Connectedness and spillovers between energy stock markets: Evidence from emerging countries

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Abstract

We analyze the connectedness between 219 energy firms from 27 emerging countries. We use weekly data between January 13, 2010 and March 24, 2021. The three-step approach proposed by Fan et al. (2021), and the spillovers analysis based LASSO-VAR model suggested by Demirer at al. (2018) are used to study the connectedness between energy stock markets. Our results reveal that energy stock markets are closely integrated across emerging countries. Principal component adjustments reveal that idiosyncratic factors in energy stock returns are relevant in financial contagion mechanisms and integration degree between them. Energy stock markets in Mongolia, Sri Lanka, Bosnia-Herzegovina, South Korea, Thailand, Taiwan, Vietnam, the Philippines, Pakistan, Argentina, Brazil and Peru show a low level of connectedness in relation to the other emerging markets. The results are robust because the Granger and partial autocorrelation networks showed that the dynamic and contemporaneous connectedness between energy stock returns was concentrated in the same markets. This fact opens relevant spaces for international diversification and attenuates the risks transmission between these markets. These results have important implications for investment decision-making and policymakers.

Keywords: energy firms, renewable energy, spillovers, connectedness.
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1. Introduction

The energy role in the economic development of countries has been unquestionable (Zhang, 2017). However, the significant use of non-renewable energy sources, particularly fossil fuels, has facilitated environmental degradation (Xu and Lin, 2016). Concern about environmental damage has led countries and companies to develop clean and renewable energy sources (He et al., 2016; Ferrer et al., 2018). According to the International Renewable Energy Agency[4] (IRENA, 2017), technological investment in renewable energies increased more than 6 times between 2004 and 2016. Despite this increase, the Energy Information Administration (EIA, 2018) reveals that the participation of these sources in the energy markets is lower than the threshold of 28% required to mitigate the adverse effects on the environment.

Changes in energy production and consumption patterns have had important effects on the economic systems and capital markets around the world. An extensive empirical literature, mainly focused on developed markets, has studied the link between stock and energy markets. The main findings of these investigations support that oil prices have negative effects on stock prices, mainly on energy firms, but positively affect the stock prices of renewable energy firms. This relationship represents an important diversification source for investors between both energy markets (Ferrer at al., 2018; Reboredo et al., 2019; Nasreen et al., 2020; Naeem et al., 2020; Hanif et al., 2021). The little evidence in emerging markets has also corroborated this relationship, and it adds that their energy stock markets tend to be shocks receivers from developed countries and oil commodity markets (Li and Wei, 2018; Evrim et al., 2020; Demirer at al., 2020). Studies focused only on energy stock markets also corroborate this connectedness between developed and emerging countries. However, all of them warn that the incidence of emerging markets in the system has increased, mainly during the global financial crisis and the Covid-19 pandemic (Singh et al., 2019; Tiwari et al., 2021).

Empirical evidence has supported its analyzes on aggregate indices at the country or region level, which represent the different energy markets around the world. This fact prevents capturing the heterogeneity coming from the disaggregated information at firm-level and considering the microeconomic implications on investment decisions and public policy. Only a few recent works offer a vision about the connectedness at firm-level, mainly focused on developed markets (Fuentes and Herrera, 2020; Foglia and Angelini, 2020). However, their findings are limited because used a small number of companies and ignored the growing systematic relevance of the energy firms from emerging countries.

Our research fills this empirical gap and analyze the connectedness for a large firm-level system comprised of 219 energy firms coming from 27 emerging markets. The analysis is based on weekly data for the period between January 13, 2010 and March 24, 2021. Our contributions can be summarized in three points. First, this is a pioneering work in analyzing the connectedness for a wide-system of energy companies and countries through the spillover approach of Demirer et al. (2018). This methodology implements the spillover measures of Diebold and Yilmaz (2012, 2014) through a LASSO-VAR model. To firm-level analysis we use the stocks returns of the each energy firm, while at country-level

[4] International Renewable Energy Agency website: https://www.irena.org

we use an equally-weighted portfolio, calculated as the simple average of the energy stock returns of the firms that belongs to the each country. This fact will allow us, on the one hand, to capture the firms heterogeneity on the connectedness, and on the other hand, it will contribute to evaluating the systematic relevance of these firms and countries within the energy stock market. This fact also has important contributions for investment decisions. Second, to process the energy stock returns this research applies the three-step method proposed by Fan et al. (2021). This method is useful for Sparse VAR or high-dimensional models because through the Principal Component Analysis (hereinafter PCA) it isolates the idiosyncratic and systematic components of the energy stock returns, leaving the non-idiosyncratic component as a determinant of the system connectedness. This is a relevant advantage because it allows us to avoid the use of the systematic control factors such as the oil prices, electricity prices or other financial assets, and it facilitates us the comparison of connectedness between energy stock returns and adjusted returns through PCA. Finally, this investigation deepens the analysis of the energy stock markets of emerging countries. Currently, these countries have achieved greater systematic relevance in the world markets, particularly in energy stock markets. According to the Global Status Report Renewables (2021), emerging economies have significantly increased investment related to renewable energies. During 2020, this investment exceeded by USD 153.4 billion that made by developed countries, and it is mainly concentrated in China. This fact has contributed to offsetting the partial or total divestment process in assets related to fossil fuels, which it reached USD15 trillion during 2020. Despite this greater importance of the emerging markets, the empirical evidence about them is still scarce and that related to the analysis of connectedness between the energy stock markets is still an unanswered question.

Our findings have three relevant implications to analyze. First, our results reveal that energy stock markets are closely integrated across emerging countries. However, the residual stock returns obtained from PCA reveal that idiosyncratic factors in energy stock returns are relevant on financial contagion mechanisms and the integration degree between them. Second, energy stock markets in Mongolia, Sri Lanka, Bosnia-Herzegovina, South Korea, Thailand, Taiwan, Vietnam, the Philippines, Pakistan, Argentina, Brazil and Peru showed lower connectedness in comparison to other emerging markets. This fact opens relevant spaces for international diversification and attenuates the risks transmission between these markets. Finally, the robustness analysis revealed that the Granger and partial autocorrelation networks, that measure the dynamic and contemporaneous connectedness between energy stock returns, was concentrated in the same markets. These results have important implications for investors, since they contribute to investment decisions-making. Furthermore, these results are also relevant for policymakers who will be able to make policy decisions based on the way in which the different energy stock markets are connected and how they can be affected by the shocks transmission.

This article is structured as follows. Section 2 presents a literature review about the connectedness between stock markets, energy stock markets and commodity oil markets. Section 3 presents the data used in this research, while the Section 4 details the methodological approaches. Section 5 shows the results obtained. Finally, Section 6 presents the conclusions and implications of this research.

2. Empirical backgrounds

The environmental degradation caused by the use of conventional energies, mainly fossil fuels, and the irruption of renewable energy sources have generated important changes in energy consumption patterns, and in the economic performance and capital markets of countries (Zhang, 2017). For this reason, energy stock markets are currently more relevant, due to their long-term implications on public policies associated to climate change and investment decisions.

There are international studies that have analyzed the energy stock markets behavior. Most of them have linked these markets with the conventional energy prices and have focused on developed markets due to their relevance on the global consumption of energy sources. Kumar et al. (2012) analyzed the relationship between the prices of the clean energy stocks and oils using a lag-augmented VAR model. Their findings showed that oil prices changes positively affect clean energy stock prices. This relationship is called the substitution effect. Higher conventional energy prices (for example, fossil fuels) generate a firms' profits reduction due to higher operating costs. This effect reduces the profits expectations by investors and also reduces the firms stock prices, particularly those the conventional energy sector. However, the increase in the fossil fuels prices encourages the development of renewable energy projects, and therefore increases the stock prices of the clean energy firms. Zhang (2017) also studied the connectedness between energy stock prices and oil prices using the methodology of Diebold and Yilmaz (2012). The author confirmed the substitution effect presence and showed that the total spillover between these markets was 49.62%, mainly explained by the influence of the stock markets of developed countries. Reboredo and Ugolini (2018) add that the relationship between conventional energy prices and renewable energy stock prices is stronger in the upper and lower quantiles. In the case of the US market, the greatest contribution to this link would come from oil prices, while in Europe this relationship would be more significant with electricity prices. For this reason, Lundgren et al. (2018) argue that the greater energy use in Europe, mainly renewable, generates a closer link between stock markets and renewable energy companies, and leads to a faster shocks transmission. In this sense, Ferrer at al. (2018) showed that the energy stock prices and oil prices have a response of up to five days to shocks, which suggests a fast and efficient transmission between them. However, their findings indicate that oil prices are not the main explanatory factor on the dynamics of renewable energy stock prices, both in the short and long term. This weak substitution effect and the oil commodity market financialization would generate greater diversification opportunities between the conventional and renewable energy stock markets. Nasreen et al. (2020) warn that the global financial crisis increased the connectedness and substitution effect to a frequency of four days, which implies a reduction in the potential benefits of diversification. Other researches also support the significant connectedness between the energy stock prices in developed markets, both conventional and renewable, and how this link would be determined by factors such as energy prices, low-carbon stock prices, commodities and others financial markets (Reboredo and Ugolini, 2016; Xia et al., 2019; Kocaarslan and Soytas, 2019; Reboredo et al., 2019; Naeem et al., 2020; Hanif et al., 2021; Geng et al., 2021a, 2021b; Saeed et al., 2021).

Emerging markets have also been analyzed in few investigations. Despite their lower level of financial and energy development, their participation in the stock and energy markets has become increasingly relevant. According to the Global Status Report Renewables (2019), the participation of these economies in renewable energy investments grew significantly, and among these countries, China concentrated 32% of the total investment during 2018. Even, during 2020, the emerging economies surpassed the investment in renewable energies made by developed economies for the sixth year running (Renewables, 2021). This suggests a close relationship between stock and energy markets in these economies. Empirically, Li and Wei (2018) analyzed the relationship between the Chinese stock market and oil prices through the copula method. Their findings demonstrated a significant connectedness between these markets, particularly at the upper and lower returns quantiles. More recently, Evrim et al. (2020) analyzed the relationship between the stock prices of developed and emerging markets and other financial markets prices such as fossil fuels energies, metals, bonds and foreign exchange. The authors used a TVP-VAR model to calculate the spillover effects using the approach of Diebold and Yilmaz (2014). Their results showed that emerging stock markets are net receivers of shocks coming from developed stock markets and oil markets. Demirer at al. (2020) also studied a wide-system made up of 21 countries, between developed and emerging, and which included the prices of stock markets, energy stocks, bonds and fuels. The authors replicated the Diebold and Yilmaz (2012) approach through a SVAR model and corroborated the significant connectedness between the prices of the stock markets, energy markets, and oils. However, the authors argue that spillover effects were asymmetric across markets.

