2] countries are Asia-Pacific1 countries excluding Russia and the U.S.

Pacific[1] countries are Australia, Canada, Chile, China, Hong Kong, Indonesia, Japan, New Zealand, Philippines and Singapore.

Pacific[2] countries are Pacific1 countries excluding China and Hong Kong.

The standard errors robust to heteroskedasticity appear in parentheses below parameter estimates, and errors are clustered by country. P value appears below χ^2 test results. Statistical significance at 1%, 5% and 10% levels of confidence is indicated by ***, ** and *, respectively.

5. CONCLUSION

In this paper we examine panel data on coal sector stock price indices available at country level and evaluate risk factors significant in determining return in the coal sector. The paper studies the effect of energy shocks on coal sector stock returns and supplements research evaluating the effect of oil prices on the stock price of oil and gas companies.

It is found that oil prices have a significant impact on coal sector returns even in the presence of coal price returns. A 1% increase in coal price return raises the coal company returns by between 0.22% and 0.30%. This result is robust across developed, emerging and differing groups of Asia-Pacific and Pacific countries, and is comparable in magnitude to findings in the literature for the effect of oil price on returns in the oil and gas sector. Oil price has a statistically significant impact on coal sector returns. A 1% increase in oil price raises coal sector returns by 0.06-0.20%. The result may follow because news about energy commodities focuses primarily on oil price. Research supports the view that the market for crude oil is an international market, whereas the market for coal is only more recently emerging as a global market. Participants in the market may perceive oil price as serving as the bench mark for future global demand for energy overall. For this reason crude oil price developments have influence on coal sector stocks. The coefficients of coal price return and oil price return are positive and statistically significant in regressions for coal sector returns in both developed and emerging markets. The exposure of coal sector return to coal price return is greater than that to oil price return for both developed and emerging markets.

Market return, interest rate premium, foreign exchange rate risk, and coal price returns are statistically significant in determining the excess coal sector stock returns. Currency depreciation has a negative impact on the return of coal companies, a result similar to that found by comparable country studies for oil and gas companies. The exchange rate does not significantly influence local currency returns in the coal sector other than through the impacts on local currency denominated market, coal and oil returns. Understanding the variables that affect the behaviour of stock prices of coal companies is of importance to market participants and to policy makers for developing efficient hedging policies for dealing with oil and energy price shocks. To hedge against energy price shocks, investors can invest in coal sectors or coal companies, since the study finds that higher oil and coal prices lead to higher returns in these areas.

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