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The power play of natural gas and crude oil in the move towards the financialization of the energy market

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ABSTRACT

The financialization of the energy market has capacitated energy commodities to affect economic activities unfathomably. Despite the availability of rich literature investigating *crude oil* and developing its strong ties with economic and financial stability and climate change, little attention has been paid to *natural gas (NG or LNG)* and its potential to affect economies. Natural gas is not merely an alternative fossil fuel and a substitute for crude oil but it also presents huge advantages in terms of cost and low carbon emission. This study contributes to the literature and provides meaningful evidence on how changes in natural gas futures prices affect the equity returns in G-5 economies using the data covering almost two decades. Our results present a few exciting insights. First, we find that oil and gas prices are weakly correlated and do not reflect the dependence of gas on oil as reported in previous studies. Second, we find that although gas price changes negatively affect equity market returns in the short run, it subsides substantially in the long run. Holistically, our findings identify the hedging potential that natural gas provides to cope with the volatility in crude oil prices. We also assert that substituting oil with natural gas may improve the sustainability and stability of financial markets in G-5 economies.

1. Introduction

Researchers have always tried to find the common factors that may reshape the returns of a specific stock or an index, or an asset class. The list is exhaustive, but these factors could be broadly classified as the macroeconomic variables, market factors, accounting practices, or simply the firms' specific factors. However, the changes in oil prices emerged as an essential determinant of stock market returns following the seminal work of [(Hamilton, 1983), (Hamilton, 1996), (Bernanke et al., 1997)] who observed that a recession always followed an increase in oil prices in the US economy. (Chen et al., 1986) and (Jones and Kaul, 1996) became the literature pioneers and presented empirical evidence on oil prices as a significant risk factor for stock returns. Since then, the relationship between oil prices and stock market returns has been studied extensively in the literature.

The analysis of literature, however, reveals divergent results and a lack of consensus in the findings. The studies of (Boyer and Filion, 2007; El-Sharif et al., 2005; Hamdi et al., 2019; Mohanty et al., 2011; Sadorsky, 2001; Sakaki, 2019) while investigating the relationship between oil prices and stock returns across equity market indices and sectoral indices of various economies (US, UK, Canada, GCC) report that stock markets react positively to oil price shock. However, the other group of studies show contrasting results and provide evidence on the negative relationship between stocks returns and oil price changes [see for example (Ciner, 2001, 2013; Driesprong et al., 2008; Miller and Ratti, 2009; Papapetrou, 2001; Sadorsky, 1999; Sajjadur and Serletis, 2019; Singhal et al., 2019). Many studies also show the negative impact of energy prices on overall financial development (Hussain et al., 2020; Li

Abbreviations: LNG, Liquefied Natural Gas; NG, Natural Gas; G5, Group of 5 (Brazil, China, India, Mexico and South Africa); CS-ARDL, Cross Sectional Autoregressive Distributed Lag; PMG, Pooled Mean Group; G8, Group of Eight Highly Industrialized Countries; EIA, Energy Information Administration; WDI, World Development Indicators; XR, Exchange Rate; PR, Policy Interest Rate; CPI, Consumer Price Index; RGR, Real GDP Growth Rate; EMP, Equity Market Prices; IPS, Im, Pesaran and Shin; CIPS, Cross Sectionally Augmented Im, Pesaran and Shin.

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et al., 2020; Wei et al., 2020). In addition, there exists a group of researchers who pose a challenge to the link between these two variables and show that oil prices have no significant impact on stock market returns (Al-Fayoumi, 2009; Al Janabi et al., 2010; Apergis and Miller, 2009; Cong et al., 2008; Henriques and Sadorsky, 2008).

Several studies highlight that the effect of oil prices on stock markets and stock returns depends on the nature of oil shock and the status of an economy (Rizvi and Itani, 2021). For example, an increase in oil prices negatively affects a firm's cash flows and equity returns in an oil-importing economy. At the same time, the reverse is true for an oil-exporting country as an increase in oil prices means higher profits and stock market appreciation. The relationship between oil price and stock returns is also different based on the nature of oil shock. In the seminal papers, (Kilian, 2009) and (Kilian and Park, 2009) provide evidence on the asymmetric effect of oil demand and supply shocks on stock return. They find that oil-demand shocks hurt stock prices while the impact of the oil-supply shock on stock prices is low. (Basher et al., 2018) also report that most stock markets react significantly to oil-demand shocks, while oil supply shocks affect only some selected stock markets.

The nexus between oil prices and stock returns becomes even more interesting when considering emerging energy and financial markets trends. Recent years have witnessed investors and firms' increasing interest in using energy futures to hedge against the volatile price of oil, which is a significant factor of production and may affect stock returns (Naqvi et al., 2021; Reddy et al., 2017). The financialization of the commodities markets is said to have played an essential role in the increasing use of energy futures by firms (Gagnon et al., 2020). The monopoly of crude oil has also been challenged with the emergence of liquefied natural gas as an alternative energy commodity since the early 2000s, coupled with the availability of energy futures based on natural gas. According to the estimates of International Energy Agency, natural gas is on the biggest rise relative to its 2019 level and is also the second largest source of energy as it represents 16% of total energy consumption followed by coal which is 10% of the consumption while oil takes the lead with 40% of total energy consumption (IEA, 2020). LNG provides the additional benefits of low cost and reduced carbon emission, and therefore, firms can substitute crude oil with natural gas as a factor of productions. This substitution may lead to an exponential increase in the use of natural gas futures to hedge against the price variability too (Bresciani et al., 2020).