Some studies have focused on studying only the interdependence between the energy stock markets from different countries, ignoring the incidence from other markets or systematic factors. Singh et al. (2019) used the Diebold and Yilmaz (2012) method on the MSCI energy equity indices from 21 countries belonging to Asia-Pacific, Europe, North America and Latin-America. The study concluded that the directional spillover effects were asymmetric across countries. The authors argue that the energy stock markets of developed countries, mainly North America and Europe, have a dominant role in the energy stock market and they are net transmitters of shocks. However, they warn that after the global financial crisis, emerging countries, particularly China, had a more significant impact on the system's spillovers. The authors highlight that the spillover effects from Russia, an oil exporting country, were not significant, which would be attributable to the economic sanctions imposed on that country. More recently, Tiwari et al. (2021) analyzed the connectedness between the energy stock markets using indices from 20 regional blocs. The study used the Diebold and Yilmaz (2014) approach through TVP-VAR and LASSO-VAR models. Their findings supported to Singh et al. (2019) and indicated that the energy stock markets of the developed countries belonging to the G7 and G12 are the main net transmitters of volatility, while the markets of Southeast Asia, Scandinavia, Far East and the Americas are the main shocks receivers. The authors add that the spillovers had significant increases during the 2008 financial crisis and the Covid-19 pandemic. It should be noted that these researches did not use any method or systematic control factor (such as oil prices) to isolate the idiosyncratic components on spillovers.

The studies discussed previously agree that there is a significant connectedness between the energy stock markets, both conventional and renewable sources. In addition, all of them have studied the developed and emerging markets through aggregate indices that represent the behavior of these sectors at the country or regional level. However, more recent works have advanced toward the firms-level study. Fuentes and Herrera (2020) studied the connectedness between the stock prices of 16 renewable energy companies from the United States, Canada, Brazil, Denmark and China, and various volatility indicators from of oil, stocks and gold markets. Using the methodology of Diebold and Yilmaz (2014), the authors conclude that there are significant and heterogeneous spillovers within and between sectors and renewable energy companies, which are mainly affected by stock markets volatility. Foglia and Angelini (2020) analyzed 24 renewable energy companies drawn from the NASDAQ and the MSCI Global Energy Efficiency Index. The authors show that the total spillover was 21.36% before the Covid-19 pandemic and that after the pandemic it rose to 61.23%. In this context, the oil market, which has mostly been a transmitter of shocks to energy companies, after the pandemic became a market that receives volatility shocks. Geng et al. (2021a) also corroborated the strong connectedness between oil and stock prices from eight renewable energy companies in Europe.

Our research proposes an empirical advance and addresses several novel aspects not covered by the existing evidence. First, it is a pioneering study that analyzes the connectedness between 219 energy firms from 27 emerging countries, being the largest-scale study at the firms-level in comparison to any previous work. The idea of studying only emerging economies arises from the growing importance that these markets have achieved in the energy market in recent years in terms of energy consumption as well as the investment they commit to the development of new energy sources (Renewables, 2019). To address this analysis, and due to the large number of companies, the study uses LASSO-VAR models. Second, the research uses the methodology proposed by Fan et al. (2021), which based on the PCA, isolates the effects of systematic and idiosyncratic factors on the dynamics of the energy stocks returns. In this way, the connectedness, spillovers measures and the networks will only reflect the incidence of the non-idiosyncratic factors.

3. Data

The data was extracted from Bloomberg database for the weekly period between January 13, 2010 and March 24, 2021. The energy stock prices are expressed in US dollars. The sample considers 219 firms from the energy sector, including 12 firms from the renewable energy sector, and which come from 27 emerging countries, mainly from Asia (Table 1). The companies used have a 100% stock market presence. Firms with incomplete records were eliminated from the sample. Appendix 1 indicates the details of the companies.

4. Econometric strategy

The econometric strategy combines different approaches to analyze the connectedness between energy stock markets. We use the three-step method proposed by Fan et al. (2021), and spillovers effects based on LASSO-VAR model suggested by Demirer et al. (2018). Finally, we used the network analysis for time series indicated by Barigozzi and Brownlees (2019) to check the robustness. The estimation sequence is detailed below.

4.1. Three-step method for Sparse VAR models

Fan et al. (2021) proposed a three-step procedure that removes the residual autocorrelation for high-dimensional models and the idiosyncratic elements from a dependent variables vector. In the first step, the following high-dimensional model is estimated:

$$r_{it} = \beta_i^{'} X_{it} + u_{it} \tag{1}$$

Where r_{it} is the vector of stock returns of the n energy firms (or countries) and X_{it} is a matrix of regressors. This matrix can include a constant, a deterministic trend and seasonal dummies or simply observable control variables. The vector β_i contains the parameters to estimate and u_{it} represent the model residuals. From this stage, the residuals $\hat{u}_{it} = r_{it} - \hat{\beta}_i{}' X_{it}$ are computed. It is tested whether the structure of $\hat{u}_{it}$ is dense or sparse considering a test that under the null hypothesis indicates that there is no aucorrelation, and therefore the structure of $\hat{u}_{it}$ is sparse. If there is no autocorrelation, we move to step 3 directly. But, if the structure of the residuals $\hat{u}_{it}$ is dense, we continue to step 2. Even the procedure can start at step 2 if exogenous factors are not used to remove the idiosyncratic components of the stocks returns in the step 1. In step 2, the residuals $\hat{u}_{it}$ are regressed as follows:

$$u_t = \Lambda F_t + U_t \tag{2}$$

where $u_t = (r_{1t}, \dots, r_{nt})'$. Regression (2) estimates the parameters of Λ and F_t for $t = 1, \dots, T$ using $\hat{u}_t$ through Principal Components Analysis (PCA) as follows:

$$\hat{U}_t = \hat{u}_t - \hat{\Lambda}\hat{F}_t \tag{3}$$

The regression (3) can be estimated through OLS procedure. We replicate again the procedure to test whether the structure of the residuals returns $\hat{U}_t$ is dense or sparse. From this step, the idiosyncratic contribution of the returns r_{it} have been removed through the PCA. Finally, the third stage indicate the estimation of the following Sparse VAR model:

$$\hat{U}_{it} = \gamma_i^{'} \hat{U}_{-it} + \varepsilon_{it} \tag{4}$$

where γ_i is the matrix of coefficients to estimate, the vector of regressors $\widehat{U}_{-it} = \left(\widehat{U}_{1t}, \dots, \widehat{U}_{i-1,t}, \widehat{U}_{i+1,t}, \dots, \widehat{U}_{nt}\right)'$ and ε_{it} is the residual vector.

4.3. Connectedness and Sparse VAR

To study the connectedness between countries or energy firms, we use the methodological framework of Diebold and Yilmaz (2012, 2014). However, for high-dimensional data, Demirer et al. (2018) proposed a pioneer work that incorporates Sparse VAR models to estimate the spillover effects. In this case, the Sparse VAR model indicated in (4) can be rewritten as follows:

$$y_{it} = \sum_{k=1}^{p} A_k y_{t-k} + \varepsilon_{it} \tag{5}$$

Where A_k is a matrix of the lags of y_t with dimension $n \times n$. Through the LASSO algorithm (Least absolute shrinkage and selection operator) the parameters in A_k can be obtained by solving:

$$\hat{A} = \arg\min_{A} \sum_{t=1}^{T} \left(y_{it} - \sum_{k=1}^{p} A_k y_{t-k} \right)^2 \tag{6}$$

subject to the constraint:

$$\sum_{k=1}^{K} \left| A_k \right|^q \leq c$$

Where LASSO solves the penalized regression with $q = 1$. Smoothly convex penalties (for example, $q = 2$) produce shrinkages as is the case with Ridge regression. From the forecast error variance decomposition of the Sparse VAR model, Demirer et al. (2018) suggest computing the connectedness measures proposed by Diebold and Yilmaz (2012, 2014). These measures use the generalized VAR modeling framework proposed by Koop, Pesaran, and Potter (1996) and Pesaran and Shin (1998), hereinafter KPPS, to obtain an invariant variance decomposition to the autoregression order p of the variables. We denote the KPPS H-step-ahead forecast error variance decomposition as:

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e_i' A_h \Sigma e_j \right)^2}{\sum_{h=0}^{H-1} \left(e_i' A_h \Sigma A_h' e_j \right)} \tag{7}$$

Where Σ is the variance matrix of the error vector ε_{it}, σ_{jj} is the standard deviation of the error of the j-th equation and e_i is a selection vector with value one at the i-th element

and 0 otherwise. Following Diebold and Yilmaz (2012), the normalized directional connectedness from firm/country *j* to firm/country *i* is:

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}(H)} \tag{8}$$

where by construction we have $\sum_{j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = 1$ y $\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = N$. In this way, the total spillover or system-wide connectedness can be represented by:

$$S^{g}(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^{g}(H)}{N} \tag{9}$$

This spillover measure quantifies the contribution of the shocks of the *n* energy firms/country to the forecast error variance (Diebold and Yilmaz, 2009). Next, the directional spillover received by energy firm/country *i* from all other energy firms/countries *j* is:

$$S_{i \leftarrow \bullet}^{g}(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^{g}(H)}{N} \tag{10}$$

Similarly, the directional spillover from firm/country *i* to the other energy firms/countries *j* is:

$$S_{\bullet \leftarrow i}^{g}(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}^{g}(H)} = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^{g}(H)}{N} \tag{11}$$

Finally, the net spillover from firm/country *i* to the remaining energy firms/countries *j* is:

$$S_{i}^{g}(H) = S_{\bullet \leftarrow i}^{g}(H) - S_{i \leftarrow \bullet}^{g}(H) \tag{12}$$

Based on the three-stage methodology proposed by Fan et al. (2021), all spillover measures will reflect shocks determined by non-idiosyncratic factors of the energy firms/countries and will not be affected by idiosyncratic elements.