Moreover, with natural gas becoming a vital part of the global economic system, it has the potential to affect economic activity similarly to crude oil (Geng et al., 2020). While the relationship and impact of oil prices changes on the financial market and economic growth is well-documented, the same is not valid for natural gas prices. For researchers, all this mean that our understanding of how changes in energy prices shape equity returns may change if we consider the existence of both oil and natural gas as alternative sources of energy within the context of increasing financialization of energy markets and the role of an individual economy's characteristics vis-à-vis its relative reliance on oil and natural gas as factors of production.

Therefore, this research assesses how alternative energy futures are reshaping the equity returns in G5 economies. Specifically, we estimate how changes in oil and natural gas prices affect the equity market returns in G5 economies, including Brazil, China, India, Mexico, and South Africa; and make several contributions to the literature on energy finance.

First, our selection of G5 economies is exclusive and inspired by numerous factors. First, these five economies have expanded exponentially over the years and represent the group to be construed closer to the major developed industrialized economies (G8). This group enables us to represent the dynamics of Asia and Africa which are the two regions recognized as potentially the largest consumer of liquefied natural gas (LNG) in recent years [(Hasan et al., 2021), (Hasan et al., 2021)]. The firms in these countries have all the incentives to change their energy mix and substitute crude oil with natural gas as a factor of production, a trend that is expected to grow over the next many years [(Bresciani et al., 2020), (Taghizadeh-Hesary et al., 2020)]. According to the annual report of International Energy Agency, Asia is a growing consumer of natural gas, and it accounted for the largest share of global liquefied natural gas (LNG) imports in 2019 (69%); with China becoming the world's largest importer of natural gas in 2018 (EIA, 2020).

Second, we focus on the pair of energy Futures where natural gas is considered as an alternative energy source to crude oil. Until the last decade, natural gas was not considered an actual substitutable commodity to crude oil due to the lack of its tradability, dependent pricing fundamentals (as gas prices were derived from oil prices) and higher cost due to unavailability of technology. However, trends changed during the last few years, and visible improvements have been made as far as the costing, pricing, and tradability of natural gas. Emerging literature reports that oil and gas prices are becoming independent and natural gas prices are determined by supply and demand fundamentals. For example, (Nick and Thoenes, 2014) finds that the crude oil price only affects natural gas prices after a substantial delay capturing the economic climate and the substitution relationship between the energy commodities. (Hulshof et al., 2016) also find a very small impact of oil price on gas prices. These findings challenge the conventional opinion that crude oil is the primary determinant of natural gas prices as argued by (Brown and Yücel, 2008; Hartley et al., 2008; Panagiotidis and Rutledge, 2007). In addition, increasing environmental awareness and a movement towards energy sources (Rizvi et al., 2021) that reduce carbon emission have also gained momentum in recent years (Su et al., 2020). Therefore the acceptability of natural gas as an alternative or a substitute of crude oil has increased.

Third, there are very few studies which study the relationship between natural gas and equity markets and there is no study, to the best of our knowledge, which study oil, natural gas and equity markets dynamics in G5 economies. The earliest such investigation to explore the relationship between natural gas prices and stock markets for EU-15 countries was conducted by (Acaravci et al., 2012). Their results show that an increase in natural gas prices affects growth in industrial production, which in turn affects stock returns. (Ahmed, 2018) studies the interdependence between natural gas prices and stock market returns in Qatar and reports that the stock market reacts little to the changes in gas prices. (Benkraiem et al., 2018), while studying the relationship between energy markets and S&P 500 index, report that natural gas and crude oil are the key variables in explaining short and long-run dynamics of S&P500. (Kumar et al., 2019) who examine the connectedness and volatility spillover between oil, natural gas and stock market in India, report no long-run cointegration between gas and stock market. A recent study (Geng et al., 2020) estimates the network connectedness between natural gas and stock market in North America and Europe and reports that two regional gas markets are affected by financial market uncertainty in the short and long term. However, the objective of their study is to measure the impact of uncertainty in financial market on gas market. In sum, we expand the literature on alternative energy resources and provide empirical evidence on the relationship between oil, natural gas and stock market in G5 economies.

The rest of the paper is structured as follow. Section 2 explains the dataset. Section 3 lays down the methodology and explains the model used to investigate the relation between alternative energy and equity markets. Section 4 shows the results and provides a discussion of our findings. It is then followed by Section 5 which concludes our study.

2. Data

As has been explained earlier that the purpose of this study is to understand the role of natural gas prices vis a vis crude oil prices on the stock market performance of G5 economies. The countries included in G5 economies are Brazil, China, India, Mexico and South Africa which are the part of our panel. The daily prices of crude oil and natural gas futures are obtained from Bloomberg for the 20 years' period starting from 2000 till 2019. The data for the representative stock market index G5 economies is also obtained from Bloomberg. The data for the control variables is obtained from World Development Indicators (WDI) for the same period of 2000 to 2019. We use the key macroeconomic variables like policy rate, inflation, GDP growth rate and the exchange rate as control variables because of their undisputed power and the relationship with the performance of stock markets. Since the WDI data is available on annual frequencies therefore, the data obtained from Bloomberg is also transformed for annual frequency by averaging the daily prices and daily index values. It is also important to note that some variables are transformed in their logarithmic form for further analysis to ensure comparability across different countries. Table 1 below explains the choice, notation, measurement, frequency and transformation of different variables used in this study.

3. Methodology

3.1. Model specification

We use an array of econometric techniques that are helpful in analysing the impact of domestic prices of crude oil and gas futures on the overall stock market performance. Since there is a possibility that the selected panel of G5 economies would respond to significant changes in energy derivative prices, at least in the long run if not in the short run, it is important to analyze this relationship in both time spans. To achieve this objective, we employ cross sectionally augmented autoregressive distributed lag model (CS-ARDL). The CS-ARDL model was originally proposed by (M. Hashem Pesaran and Smith, 1995) and is quite a dated model, however it has been significantly enhanced by (Chudik and Pesaran, 2015) lately. The choice of this model is primarily motivated by the two reasons. First is the widely accepted realization of the fact that disturbances in panel data models are NOT cross sectionally independent, which is one of the most common assumption we make while working with panel data (Chudik and Pesaran, 2015; Wooldridge, 1995). It is further emphasized by the (Chudik and Pesaran, 2015) that CS-ARDL estimation employs both MG (mean group) and PMG (pooled mean group) estimators. As a result the CS-ARDL helps us incorporating the cross sectional dependence and save us from the unaccounted for residual dependence which may result in the loss of estimator's efficiency and the invalidity of the test statistics. The second reason of using CS-ARDL is its specific relevance, pointed out by (Westerlund, 2007). For the proper deployment of CS-ARDL model, the time dimension (T) must be large enough so that the estimations can be made for each cross sectional unit. Since in our sample, described above, the time series dimension is significantly larger than the cross sectional dimension (T > N), therefore using CS-ARDL is the natural choice. This view is strongly supported by (Arnold et al., 2011; Cavalcanti et al., 2015; Erülgen et al., 2020; Odugbesan and Rjoub, 2019; Samargandi et al., 2015) owing to the consistent estimates of the mean of the short term coefficients provided by the PMG approach used in CS-ARDL model.

Since our primary objective is to explore how the derivative prices of two energy futures (Crude oil and Natural Gas) can impact the stock prices in G5 economies. We set up our primary model using panel ARDL approach;

$$EMP_{i,t} = \alpha_i + \sum_{k=1}^{p}\beta_0 EMP_{i,t-k} + \sum_{k=0}^{q}\beta_1 OIL_{i,t-k} + \sum_{k=0}^{q}\beta_2 GAS_{i,t-k} + \sum_{k=0}^{q}\beta_3 X_{i,t-k} + \varepsilon_{i,t} \tag{1}$$

To capture and distinguish between long run and short run dynamics, unrestricted error correction model (ECM) specification can be derived from Eq. (1);

$$\begin{aligned}\Delta EMP_{i,t} =& \alpha_i + \phi_i\left(EMP_{i,t-k} + \omega_1 OIL_{i,t-k} + \omega_2 GAS_{i,t-k} + \omega_3 X_{i,t-k}\right)\\ &+ \sum_{k=1}^{p-1}\lambda_{ik}\Delta EMP_{i,t-k} + \sum_{k=0}^{q-1}\lambda'_{ik}\Delta OIL_{i,t-k} + \sum_{k=0}^{q-1}\lambda''_{ik}\Delta GAS_{i,t-k}\\ &+ \sum_{k=0}^{q-1}\lambda'''_{ik}\Delta X_{i,t-k} + \varepsilon_{i,t}\end{aligned} \tag{2}$$

Where i and t represent each G5 economy and time period respectively, EMP is the stock market index in local currency, OIL and GAS are the international USD prices of energy futures contracts[1] and X is a vector of control variables that include exchange rate (XR), policy interest rate (PR), consumer price index (CPI) and real GDP growth rate (RGR) in both equations. In Eq. (2), the lambda operator λ and its different variants represent short run coefficients of the lagged values of dependent (EMP), independent (OIL and GAS) and the control variables. The long run coefficients for OIL, GAS and the control variables are ω_1, ω_2 *and* ω_3. Finally the speed of adjustment in the dependent variable in response to the changes in explanatory variables or the error correction term is shown by the operator ϕ_i in Eq. (2).

3.2. Panel unit root testing

Before applying the above specification, as part of the preliminary investigation of time series data it is obligatory to gauge the level of stationarity in time series. Keeping in view the possibility of cross sectional dependence in the data, we employ CIPS (M. Hashem Pesaran, 2007) which is a second-generation cross-sectionally augmented version of IPS test (Im et al., 2003). CIPS test does not only absolve the assumption of cross sectional independence but also allow autoregressive parameters to vary across cross sections to accommodate heterogeneity in the panel.

3.3. Cointegration test

To analyze the possible cointegration relationships among variables we apply Pedroni panel cointegration test (Pedroni, 1999, 2004) which is an extension of Engle-Granger framework to tests cointegrating relationship within a panel data. The test is extremely powerful as it is based on seven test statistics to evaluate the null hypothesis of no cointegration. These statistics allow heterogeneity not only in the long run slope and intercept coefficients but in the short run dynamics as well across different cross sections. The general framework of the test is as follows

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i}x_{1i,t} + \beta_{2i}x_{2i,t} + \ldots + \beta_{Mi}x_{Mi,t} + e_{i,t} \tag{3}$$

Where $t = 1, \ldots, T$; $i = 2, \ldots, N$; $m = 1, \ldots M$; the vector y and x are assumed to be integrated of order one i.e. I(1). The estimated parameters α_i*and* δ_i are the individual and trend effects, which can be removed by setting them equal to zero.