5. Empirical results

5.1. Data description

The stock returns were calculated from Wednesday to Wednesday to mitigate the incidence of the geographical location of the stock markets and the weekend anomalies. Table 1 presents the statistical analysis at country-level. For the analysis at country-level, the energy stock returns are represented by the returns of an equally-weighted portfolio, calculated as the simple average of the energy stock returns of the firms of each country. According to the mean and median, the weekly returns of the energy markets oscillate around 0% and most of them present a negative skewness. In addition, there is a significant heterogeneity between countries in terms of returns and risk. In general, the energy stock markets of Asia have the lowest risk records. Statistically, all the stock returns time series present kurtosis excess, non-normal distribution and a stationary structure supported by the ADF test. Appendix 2 shows the statistical analysis of the weekly returns time series at firm-level.

Table 1. Statistics by country.

Region/Countries	Firms	Mean	Median	Std. Dev.	Min	Max	Skewness	Kurtosis	Shapiro-Wilk	ADF test
Asia & Oceania										
Hong Kong (HK)	6	0.0259	0.0670	2.4557	-11.6964	11.1737	-0.0588	4.9541	4.660***	-23.834***
China (CH)	32	0.1463	0.1678	3.4605	-26.1921	14.7383	-1.3201	14.8563	9.281***	-22.546***
Taiwan (TW)	11	0.1198	0.0700	2.1446	-13.9927	6.6731	-0.4873	6.8530	6.304***	-23.164***
South Korea (KS)	22	0.1762	0.2624	2.8607	-19.8321	13.4420	-0.6843	8.8084	7.251***	-23.364***
Pakistan (PK)	16	0.1420	0.0771	3.2730	-20.2799	11.7565	-0.5107	6.5090	6.024***	-20.254***
Sri Lanka (SL)	4	0.0809	-0.0909	3.0770	-11.6644	23.1816	1.3373	11.1483	8.537***	-24.403***
Thailand (TH)	18	0.2614	0.4581	3.2601	-20.4069	14.8670	-0.6874	7.9521	7.606***	-22.292***
Indonesia (IJ)	7	0.1801	0.2309	4.6934	-25.9236	24.5668	-0.0149	6.8352	6.931***	-20.492***
India (IN)	6	0.0175	0.1869	3.6570	-16.1070	13.5693	-0.1299	4.5649	4.439***	-21.872***
Singapore (SP)	2	-0.1390	-0.1295	3.8213	-20.9685	16.9669	0.0229	7.0587	7.289***	-22.360***
Malaysia (MK)	6	0.0805	0.0719	2.3148	-12.9017	9.4651	-0.3152	5.7736	5.679***	-24.339***
Philippines (PM)	8	0.1749	0.0551	2.7143	-12.3376	10.9881	-0.0833	5.0278	5.315***	-22.770***
Vietnam (VM)	11	0.0738	0.1664	2.5681	-12.0504	12.7383	-0.0498	6.1950	6.612***	-23.512***
Mongolia (MG)	5	0.1666	-0.4369	5.4444	-19.1571	39.0368	2.4328	16.1103	10.295***	-19.928***
America										
Argentina (AR)	9	0.3051	0.4460	6.3224	-49.6263	30.1107	-0.8577	11.2159	7.926***	-23.283***
Brazil (BR)	18	0.0458	0.0188	4.3215	-28.4373	20.4246	-0.4570	7.9603	7.002***	-21.481***
Chile (CL)	6	-0.0287	-0.0226	3.2640	-24.4674	13.4432	-0.3595	9.0507	7.064***	-24.261***
Peru (PE)	5	0.1001	-0.0395	2.7103	-19.1099	20.0205	0.3859	13.1668	8.603***	-21.800***
Colombia (CO)	4	0.0539	0.2573	3.8687	-30.2266	24.1598	-0.6451	14.4056	8.945***	-23.728***
Europa										
Romania (RM)	2	0.1762	0.1374	3.4622	-13.9996	15.0427	0.1153	5.2180	6.061***	-23.556***
Montenegro (MN)	2	0.0819	-0.0632	3.9675	-18.0413	23.7765	0.4487	7.5878	7.866***	-28.787***
Czech Republic (CR)	1	-0.0587	0.0712	3.5207	-20.5877	16.9211	-0.1008	6.7200	6.361***	-26.208***
Russia (RU)	11	0.1227	0.1938	4.4541	-27.9081	29.6397	-0.2121	11.0673	8.450***	-24.440***
Slovenia (SV)	1	0.0382	0.0398	3.0347	-16.0297	15.6794	0.1009	6.4210	6.325***	-24.139***
Turkey (TK)	2	0.0250	0.2169	4.7959	-26.3367	19.5193	-0.3914	6.0378	5.927***	-26.092***
Bosnia-Herzegovina (BH)	3	-0.0099	-0.3059	5.5317	-16.4906	62.3759	4.4211	46.0979	11.400***	-18.849***
Hungary (HG)	1	0.0139	-0.0523	4.7626	-28.4656	27.6560	-0.0977	8.6828	7.614***	-26.263***

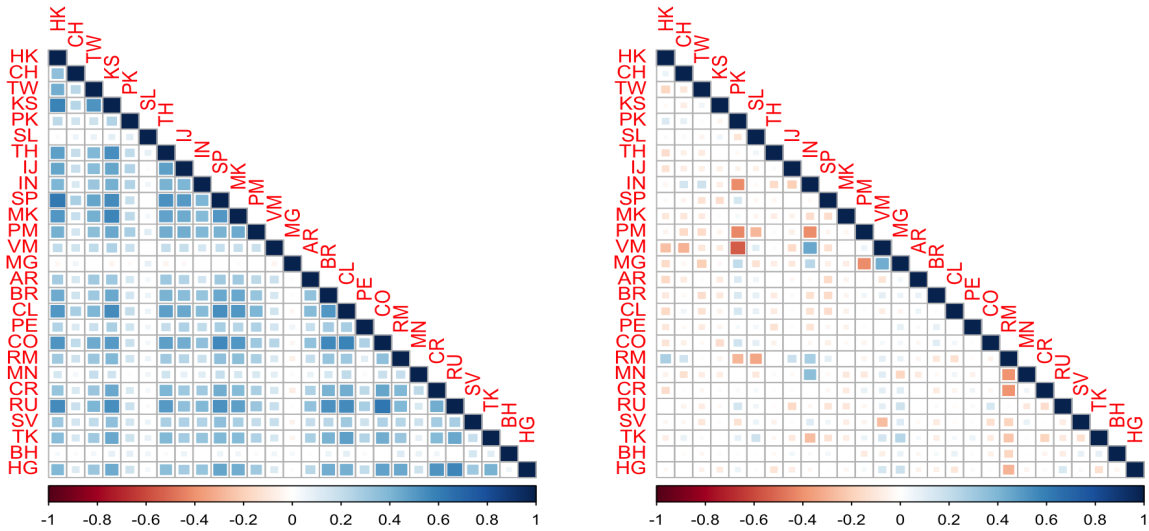
Notes: The returns time series of each country *i* corresponds to a simple average or portfolio equally-weighted among the energy companies of country *i*. ADF corresponds to Augmented Dickey-Fuller test. This test only considers the random walk specification. Superscripts ***, **, * indicate statistical significance at 1%, 5%, and 10%, respectively. Source: Authors' elaboration.

Figure 1a shows the Pearson correlations between each energy stock market at country-level. There are two interesting facts stand out. First, in most cases we observed positive and significant correlations at 1% between the energy stock markets. The markets of China and Vietnam have the lowest correlations within them. This fact reveals that the

energy stock markets are closely integrated among emerging countries, which facilitates the risks contagion and limits the diversification possibilities in this stock sector. Second, in most cases the correlations between the energy stock markets of Sri Lanka, Mongolia and Bosnia-Herzegobina, and the other markets showed insignificant correlations. Initially, these results show that these markets have qualities that allow risk diversification in the energy sector. Figure 2 shows similar patterns in the correlations between the energy stock returns at firms-level.

Figure 1. Unconditional correlations matrix for energy stock returns at country-level.

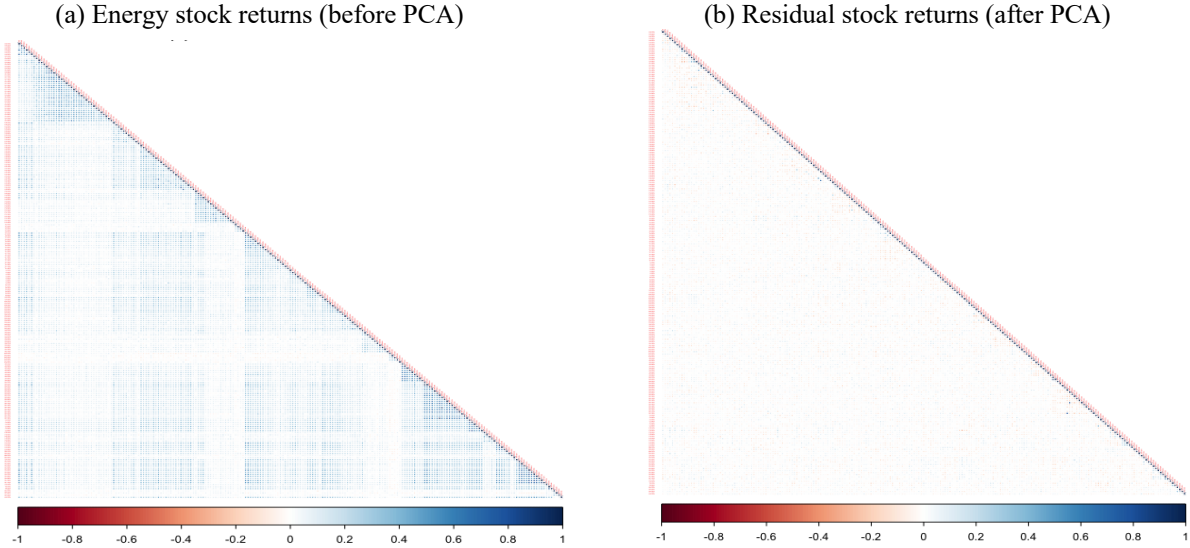
(a) Energy stock returns (before PCA) (b) Residual stock returns (after PCA)



Source: Authors' elaboration.

Figure 2. Unconditional correlations matrix for energy stock returns at firms-level.