The residual $e_{i,\,t}$ will be of order I(1) under the null hypothesis of no cointegration. This can be tested by running an auxiliary regression on the residuals obtained from Eq. (3) for each cross section. The auxiliary regression would be like;

$$e_{i,t} = \rho_i e_{i,t-1} + u_{i,t} \tag{4}$$

Or

$$e_{i,t} = \rho_i e_{i,t-1} + \sum_{j=1}^{Pi}\psi_{ij}\Delta e_{i,t-j} + v_{i,t} \tag{5}$$

The test statistics for Pedroni panel cointegration $\aleph_{N,\,T}$ can be constructed from the residuals of either Eq. (4) or (5). After standardization however the standardized statistic would be asymptotically normally distributed

[1] The model has been re-estimated by using domestic prices of energy futures converted at spot exchange rate for each country. Our results are robust and show no significant difference.

Table 1
Description, estimation and transformation of variables.

Variables	Notation	Original unit/measurement	Frequency	Specification used in the study	Source
Equity Market Price Index	EMP	Local currency Indices (BVSP, SSE, BSE, MXX and JSE for Brazil, China, India, Mexico and South Africa respectively)	Annual (Average) For 20 Years	Log Transformation	Bloomberg
Domestic Price of Oil Futures	OIL	Prices of Oil Futures denominated in USD	Annual (Average) For 20 Years	Log Transformation	Bloomberg
Domestic Price of Natural Gas Futures	GAS	Prices of Natural Gas Futures denominated in USD	Annual (Average) For 20 Years	Log Transformation	Bloomberg
Spot Exchange Rate (Direct Quote)	XR	Units of Local Currency against One unit of USD	Annual (Average) For 20 Years	Log Transformation	WDI
Policy Interest Rate	PR	Percentage Rate	Annual (Average) For 20 Years	Percentage	WDI
Consumer Price Index	CPI	Index based on domestic Prices of representative basket of goods	Annual (Average) For 20 Years	Log Transformation	WDI
Real GDP Growth Rate	RGR	Percentage Rate	Annual (Average) For 20 Years	Percentage	WDI

Note: For robustness purposes we re-estimate the entire model using Domestic prices of Oil and Gas futures by converting international USD prices at spot exchange rate for each country. There is no significant difference in results provided by both estimations.

$$\frac{\aleph_{N,T} - \mu\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1) \tag{6}$$

Where μ *and* v are Monte Carlo generated adjustment terms.

3.4. Testing for cross sectional dependence

After completing our investigation for the presence of unit root and the cointegration relationships, we conduct the examination for cross sectional dependence. For this purpose we employ Pesaran cross-sectional dependence test (Pesaran, 2004). The null hypothesis assumes the absence of cross sectional dependence and that the units included in the panel are independent, while the alternative hypothesis suggests the existence of cross sectional dependence among units. The test statistics is based on pairwise correlation coefficients and is iid with zero mean and finite variance of 1, conditioned upon that all regressors are strictly exogenous.

$$CSD = \sqrt{\frac{2t}{n(n-1)}\left(\sum_{i=1}^{n-1}\sum_{j=i+1}^{n}\widehat{\rho_{i,j}}\right)} \tag{7}$$

CSD statistics is based on pairwise correlation coefficients and follows the asymptotically standard normal two tailed distribution with a zero mean and a finite variance of 1, conditioned upon that all regressors are strictly exogenous.

4. Discussion and interpretation of results

4.1. Descriptive statistics and correlation structure

We begin our analysis with the presentation of descriptive statistics in Table 2. Most common descriptive statistics for each variable considered are being reported not only in aggregate but for all five countries included in our panel. All variables are transformed in their logarithmic form except the Policy interest rate (PR) and the real GDP growth rate (RGR) which are presented in percentage points. Both international and domestic prices of Oil and Gas futures are also reported in Table 2. The domestic prices of Oil and Gas futures are obtained by converting their international prices at the spot exchange rate denominated as direct quote i.e. local currency per unit of foreign currency (USD).

Table 3 reports the correlation structure for all variables. The significance of each correlation coefficient can be evaluated by looking at the associated probability. The most important and noteworthy element of this structure is the correlation between international prices of Oil and Gas which is low and insignificant. There is a general notion that the prices of two energy alternatives are highly correlated owing to their price linking mechanism and earlier studies (Brown and Yücel, 2008; Hartley et al., 2008; Panagiotidis and Rutledge, 2007) supported this notion but more recent studies are challenging this belief [e.g., (Nick and Thoenes, 2014), (Hulshof et al., 2016)]. Moreover, the connection might be true in short run and for high frequency data, however, as shown in Table 3, that for long run annual data the two commodity prices have no significant correlation between them. This observation clearly reinforces our motivation in this paper where we seek to evaluate the increasing importance of Natural Gas prices for the financial market returns in G5 economies. It is to be noted however, that if we look at the correlation coefficient between *domestic* prices of Oil and Gas, we may find significantly high correlation due to their common multiple i.e. exchange rate. The other important observation is the positive correlation of stock market prices with the Oil futures and the negative correlation with the Gas futures in overall sample. This also justifies the theme of this paper as both correlation coefficients are significant.

4.2. Panel unit root and stationarity testing

For unit root testing we employ CIPS (M. Hashem Pesaran, 2007) panel unit root test which is a second-generation cross-sectionally augmented version of IPS test (Im et al., 2003). CIPS test does not only absolve the assumption of cross-sectional independence but also allow autoregressive parameters to vary across cross sections to accommodate heterogeneity in the panel. The test is designed to evaluate the null hypothesis that unit root is present which means that financial time series is nonstationary. The results are reported in Table 4 and first panel provides the results of CIPS test at level. Null hypothesis of unit root cannot be rejected in most of the cases which leads us to estimate all series at their first difference form where the null of unit root is significantly rejected. This clearly indicates that all variables are stationary only in their first difference form and the order of integration is I(1).