(a) Energy stock returns (before PCA) (b) Residual stock returns (after PCA)



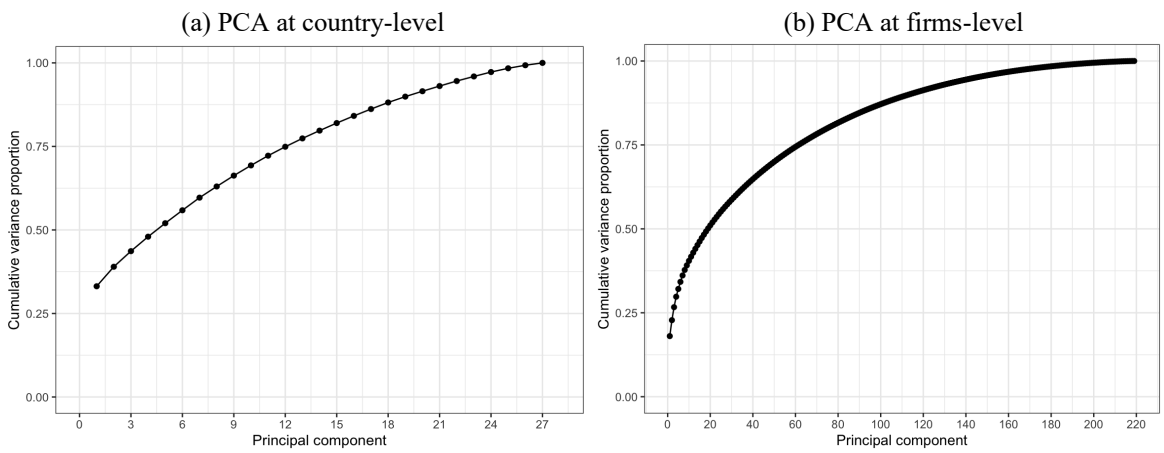
Source: Authors' elaboration.

5.2. Three-step method: PCA control

According to Fan et al. (2021), the PCA is used to remove the influence of systematic factors on the energy stock returns. In this case, these components correspond to a linear combination between the stocks returns of energy firms (or of the markets at the country-level). Figure 3 shows the incidence of the principal components on the variance of the stocks returns, both at the country-level and at the firm-level.

To implement step 2 of the method proposed by Fan et al. (2021), we estimate model (3) through an OLS regression for each time series of stock returns of the country or firm, depending on whether the analysis is developed at country-level or at firm-level, respectively. The regressors used as control variables correspond to the *k*-first principal components, whose selection is not a trivial issue. The selection criteria considers that the principal components must explain at least 50% of the stock returns variance. For this reason, for the analysis at the country-level we used the first 5 principal components, which explain 52.01% of the returns variance, while for the analysis at the firm-level the first 20 components were used, whose explanatory capacity on the variance was 51.03%.

Figure 3. Principal Components and variance proportion for energy stock returns.



Source: Authors' elaboration.

The residual stock returns through PCA, obtained as the residuals of the model (3), represent the stock returns of the energy markets or firms without the incidence of idiosyncratic factors and, therefore, are influenced only by the non-idiosyncratic component of the country or company, respectively. Figure 1b shows the correlations of residual returns at country-level. These returns have lower correlations than those presented in Figure 1a. Figure 2b shows similar patterns in the correlations between the energy stock returns at firms-level. These facts demonstrate that the idiosyncratic components in the energy stock markets are relevant to the degree of integration, diversification and risk transmission between them. In addition, the lower correlations between the residual returns

show greater diversification possibilities between energy stock markets of emerging countries.

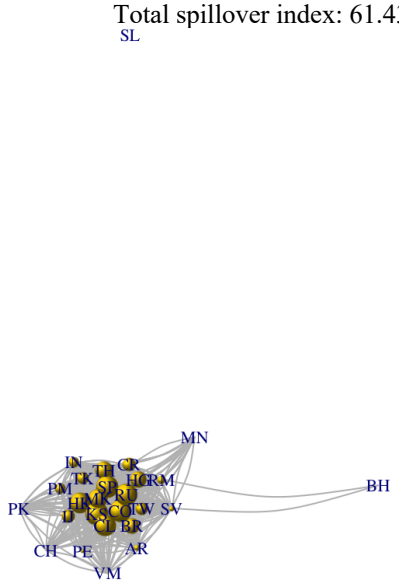
5.3. Spillovers and portfolio management

Demirer et al. (2018) extend the methodology proposed by Diebold and Yilmaz (2012, 2014) through LASSO-VAR model. This approach allows to compute the connectedness measures using a high-dimensional data structure. Tables 2 and 3 show the spillover effects among the 27 energy stock markets. These connectedness measures were calculated from the LASSO-VAR(1) model indicated in equation (5) and consider a KPPS 10-weeks-ahead forecast error variance decomposition. The results show two interesting facts to analyze. First, the wide-system total spillover is sensitive to PCA adjustment. The total spillover of the system was 61.43% for energy stock returns, while for residual returns decreased to 24.45%. This finding reveals the systematic importance of the idiosyncratic factors on the shocks transmission between energy stock markets. Second, the nature of the net transmission of shocks also depends on the PCA adjustment. For the case of the stock returns, the main net transmitters countries are South Korea, Chile, Singapore, Russia, Colombia, Hong Kong, Malaysia and Thailand, while for residual returns they are the energy stock markets of Romania, India, Vietnam and Pakistan. This fact suggests that the magnitude and direction of shocks transmitted between stock markets are significantly affected by systematic and idiosyncratic factors associated with the integration degree between them.

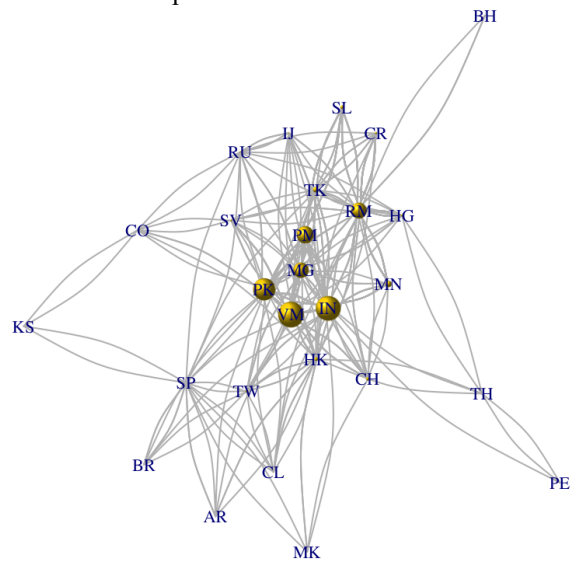
Figures 4 and 5 show spillovers effects. On the one hand, we observed that most of the energy stock markets are highly connected (Figure 4a). Although the energy markets of Sri Lanka, Mongolia, Bosnia-Herzegovina and Montenegro are the least sensitive to shocks from other markets. China, Vietnam, Pakistan, Peru, Argentina and Slovenia are also markets that receive insignificant shocks, although they are a little more connected to the rest of the energy stock markets. All these markets would allow building highly diversified investment portfolios in the energy sector among emerging countries. On the other hand, the network for residual stock returns shows a more dispersed structure and in which most markets are insensitive to transmitted shocks (Figure 4b). We observed diverse countries in the external part of the network, while the markets of Vietnam, India, Pakistan, Philippines, Mongolia and Romania stand out due to the magnitude of the spillovers transmitted to other energy markets. The energy stock markets of South Korea, Brazil, Argentina, Peru, Malaysia, Bosnia-Herzegovina, Thailand, Singapore, Colombia, Chile and Indonesia would be the least sensitive markets to shocks and would offer better performance for internationally diversified portfolios. These findings corroborate that at the country-level there are significant advantages to diversifying the risk of investments made in the energy sector when decision-making considers the incidence of idiosyncratic factors common to the markets. The spillover effects matrix also confirms these results (Figure 5). For more detail, Appendix 3 shows global and local statistics at the country-level.

Figure 4. Spillovers network at country-level

(a) Energy stock returns (before PCA)
Total spillover index: 61.43%



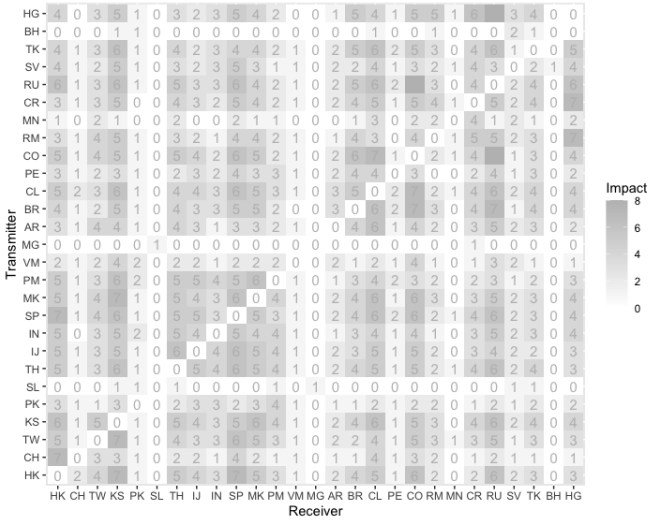
(b) Residual stock returns (after PCA)
Total spillover index: 24.45%



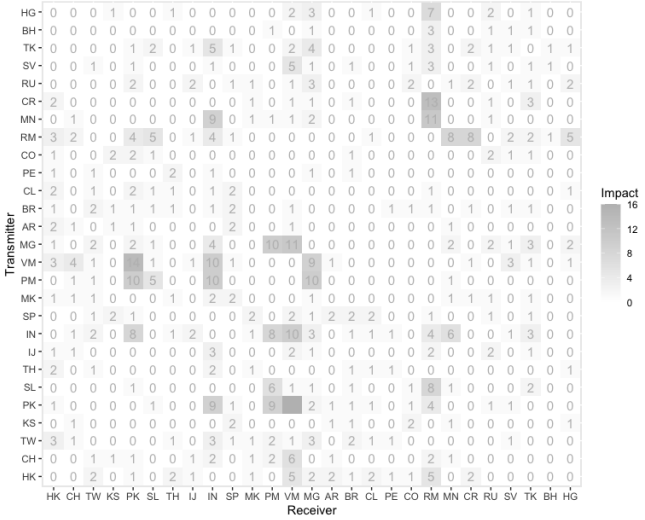
Notes: Spillovers network was computed through LASSO-VAR(1). Spillovers measures consider a KPPS *10*-weeks-ahead forecast error variance decomposition. The size of nodes represent the relative importance of the spillover to other energy markets. Source: Authors' elaboration.