4.3. Existence of panel cointegration and cross sectional dependence

After confirming the order of integration for all series, the next logical step is to check whether the series are cointegrated or not. For this purpose we employ Pedroni panel cointegration test (Pedroni, 1999, 2004) which is an extension of Engle-Granger framework to tests cointegrating relationship within a panel data. The test reports seven test statistics, four for "within dimension" and three for "between dimension". The test clearly rejects the null hypothesis of "No Panel Cointegration" and provides strong justification to us to deploy ARDL model and its error correction specification to investigate the long run and short run dynamics. The results are reported in Table 5.

The final part of the preliminary investigation is to employ Pesaran

Table 2
Descriptive statistics.

COUNTRY	Mean	Median	Max	Min.	Std. Dev.	Skew.	Kurt.	Obs.
Equity Market Index (EMP)								
Brazil	10.61	10.88	11.52	9.35	0.64	−0.76	2.27	20.00
China	7.75	7.80	8.35	7.05	0.34	−0.32	2.24	20.00
India	9.48	9.72	10.55	8.09	0.81	−0.53	1.96	20.00
Mexico	10.05	10.36	10.80	8.72	0.77	−0.78	2.03	20.00
South Africa	10.14	10.25	10.94	9.02	0.69	−0.42	1.75	20.00
All	9.61	9.91	11.52	7.05	1.19	−0.50	1.98	100.00
Futures Prices (International, USD) of Crude oil (OIL)								
Brazil	4.04	4.08	4.60	3.26	0.44	−0.39	2.03	20.00
China	4.04	4.08	4.60	3.26	0.44	−0.39	2.03	20.00
India	4.04	4.08	4.60	3.26	0.44	−0.39	2.03	20.00
Mexico	4.04	4.08	4.60	3.26	0.44	−0.39	2.03	20.00
South Africa	4.04	4.08	4.60	3.26	0.44	−0.39	2.03	20.00
All	4.04	4.08	4.60	3.26	0.43	−0.39	2.03	100.00
Futures Prices (Domestic, Local Currency) of Crude oil (OIL)								
Brazil	4.94	4.99	5.47	4.08	0.40	−0.85	2.94	20.00
China	6.01	6.05	6.54	5.37	0.37	−0.32	1.82	20.00
India	7.99	8.03	8.66	7.11	0.49	−0.53	2.16	20.00
Mexico	6.59	6.71	7.13	5.49	0.56	−0.89	2.43	20.00
South Africa	6.24	6.40	6.92	5.41	0.51	−0.50	1.86	20.00
All	6.35	6.36	8.66	4.08	1.09	0.26	2.46	100.00
Futures Prices (International, USD) of Natural Gas (GAS)								
Brazil	1.47	1.41	2.19	0.93	0.41	0.35	1.97	20.00
China	1.47	1.41	2.19	0.93	0.41	0.35	1.97	20.00
India	1.47	1.41	2.19	0.93	0.41	0.35	1.97	20.00
Mexico	1.47	1.41	2.19	0.93	0.41	0.35	1.97	20.00
South Africa	1.47	1.41	2.19	0.93	0.41	0.35	1.97	20.00
All	1.47	1.41	2.19	0.93	0.40	0.35	1.97	100.00
Futures Prices (Domestic, Local Currency) of Natural Gas (GAS)								
Brazil	2.37	2.29	3.08	1.71	0.35	0.33	2.45	20.00
China	3.44	3.34	4.30	2.80	0.48	0.28	1.74	20.00
India	5.42	5.33	5.98	5.02	0.28	0.57	2.34	20.00
Mexico	4.02	4.03	4.59	3.48	0.30	0.26	2.66	20.00
South Africa	3.67	3.66	4.30	3.14	0.25	0.46	4.06	20.00
All	3.78	3.72	5.98	1.71	1.05	0.22	2.40	100.00
Spot Exchange Rate Direct Quote (XR)								
Brazil	0.90	0.85	1.37	0.51	0.27	0.24	1.69	20.00
China	1.97	1.93	2.11	1.82	0.12	0.21	1.43	20.00
India	3.95	3.87	4.25	3.72	0.18	0.53	1.69	20.00
Mexico	2.55	2.53	2.96	2.23	0.24	0.57	2.14	20.00
South Africa	2.21	2.12	2.69	1.85	0.28	0.47	1.79	20.00
All	2.32	2.13	4.25	0.51	1.02	0.27	2.40	100.00
Policy Lending/Interest Rate (PR)								
Brazil	47.03	45.78	67.08	27.39	10.24	0.08	2.43	20.00
China	5.47	5.58	7.47	4.35	0.83	0.28	3.04	20.00
India	10.84	10.68	13.31	8.33	1.32	0.18	2.27	20.00
Mexico	7.39	7.39	16.93	3.42	3.20	1.37	5.21	20.00
South Africa	11.39	10.54	15.75	8.50	2.32	0.62	2.02	20.00
All	16.42	10.05	67.08	3.42	16.28	1.66	4.36	100.00
Consumer Price Index (CPI)								
Brazil	4.59	4.58	5.12	3.96	0.36	−0.13	1.97	20.00
China	4.60	4.59	4.83	4.39	0.15	−0.02	1.53	20.00
India	4.57	4.55	5.20	4.00	0.41	0.08	1.49	20.00
Mexico	4.57	4.58	4.95	4.15	0.24	−0.09	1.86	20.00
South Africa	4.58	4.59	5.07	4.09	0.31	0.07	1.71	20.00
All	4.58	4.59	5.20	3.96	0.30	−0.03	2.16	100.00
Real GDP Growth Rate (RGR)								
Brazil	2.39	2.46	7.53	−3.55	2.84	−0.38	2.93	20.00
China	9.02	8.81	14.23	6.11	2.11	0.80	3.14	20.00
India	6.51	7.23	8.50	3.09	1.71	−0.62	2.01	20.00
Mexico	2.09	2.30	5.12	−5.29	2.36	−1.46	5.78	20.00
South Africa	2.64	2.82	5.60	−1.54	1.89	−0.28	2.55	20.00
All	4.53	4.09	14.23	−5.29	3.53	0.05	3.08	100.00

Note: Each panel of Table 1 provide the descriptive statistics of different variables across all cross sections and on overall basis. All variables have been transformed into their logarithmic form except Policy Interest Rate (PR) and the Real GDP Growth Rate which are in percentages.

Table 3
Correlation matrix.

Correlation Probability	EMP	OIL	GAS	XR	PR	CPI	RGR
EMP	1.000000						
	–						
OIL	0.360353***	1.000000					
	0.0002	–					
GAS	−0.240441**	0.083675	1.000000				
	0.0160	0.4079	–				
XR	−0.098940	−0.027974	−0.118424	1.000000			
	0.3274	0.7823	0.2406	–			
PR	0.378915***	−0.140049	0.084149	−0.615857***	1.000000		
	0.0001	0.1646	0.4052	0.0000	–		
CPI	0.475425***	0.482513***	−0.638179***	0.105689	−0.143628	1.000000	
	0.0000	0.0000	0.0000	0.2953	0.1540	–	
RGR	−0.641035***	0.069985	0.291901***	0.205104**	−0.323685***	−0.161257	1.000000
	0.0000	0.4890	0.0032	0.0407	0.0010	0.1090	–

Note: ***, ** and * shows significance at 1%, 5% and 10%. All variables have been taken in their logarithmic form except Policy Interest Rate (PR) and Real GDP Growth Rate (RGR) which are in percentages.

Table 4
Panel unit root/stationarity testing.

Variables	Individual intercept	Individual intercept & trend
Level		
EMP	−0.54275	0.06799
OIL	−1.50267*	0.49422
GAS	−0.61679	−0.42935
XR	−1.70885	0.90651
PR	−1.24845	−1.43719
CPI	−2.15531	−2.10351
RGR	−1.64403*	−1.16657
First Difference		
EMP	−3.44651***	−2.87006***
OIL	−3.16298***	−2.51273***
GAS	−5.04129***	−3.69644***
XR	−3.56483***	−3.38696***
PR	−5.54493***	−4.29855***
CPI	−3.99467***	−2.68250***
RGR	−5.78844***	−4.57180***

Note: ***, ** and * shows significance at 1%, 5% and 10%. All variables have been taken in their logarithmic form except Policy Interest Rate (PR) and Real GDP Growth Rate (RGR) which are in percentages.

Table 5
Pedroni's residual based cointegration test.

	Within dimension statistic	Between dimension statistic
Panel v-Statistic	2.9865***	
Panel rho-Statistic	−2.2326**	−1.9547*
Panel PP-Statistic	−2.9233***	−2.7641***
Panel ADF-Statistic	−3.4598***	−4.2517***

Note: ***, ** and * shows significance at 1%, 5% and 10%.

cross-sectional dependence test (M.H. Pesaran, 2004). The null hypothesis is that there exists no cross section dependence and that the units included in the panel are independent. The results provided in Table 6 reveal that the null hypothesis of no cross sectional independence is rejected at 1% confirming the presence of strong cross sectional dependence in the data. These results are in line with the argument that increased global economic and financial integration has increased the degree of contagion and that the countries with different location and dynamics be equally exposed to the global shocks. This test in particular also justifies all the choices we have recommended earlier in our methodology including the selection of CS-ARDL model, CIPS Unit root test and the Pedroni's panel cointegration test. All these recommended methodologies are apt to deal with a panel with significant cross sectional dependence.

Table 6
Cross sectional dependency test.

Variables	Test statistics	*P*-value
EMP	12.16***	0.000
OIL	14.14***	0.000
GAS	14.12***	0.000
XR	3.99***	0.000
PR	6.01***	0.000
CPI	13.99***	0.000
RGR	4.67***	0.000

Note: ***, ** and * shows significance at 1%, 5% and 10%. All variables have been taken in their logarithmic form except Policy Interest Rate (PR) and Real GDP Growth Rate (RGR) which are in percentages. Null hypothesis of No Cross Section Dependence is tested.

The results of Pesaran (2004) cross-section dependency test reported in Table 6 clearly refute the null hypothesis of cross sectional independence at a 1% significance level. This implies that infact chosen cross sections, in this case the G5 economies, are significantly dependent on each other based on the variables included in our model. These results are intuitive and are backed up by the fact that due to increased economic and financial integration (Rizvi et al., 2013) as well as the increased trading volume that exist between these countries, observing such cross sectional dependence is highly plausible. This cross sectional dependence also indicate that the G5 economies are collectively able to affect the global economic activities in addition to affecting each other. One implication of this finding, however, is that cross sectional dependence invalidates the use of first-generation unit root tests and therefore this study must deploy panel unit root tests that are capable to cope up with the problem of dependency and heterogeneity among cross-section entities.