Figure 5. Spillover matrix at country-level.

(a) Energy stock returns (before PCA)
Total spillover index: 61.43%



(b) Residual stock returns (after PCA)
Total spillover index: 24.45%



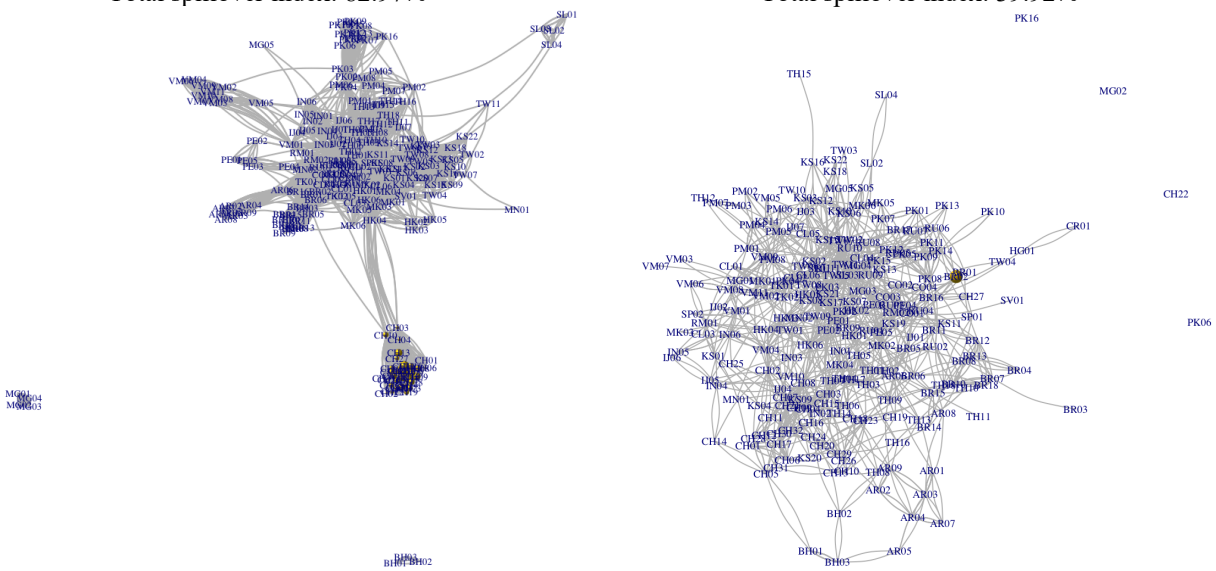
Notes: Spillovers matrix was computed through LASSO-VAR(1). Spillovers measures consider a KPPS *10*-weeks-ahead forecast error variance decomposition. Source: Authors' elaboration.

We observed similar results at the firm-level, although with a greater degree of heterogeneity within each country. Figure 6 shows the network of spillover effects between the 219 energy firms. On the one hand, it is observed that the total spillover of the entire stock returns system was 82.97%, in which the energy stocks of Chinese firms generate the largest spillovers (Figure 6a). Energy companies from Mongolia and Bosnia-Herzegovina do not experience significant spillovers with energy firms from other markets, allowing portfolios made up of stocks from these countries to have greater diversification margin. Stocks from other markets such as those of South Korea, Thailand, Taiwan, Vietnam, Philippines, Sri Lanka, Pakistan, Montenegro, Argentina, Brazil and Peru are located in the outer zones of the network and have more significant spillovers with the energy markets located in the central zone of the network. Despite this, it is also possible to diversify the portfolios because the degree of connectedness between them is not relevant. On the other hand, the total spillover of the residual returns system was 39.92%. This fact, similar to that observed in the country-level analysis, corroborates the relevance of idiosyncratic factors on the risk transmission and contagion mechanisms among energy companies at an international level. The network presents a more dispersed structure (Figure 6b). The periphery of the network is made up of some companies from South Korea, Pakistan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, Mongolia, Bosnia-Herzegovina, China, Czech Republic, Argentina and Brazil. An interesting finding is that the renewable energies firms have similar connectedness to conventional energy firms within the same country. This facts allows a greater degree of diversification for portfolios built between countries in relation to those focused only on stocks of the same country. For more detail, Appendix 4 shows global and local statistics for each energy company.

Figure 6. Spillovers network at firms-level

(a) Energy stock returns (before PCA)
Total spillover index: 82.97%

(b) Residual stock returns (after PCA)
Total spillover index: 39.92%



Notes: Spillovers matrix was computed through LASSO-VAR(1). Spillovers measures consider a KPPS *10*-weeks-ahead forecast error variance decomposition. The size of nodes represent the relative importance of the spillover to other energy firms. Source: Authors' elaboration.

5.4. Checking the robustness

According to the framework of LASSO-VAR models with penalty mechanisms, Barigozzi and Brownless (2019) proposed the NETS algorithm (Network estimation for time series) for the networks estimation applied to time series. On the one hand, the network approach decomposes the Sparse VAR model into directed network, represented by the Granger causality structure, which measures the dynamic relationship between all times series. Barigozzi and Brownless (2019) define this network $\mathcal{N}_g = (\mathcal{V}, \mathcal{E}_g)$ as a combination of the set of n vertices $\mathcal{V}$ that correspond to n time series of the vector y_t and the set of edges $\mathcal{E}$ of the subset $\mathcal{V} \times \mathcal{V}$ where the presence of an edge from energy firm/country i to firm/country j denotes that i causes in the Granger sense to j. On the other hand, the undirected network are represented by the contemporaneous partial correlation between the time series. This network $\mathcal{N}_c = (\mathcal{V}, \mathcal{E}_c)$ indicates that the edge between i and j will exist if i is partially correlated to j. Both components will be estimated from the LASSO-VAR model indicated in the following equation (5).

Figure 7 shows the dynamic connectedness through the Granger network, while Figure 9 presents the contemporaneous network for the 27 emerging energy stock markets. In both cases, we observed a dense network that corroborates the significant degree of integration between the energy stock markets. According to various studies, this fact hinders the international diversification possibilities and accentuates the risks transmission between these markets (Singh et al., 2019; Fuentes and Herrera, 2020; Foglia and Angelini, 2020; Geng et al., 2021a).

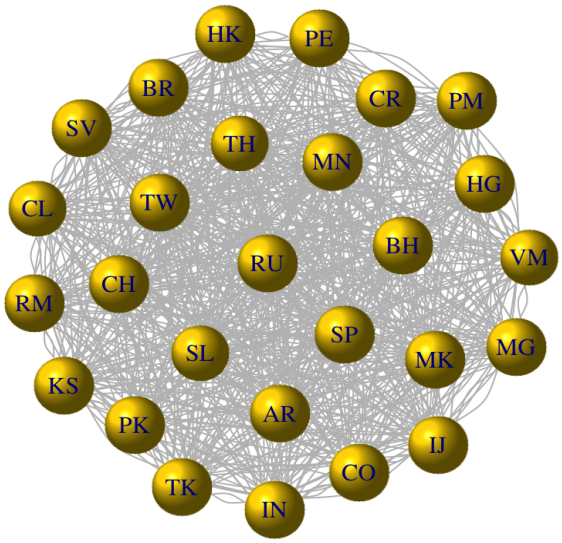
Figure 7b shows that residual returns in some energy stock markets have less significant dynamic linkages with the energy markets of the other countries. Energy stock markets such as Romania, Philippines, India, Vietnam, Singapore, Malaysia, Hong Kong, Peru and Czech Republic have these qualities, which would allow greater spaces for international diversification and mitigate financial contagion in relation to those markets located in the densest part of the network. These diversification possibilities are associated with specific factors of each market. This fact confirms the main results obtained from the spillover framework of Demirer et al. (2018), and it also supports its investment implications mainly between the energy market of Vietnam, Malaysia, Singapore and Peru. In fact, the denser network described by Figure 7a supports the idea that the influence of common systematic factors would facilitate the integration and risks contagion between the markets. These findings are corroborated by the adjacency matrices (Figure 8). The shocks transmitted from the almost all markets generate dynamic connectedness in almost all other countries when idiosyncratic factors have not been isolated (Figure 8a). However, these connectedness tend to vanish in the mentioned markets after PCA control (Figure 8b). Additionally, Appendix 5 presents the global and local statistics of the Granger network. The measures of centrality degree, betweenness, closeness, authority score, and eccentricity of the network of residual energy stock returns describe its high degree of density and the almost similar participation of all vertices (markets) in the dynamic relationships of this sector.

Figure 9 shows two high-density networks that reveal that contemporaneous connectedness between energy stock markets are close and significant. Regardless of PCA control, this evidence supports that the integration of these markets is high and it would be

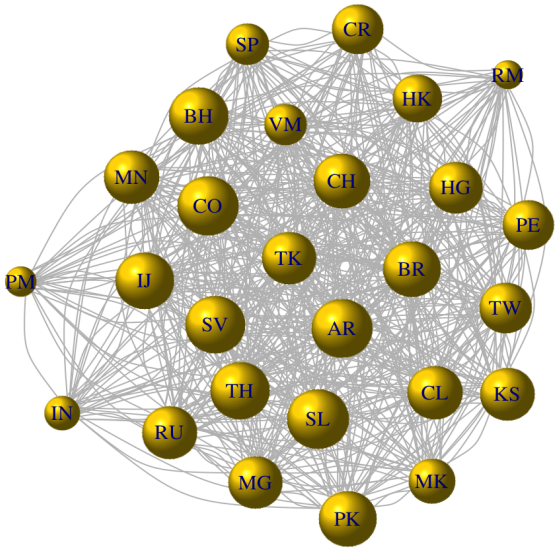
explained by both idiosyncratic and non-idiosyncratic factors. These results can also be seen in the adjacency matrices of the contemporaneous network, where it is evident that the shocks transmitted by almost all the energy markets are received by all the others (Figure 10).

Figure 7. Dynamic connectedness at country-level: Granger network.