4.4. Oil and gas futures prices and stock market performance

Table 7 below presents the long run and short run estimates along with error correction term and deterministic trend estimated through CS-ARDL model. We first discuss the short run coefficients some of

Table 7
Long run and short run effects of oil and gas futures prices on equity market prices (PMG estimates).

Regressor: EM	Coefficient	Std. Error	*t*-Statistic	Prob.*
	Long Run Equation			
OIL	0.851820***	0.208722	4.081125	0.0002
GAS	0.160788	0.146972	1.094002	0.2793
XR	0.366546	0.405340	0.904292	0.3703
PR	0.006589	0.010992	0.599399	0.5517
CPI	−1.375905	0.856408	−1.606599	0.1146
RGR	0.095077***	0.022993	4.134963	0.0001
	Short Run Equation			
ECC	−0.312941***	0.082209	−3.806647	0.0004
ΔOIL	−0.294213*	0.141184	−2.083895	0.0424
ΔGAS	−0.161711***	0.034190	−4.729777	0.0000
ΔXR	−0.876765*	0.484477	−1.809713	0.0765
ΔPR	−0.015822	0.024966	−0.633731	0.5292
ΔCPI	2.370446	3.210775	0.738279	0.4639
ΔRGR	0.054908	0.051245	1.071491	0.2892
C	2.320277***	0.676099	3.431858	0.0012
TREND	0.042268***	0.015572	2.714321	0.0091

Note: ***, ** and * shows significance at 1%, 5% and 10%. All variables have been taken in their logarithmic form except Policy Interest Rate (PR) and Real GDP Growth Rate (RGR) which are in percentages.

which are worth mentioning. First of all, the negative and significant error correction term confirms the presence of long run causal relationship between stock market performance and explanatory variables and also ensures the existence of long run equilibrium through adjustment process. The coefficients for both Oil and Gas, the main variables of interest in our study, are negative and significant. This implies that on aggregate the stock markets in G5 economies bleed and suffer when the price of any of the alternative energy source increases. The main rationale behind it that in short run companies cannot make speedy adjustment in response to the increased energy prices and they need to take the hit of high prices particularly when they are not hedged against uncertain price movements. This finding is extremely important because if in the presence of oil and other control variables, the impact of gas futures prices is negative on stock market performance it clearly indicates that a significant proportion of industrial and economic activities in G5 countries are now as dependent on gas as they are on oil. However, when it comes to the long run impact of alternative fuel prices on stock market performance, gas prices seem to have fading impression. Oil Futures prices seem to move in harmony with the stock market performance, albeit the positive sign of it is not what is generally expected. It looks as if stock markets in G5 countries are responding positively to increased Oil Futures prices.

4.5. Robustness tests

To ensure the robustness of the estimated coefficients reported in Table 7 and the inference drawn based on them, we provide the short run coefficients estimated for each cross section in Table 8. The results broadly support our hypothesis that natural gas is visibly becoming an alternative energy source especially for industrial and emerging economies [(Benkraiem et al., 2018), (Geng et al., 2020)]. There hasn't been any doubt about the impact of Oil prices on stock market performance as the phenomenon has been widely researched and proven [(Boyer and Filion, 2007; El-Sharif et al., 2005; Hamdi et al., 2019; Mohanty et al., 2011; Sadorsky, 2001; Sakaki, 2019); (Ciner, 2001, 2013; Driesprong et al., 2008; Miller and Ratti, 2009; Papapetrou, 2001; Sadorsky, 1999; Sajjadur and Serletis, 2019; Singhal et al., 2019)]. However, it would be interesting for the readers to infer from the results of Table 8, which indeed are corroborating with the results of Table 7, that except for China, the short run impact of natural gas prices on stock market performance is negative and significant in all G5 economies. These results are consistent with the findings of [(Ahmed, 2018), (Benkraiem et al., 2018) and (Geng et al., 2020)] who also report the increasing role of natural gas in the financial markets.

Finally in Table 9, we report the long run estimates Oil and Gas prices estimated using different model including Robust Least Square, Panel Least Square with no effects, Panel Least Square with Cross Section Fixed Effects, Panel EGLS with Period Random Effects and Panel GMM.

All models unanimously confirm the inference drawn based on the results of Table 7 above i.e. positive role of oil prices on the stock market performance but no impact of gas prices in the long run. The positive role of oil prices on stock market performance is albeit counterintuitive if we assume that the change is driven by a supply-side shock (Cunado and Perez de Gracia, 2014; Cunado and Pérez de Gracia, 2003). However, it makes perfect sense if the change in oil prices is rather driven by the demand-side shocks (Diaz and de Gracia, 2017; Kang et al., 2017). Moreover, researchers throughout the time have been confirming the positive impact of oil prices on aggregates stock market performance for different countries and sample periods which makes our results highly robust, reliable and generalizable (Alamgir and Amin, 2021; Boyer and Filion, 2007; Youssef and Mokni, 2019).

5. Conclusion and discussion

The debate on the nexus between oil prices and stock returns is fierce and inconclusive and is becoming even more interesting when one considers the emerging trends in energy and financial markets. One such significant trend is the availability of liquefied natural gas (LNG) as an energy commodity that has abundant reasons to persuade firms considering it as an alternative and substitute to crude oil. With the increased financialization of energy market where natural gas is becoming an important part of the global economic system, it has all the potential to affect economic activity similarly as crude oil. While the relationship and impact of oil prices changes on financial market and economic growth is well documented, the same is not true for natural gas prices and in this study, we try to fill this void.