(a) Energy stock returns (before PCA)



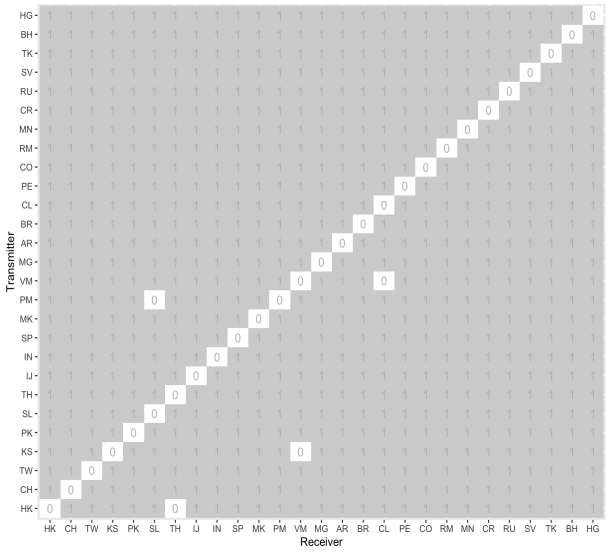
(b) Residual stock returns (after PCA)



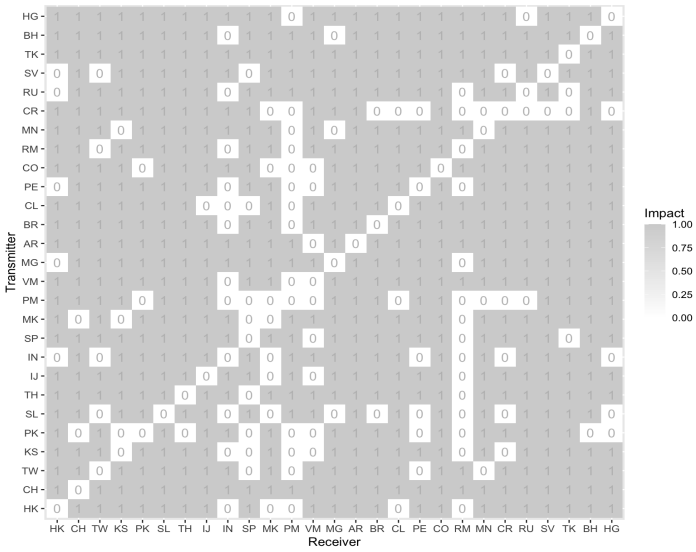
Notes: Adjancency matrix associated with the Granger network implied by the VAR autoregressive matrices. The size of nodes represent the relative importance of the spillover to other energy markets. Network was computed through NETS algorithm. Source: Authors' elaboration.

Figure 8. Adjancency matrix at country-level: Granger network.

(a) Energy stock returns (before PCA)



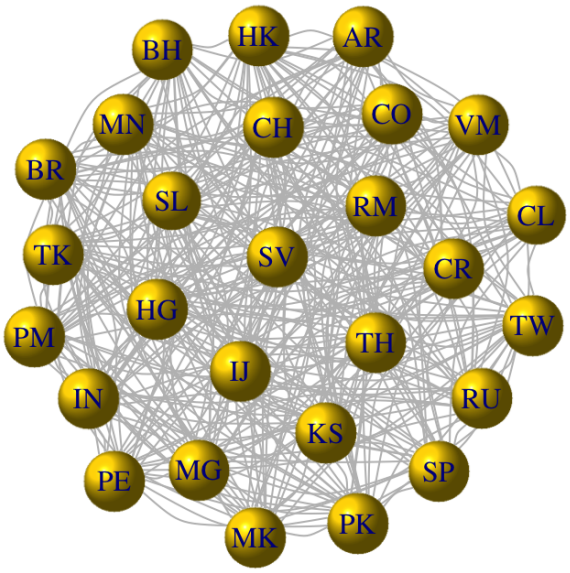
(b) Residual stock returns (after PCA)



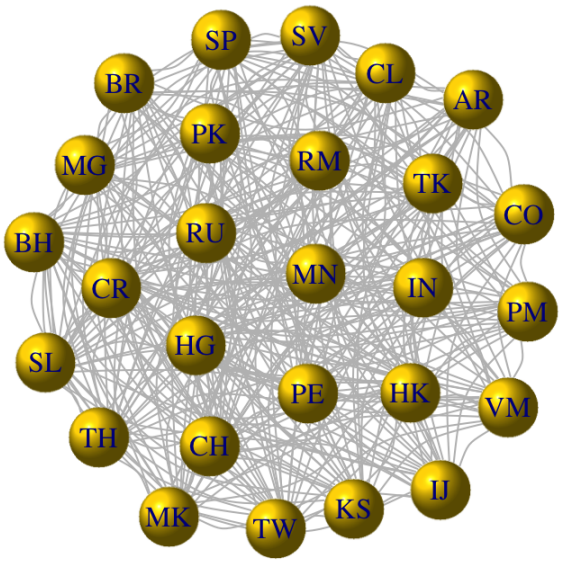
Notes: Adjancency matrix associated with the Granger network implied by the VAR autoregressive matrices. Network was computed through NETS algorithm. Source: Authors' elaboration.

Figure 9. Contemporaneous connectedness at country-level: Partial autocorrelation

(a) Energy stock returns (before PCA)



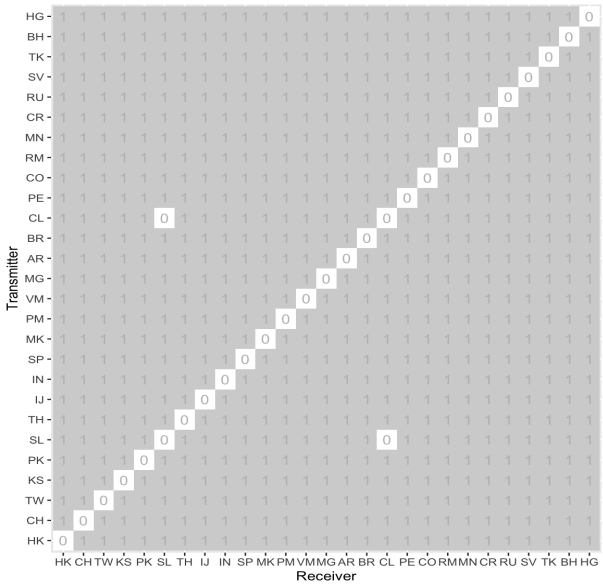
(b) Residual stock returns (after PCA)



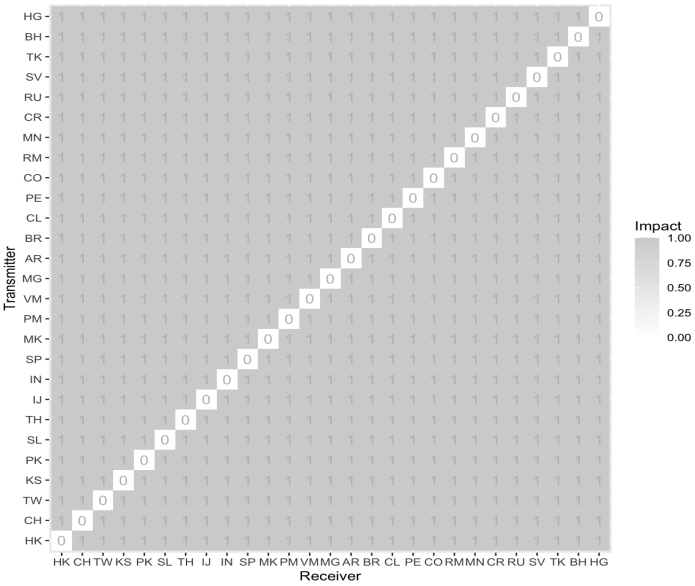
Notes: Adjancency matrix associated with the contemporaneous network implied by the VAR innovation concentration matrix. The size of nodes represent the relative importance of the spillover to other energy markets. Network was computed through NETS algorithm. Source: Authors' elaboration.

Figure 10. Adjancency matrix at country-level: Contemporaneous network.

(a) Energy stock returns (before PCA)



(b) Residual stock returns (after PCA)

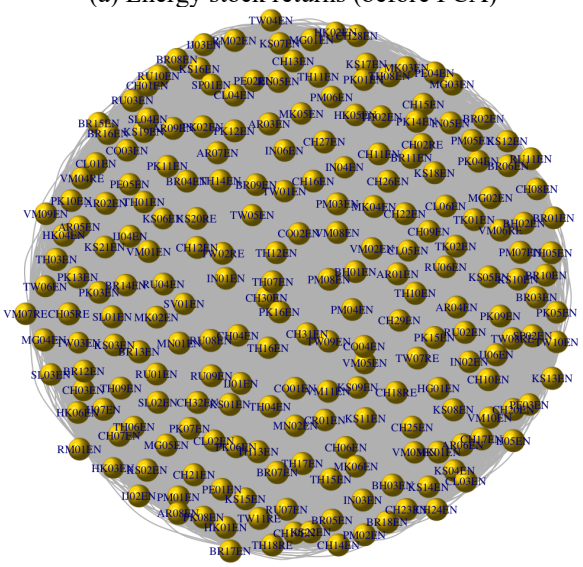


Notes: Adjancency matrix associated with the contemporaneous network implied by the VAR innovation concentration matrix. Network was computed through NETS algorithm. Source: Authors' elaboration.

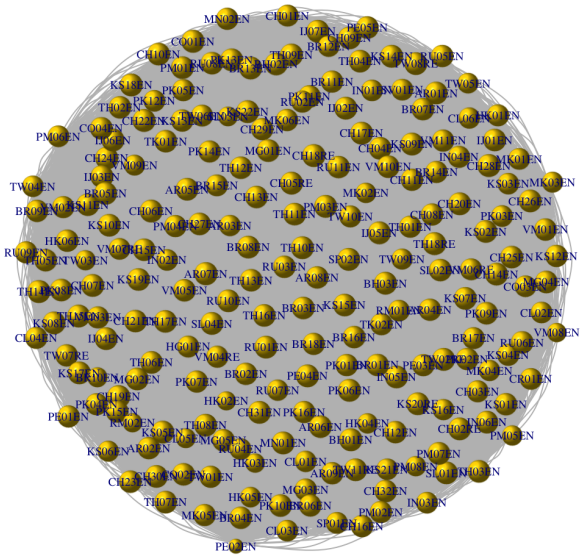
Figures 11 and 12 present the Granger and contemporaneous networks between the 219 energy firms from the emerging markets. In both cases, significant connectedness relationships are observed, both dynamic and contemporaneous. Based on the global and local statistics of the networks of Granger causality and partial autocorrelation, the 50% of firms with lower authority scores were classified. According to this classification, we obtained the energy firms with lower degree of connectedness within the networks. These firms were concentrated in the energy markets of South Korea, Thailand, Taiwan, Vietnam, Philippines, Pakistan, Brazil, and Peru (see Appendix 7). These empirical findings confirm most of the results obtained from the spillover approach of Demirer et al. (2018). In addition, renewable energy firms had a scarce presence within the stocks with the lowest authority score records. In terms of implications for investment decisions and portfolio management, the energy stocks of these markets offer significant advantages for risk diversification and for mitigating financial contagion within the sector, mainly between the markets of emerging Asia and Latin America.

Figure 11. Dynamic connectedness at firms-level: Granger network.

(a) Energy stock returns (before PCA)



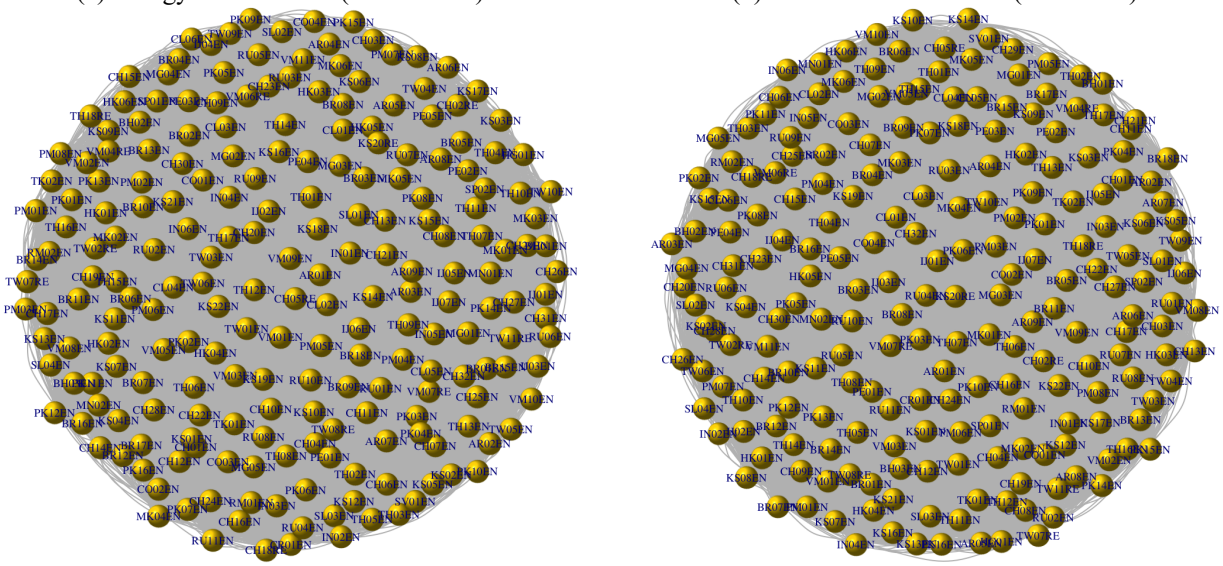
(b) Residual stock returns (after PCA)



Notes: Adjancency matrix associated with the Granger network implied by the VAR autoregressive matrices. The size of nodes represent the relative importance of the spillover to other energy firms. Network was computed through NETS algorithm. Source: Authors' elaboration.

Figure 12. Contemporaneous connectedness at firms-level: Partial autocorrelation

(a) Energy stock returns (before PCA) (b) Residual stock returns (after PCA)



Notes: Adjancency matrix associated with the contemporaneous network implied by the VAR innovation concentration matrix. The size of nodes represent the relative importance of the spillover to other energy firms. Network was computed through NETS algorithm. Source: Authors' elaboration.

6. Conclusions and discussion

Energy stock markets have achieved systematic relevance due to the economic and financial consequences of the climate change on energy consumption patterns and the development of renewable sources. A wide international empirical evidence has shown the strong connectedness between energy stock markets and how various systematic factors such as oil prices, stock prices, commodity prices affect them. Most of these studies have studied these relationships basing their analyzes on aggregate indices at the level of markets or regions, but ignoring the information at firm-level as determinant of the connectedness. In addition, they have concentrated on developed markets due to their importance on energy demand around the world. However, the importance of the energy stock markets has also gone hand in hand with a greater contribution from emerging markets. Growing investments for clean energies development and the persistent disinvestment process in fossil energies assets are key facts related to these markets. Despite this, the relationship between the energy stock markets of the emerging countries has been scarcely studied by empirical evidence.

Our research filled this gap by studying at emerging markets. The scopes of the contributions of this article are empirical and methodological. Empirically, this article is was the first study to use a wide-system of energy firms both conventional and renewable. This contribution has important implications on investment decision-making in the energy

sector of the emerging markets. Methodologically, this work also supposed an advance because it applies different approaches. We used the three-step method of Fan et al. (2021) to isolate the idiosyncratic components from energy stock returns and avoid the use control factors such as the prices of oil, commodities and other financial assets. From this adjustment, we applied the spillover method proposed by Demirer et al. (2018) to control the high-dimensional of the data through LASSO-VAR model and estimate the connectedness between energy stock markets or firms. From these approaches it was possible to estimate the relevance of the idiosyncratic and non-idiosyncratic factors on international diversification, shocks transmission and portfolio management in the energy sector.

Our findings have three relevant conclusion to analyze. First, our results reveal that energy stock markets are closely integrated across emerging countries. However, the residual stock returns obtained from PCA reveal that idiosyncratic factors are related to higher correlations and spillovers of the stock returns between market or firms in the energy sector. This fact implies that the idiosyncratic factors are relevant on financial contagion mechanisms and the integration degree between them. Second, the Chinese firms transmit significant spillovers to other energy firms. However, the energy stock markets in Mongolia, Sri Lanka, Bosnia-Herzegovina, South Korea, Thailand, Taiwan, Vietnam, the Philippines, Pakistan, Argentina, Brazil and Peru showed lower spillovers in comparison to other emerging markets, mainly at firms-level. After PCA control, the spillovers between residual energy stocks returns showed a similar patterns, but with connectedness measures less relevant and a more disperse spillover networks. In addition, there was no evidence that supports the substitution effect between conventional and renewable energy stock within the same country because these energy firms had similar connectedness patterns. This fact suggest that the portfolio of energy stock has relevant spaces for international diversification and attenuates the risks transmission between these markets and kind of energy firms. Finally, the dynamic and contemporaneous connectedness measures between energy stock returns were concentrated in the same markets. This result implies that an internationally diversified portfolio of energy stock has similar performance at short-term y long-term.

These results have important implications for investors, since they contribute to investment decisions-making. In terms of investment decisions and portfolio management, the energy stocks of these markets offer significant advantages for risk diversification and for mitigating financial contagion within the sector, mainly between the markets of emerging Asia and Latin America. Furthermore, these results are also relevant for policymakers who will be able to make policy decisions based on the way in which the different energy stock markets are connected and how they can be affected by the shocks transmission.

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Table 2. Spillovers between energy stock markets at country-level: Stock returns