We specifically look at how changes in the prices of oil and natural gas Futures affects the equity market returns in G5 economies which

Table 8
Cross section short run coefficients.

Regressor: EM	Brazil	China	India	Mexico	South Africa
ECC	−0.35472***	−0.0253	−0.51783***	−0.27071***	−0.39614***
ΔOIL	−0.28594***	−0.83862***	−0.05212***	−0.16085**	−0.13354***
ΔGAS	−0.2443***	−0.05348	−0.22502***	−0.15079***	−0.13497***
ΔXR	−0.61819***	−2.53226	−1.28596***	−0.18391	0.236494***
ΔPR	−0.00745***	−0.11017***	−0.01073***	0.034566***	0.014668***
ΔCPI	2.098081	14.80632	−0.54545	−2.56532	−1.9414
ΔRGR	0.00144***	0.257541***	−0.02103***	0.009515***	0.027076***
C	3.46769	−0.22674	2.336681	2.575148	3.448605
TREND	0.059421***	0.009256***	0.089039***	0.006805***	0.046821***

Note: ***, ** and * shows significance at 1%, 5% and 10%. All variables have been taken in their logarithmic form except Policy Interest Rate (PR) and Real GDP Growth Rate (RGR) which are in percentages.

Table 9
Long run coefficients across different models.

Regressor: EM	Robust least square	Panel least square	Panel least square (cross section fixed effect)	Panel EGLS (period random effect)	Panel GMM
OIL	0.878991*** (0.203119)	0.834746*** (0.194649)	0.492841*** (0.097938)	0.783840*** (0.201873)	0.749038*** (0.279712)
GAS	0.203791 (0.179170)	0.228974 (0.171698)	−0.029149 (0.102124)	0.368183 (0.251162)	0.253096 (0.184315)
R-Squared	*0.660128*	*0.740364*	*0.964630*	*0.741820*	*0.624946*

Note: ***, ** and * shows significance at 1%, 5% and 10%.
The number reported in parenthesis () below the estimated coefficient is Standard Error.
All variables have been taken in their logarithmic form except Policy Interest Rate (PR) and Real GDP Growth Rate (RGR) which are in percentages, however, the results reported are only for Oil and Gas prices due to the brevity and focus of this study.
Cross Section Random Effects estimation cannot be run as it requires that number of cross sections should be greater than the number of coefficients for between estimator for estimate of RE innovation variance.

include Brazil, China, India, Mexico and South Africa using CS-ARDL model for the data spanning over two decades. Our findings present some interesting insights. First and foremost is that the correlation between Oil and Gas Futures is very low and insignificant. This is opposite to the conventional view that assumes strong dependence of Gas prices on Oil; and supports the recent evidence of low or insignificant relationship between oil and gas.

The results of PMG analysis, which we find appropriate on the basis of Hausmann test, reveal that our hypothesis of Gas prices being an important determinant of stock market performance cannot be rejected at least in the short run. Short run PMG coefficients confirms the negative and significant impact of Gas prices on stock market performance in G5 economies, very similar to the impact of Crude oil. In the long run however, we do not find Gas prices as a significant explanatory variable for the stock market performance. Crude oil nonetheless retains its importance in the long run with a significant and positive coefficient. This positive long run impact of crude oil on stock market performance is in line with the strand of literature which argues for a positive relationship between oil and stock market return; and may also suggest that these economies are able to make necessary adjustments in the long run to deal with the oil price volatility. It also suggests that, in the long run, the intrinsic growth of these economy is substantial enough to offset the increased oil prices; and stock market grows at a faster pace in the long run even when the oil prices are on rise. This argument could be supported with the observation that prior to Global Financial Crisis the increasing oil prices were linked to growth in developing countries; and this this positive relationship could be linked with investors confidence and business performance as investors associate rising oil prices with a stronger business performance and a booming economy.

In sum, the results support the dominance of oil in affecting the financial activity of G5 economies while the role of natural gas is evolving due to the decoupling of oil and gas prices. Natural gas is visibly becoming an alternative energy resource on the one hand, due to the availability of liquified technology and on the other hand because of its potential to protect the environment. Similarly, natural gas is also becoming an important part of the economic system as it has the potential to affect equity market activity in the similar way as done by crude oil especially for emerging G5 economies. This phenomenon has also important implications for investors, businesses, portfolio managers and policymakers. The negative correlation between oil and gas futures provides firms and portfolio managers with an opportunity to hedge commodity portfolio risk; and suggest an increasing interest of market in oil and natural gas as alternative assets classes for portfolio diversification. In addition, while positive relation of crude oil with stock market in the long run means that stock markets in G5 economies have learnt to turn adverse changes in prices of oil to their benefits but, the absence of long-run connectedness between natural gas and stock markets suggest that gas market has either not become fully integrated or increase in gas prices in recovered by increasing output prices leaving stock prices unchanged and therefore, markets and policymakers still need to pay heed to the changes in the natural gas prices and the determinants of its prices as the use of natural gas continues to grow in G5 economies. For researchers, it means that the role of natural gas in economic activity will continue to inspire them to better understand gas-stock nexus where the analysis can be expanded in different dimension for example, increasing the sample of countries and the classification of the economies in terms of being importer or exporters of natural gas and oil.

Credit authors statement

Syed Kumail Abbas Rizvi: Conceptualization, Data curation, Software, Investigation, Writing – original draft.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2022.106131.

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