	HK	CH	TW	KS	PK	SL	TH	IJ	IN	SP	MK	PM	VM	MG	AR	BR	CL	PE	CO	RM	MN	CR	RU	SV	TK	BH	HG	From
HK	20.2	2.5	3.5	6.8	0.9	0.0	4.8	3.9	3.2	7.5	5.3	3.4	0.8	0.1	1.7	3.8	5.3	1.2	5.6	2.0	0.4	2.3	6.5	1.9	3.2	0.0	3.3	79.8
CH	6.7	54.2	2.8	3.1	1.3	0.2	2.0	1.8	0.8	4.2	2.0	1.0	1.3	0.2	1.2	1.4	4.3	0.9	2.5	1.6	0.1	1.1	2.0	1.2	1.2	0.0	0.9	45.8
TW	4.7	1.4	26.9	7.4	0.7	0.1	4.1	3.4	2.7	5.5	4.9	3.2	1.0	0.0	2.5	2.5	4.5	0.9	5.4	2.9	0.9	2.9	4.5	1.2	2.8	0.0	3.0	73.1
KS	6.2	1.1	5.0	18.3	1.0	0.2	5.3	3.8	3.2	5.5	5.9	3.5	1.3	0.0	1.8	3.8	5.5	1.4	4.7	2.8	0.4	3.8	5.6	2.2	3.9	0.1	3.7	81.7
PK	2.6	1.3	1.4	3.1	55.1	0.4	2.4	3.2	3.3	1.7	2.8	3.6	1.4	0.1	1.1	1.3	2.2	1.1	2.2	1.5	0.0	0.8	2.3	0.9	1.9	0.3	1.9	44.9
SL	0.1	0.3	0.4	0.8	0.6	91.3	0.5	0.0	0.2	0.0	0.2	0.7	0.0	0.8	0.2	0.3	0.5	0.2	0.2	0.4	0.3	0.2	0.1	0.5	0.5	0.2	0.2	8.7
TH	5.2	0.8	3.3	6.3	0.9	0.1	21.8	4.8	3.7	6.1	5.0	3.9	0.9	0.0	2.1	3.7	5.1	0.8	5.3	2.0	0.6	3.6	5.9	1.5	3.6	0.0	3.0	78.2
IJ	5.0	0.9	3.3	5.5	1.5	0.0	5.8	26.1	3.7	6.2	5.0	4.2	0.8	0.1	1.7	3.4	5.2	1.5	5.4	1.7	0.1	2.7	3.6	1.6	2.4	0.1	2.5	73.9
IN	4.7	0.5	3.0	5.2	1.7	0.1	5.1	4.3	30.3	4.7	4.4	4.3	0.5	0.0	0.7	3.4	4.4	1.3	3.8	1.1	0.2	2.7	4.8	1.9	3.4	0.0	3.5	69.7
SP	7.1	1.5	3.9	5.7	0.5	0.0	5.3	4.5	2.9	19.1	5.1	3.0	0.6	0.0	1.7	3.9	5.6	1.6	6.1	2.4	0.6	3.7	5.6	2.4	3.0	0.1	4.2	80.9
MK	5.5	0.8	3.8	6.8	1.0	0.0	4.8	4.0	3.0	5.6	21.0	4.0	0.8	0.0	1.9	4.4	5.7	1.3	5.6	2.8	0.3	3.1	4.9	1.5	3.2	0.1	3.9	79.0
PM	5.0	0.6	3.5	5.7	1.9	0.2	5.3	4.8	4.2	4.6	5.7	29.5	0.9	0.0	1.5	3.0	4.5	1.7	3.1	2.3	0.3	2.2	3.4	1.0	2.2	0.0	3.0	70.5
VM	2.4	1.4	2.2	4.1	1.5	0.0	2.3	1.9	1.1	1.9	2.2	1.7	57.8	0.1	1.8	1.2	1.6	1.3	3.7	1.1	0.4	1.2	2.7	1.9	1.2	0.1	1.1	42.2
MG	0.3	0.4	0.0	0.2	0.2	0.9	0.2	0.2	0.0	0.0	0.1	0.0	0.3	94.4	0.1	0.1	0.2	0.2	0.1	0.4	0.1	0.6	0.0	0.3	0.2	0.2	0.0	5.6
AR	3.2	0.9	3.6	3.7	0.8	0.1	3.8	2.5	0.9	3.5	3.5	1.9	1.2	0.0	38.6	4.5	5.6	1.5	4.5	1.6	0.2	2.7	4.7	1.7	2.8	0.0	2.1	61.4
BR	4.4	0.6	2.2	4.9	0.5	0.1	3.9	3.0	2.6	4.8	4.9	2.3	0.5	0.0	2.7	23.4	6.3	2.0	7.4	2.7	0.3	4.0	6.7	1.2	4.0	0.1	4.5	76.6
CL	5.0	1.5	3.2	5.8	0.8	0.1	4.5	3.8	2.8	5.7	5.2	2.9	0.5	0.0	2.8	5.2	19.3	1.6	6.6	1.9	0.8	3.7	6.0	1.8	4.4	0.2	3.6	80.7
PE	2.9	0.8	1.5	3.5	0.9	0.1	1.7	2.7	1.9	3.9	2.9	2.8	1.0	0.1	1.8	4.1	3.9	46.9	3.4	0.5	0.0	2.4	3.8	1.3	3.2	0.0	2.2	53.1
CO	5.3	0.9	3.8	4.9	0.7	0.0	4.6	3.9	2.4	6.1	5.1	1.9	1.2	0.0	2.2	6.0	6.5	1.4	19.0	2.5	0.6	4.0	7.7	1.4	3.5	0.0	4.3	81.0
RM	3.1	1.0	3.5	5.0	0.8	0.1	3.0	2.0	1.1	4.1	4.3	2.5	0.6	0.2	1.3	3.7	3.2	0.3	4.2	32.3	1.1	5.1	5.1	1.9	3.3	0.5	6.6	67.7
MN	1.2	0.1	2.4	1.5	0.0	0.2	1.8	0.4	0.5	2.1	1.1	0.7	0.5	0.1	0.3	1.0	2.9	0.1	2.3	2.3	69.2	3.8	1.1	1.8	0.6	0.3	1.7	30.8
CR	2.9	0.5	2.7	5.4	0.4	0.1	4.3	2.7	2.3	5.0	3.8	1.9	0.5	0.2	1.8	4.4	5.0	1.3	5.5	4.1	1.4	25.8	4.9	2.3	3.7	0.1	7.0	74.2
RU	6.0	0.7	3.2	5.7	0.8	0.0	5.1	2.6	3.0	5.5	4.4	2.2	0.9	0.0	2.3	5.4	5.9	1.5	7.6	3.0	0.3	3.6	18.8	1.6	3.9	0.0	6.2	81.2
SV	3.8	0.9	1.8	5.0	0.7	0.2	2.9	2.4	2.5	5.0	2.9	1.4	1.3	0.1	1.8	2.1	3.8	1.1	2.9	2.3	1.0	3.5	3.4	40.4	1.8	0.7	4.3	59.6
TK	4.2	0.6	2.8	5.7	0.9	0.2	4.4	2.4	3.1	4.2	4.1	2.0	0.6	0.1	2.0	4.6	6.2	1.9	4.9	2.7	0.3	3.8	5.6	1.2	27.0	0.3	4.5	73.0
BH	0.0	0.1	0.2	0.6	0.5	0.2	0.0	0.2	0.0	0.4	0.3	0.0	0.2	0.2	0.0	0.4	0.8	0.1	0.0	1.3	0.4	0.2	0.0	1.6	0.9	91.0	0.3	9.0
HG	3.9	0.4	2.7	4.7	0.8	0.1	3.3	2.3	2.8	5.2	4.4	2.4	0.4	0.0	1.3	4.6	4.4	1.1	5.4	4.9	0.6	6.5	7.8	2.5	4.0	0.1	23.7	76.3
To others	101.5	22.2	69.7	117.2	22.4	3.7	91.1	71.7	57.7	109.0	95.6	61.5	20.1	2.5	40.4	82.1	108.8	29.2	108.5	54.7	11.8	74.6	108.7	40.3	68.8	3.5	81.6	*Total*
Including own	121.6	76.4	96.6	135.5	77.5	95.0	112.9	97.8	88.1	128.0	116.6	90.9	77.9	96.9	79.0	105.5	128.1	76.0	127.5	87.0	81.0	100.4	127.5	80.6	95.7	94.5	105.3	*spillover*
Net	21.6	-23.6	-3.4	35.5	-22.5	-5.0	12.9	-2.2	-11.9	28.0	16.6	-9.1	-22.1	-3.1	-21.0	5.5	28.1	-24.0	27.5	-13.0	-19.0	0.4	27.5	-19.4	-4.3	-5.5	5.3	*61.43%*

Notes: Spillovers matrix was computed through LASSO-VAR(1). Spillovers measures consider a KPPS *10*-weeks-ahead forecast error variance decomposition. Source: Authors' elaboration.

Table 3. Spillovers between energy stock markets at country-level: Residual stock returns

	HK	CH	TW	KS	PK	SL	TH	IJ	IN	SP	MK	PM	VM	MG	AR	BR	CL	PE	CO	RM	MN	CR	RU	SV	TK	BH	HG	From
HK	72.6	0.4	2.4	0.0	1.1	0.0	1.5	1.2	0.1	0.0	0.8	0.2	4.9	1.7	1.8	0.7	1.9	0.7	0.9	4.8	0.2	1.5	0.0	0.1	0.4	0.0	0.1	27.35
CH	0.4	79.7	0.9	0.5	0.6	0.1	0.3	0.5	2.0	0.2	0.9	2.0	5.9	0.1	0.7	0.0	0.2	0.1	0.3	2.5	1.4	0.0	0.2	0.1	0.5	0.0	0.0	20.30
TW	2.6	0.9	79.2	0.3	0.0	0.2	0.6	0.4	2.5	1.2	0.6	1.9	0.9	3.3	0.0	1.7	1.2	0.5	0.0	0.0	0.3	0.1	0.5	0.8	0.0	0.1	0.2	20.76
KS	0.0	0.6	0.3	89.9	0.1	0.3	0.0	0.4	0.4	1.8	0.0	0.2	0.5	0.1	0.6	0.9	0.2	0.2	1.9	0.2	0.5	0.0	0.1	0.0	0.0	0.0	0.7	10.13
PK	0.8	0.4	0.0	0.1	50.7	0.6	0.0	0.1	9.0	0.9	0.1	8.9	15.7	2.0	0.7	0.9	1.1	0.0	1.4	3.9	0.0	0.0	1.3	0.8	0.4	0.0	0.2	49.27
SL	0.0	0.1	0.1	0.2	1.0	75.9	0.4	0.3	0.0	0.1	0.2	6.2	0.9	1.0	0.2	0.6	0.5	0.2	0.6	8.1	0.5	0.2	0.2	0.3	2.4	0.0	0.0	24.10
TH	1.9	0.3	0.7	0.0	0.0	0.5	88.7	0.1	1.9	0.1	0.5	0.1	0.0	0.3	0.0	0.5	0.8	1.5	0.2	0.0	0.1	0.0	0.0	0.3	0.1	0.0	1.3	11.26
IJ	1.5	0.5	0.4	0.4	0.1	0.3	0.0	84.0	3.4	0.0	0.2	0.4	2.0	0.5	0.1	0.1	0.0	0.0	0.0	2.5	0.1	0.1	2.2	0.0	0.7	0.2	0.4	16.02
IN	0.1	1.2	1.5	0.2	8.4	0.0	1.0	1.9	47.5	0.0	1.1	8.1	10.0	2.7	0.0	0.8	0.8	0.6	0.1	3.8	6.1	0.0	0.1	0.7	3.2	0.0	0.1	52.55
SP	0.0	0.2	1.2	1.6	1.5	0.1	0.1	0.0	0.0	81.3	1.7	0.2	1.6	0.6	1.9	2.0	1.6	0.1	0.4	0.9	0.1	0.1	1.0	0.2	1.3	0.2	0.0	18.69
MK	0.9	1.0	0.6	0.0	0.1	0.2	0.5	0.2	2.0	1.8	87.4	0.1	0.0	0.6	0.2	0.2	0.3	0.2	0.0	0.0	0.9	0.7	0.9	0.4	0.5	0.0	0.1	12.61
PM	0.1	1.5	1.4	0.1	10.3	4.8	0.0	0.3	10.0	0.1	0.1	58.8	0.2	9.9	0.0	0.1	0.0	0.0	0.2	0.1	0.6	0.4	0.1	0.1	0.3	0.4	0.1	41.22
VM	3.2	3.5	0.5	0.3	14.4	0.5	0.0	1.1	10.0	0.9	0.1	0.2	47.5	9.1	0.7	0.3	0.3	0.0	0.0	0.4	0.5	0.5	0.5	3.1	1.0	0.2	1.1	52.53
MG	1.3	0.1	2.4	0.0	2.1	0.8	0.2	0.4	3.5	0.4	0.4	9.7	11.0	56.2	0.1	0.2	0.1	0.4	0.1	0.3	1.7	0.5	1.8	0.8	3.2	0.4	1.9	43.83
AR	2.3	0.7	0.0	0.6	1.3	0.3	0.0	0.1	0.0	2.1	0.2	0.0	1.2	0.2	88.6	0.4	0.3	0.1	0.1	0.2	0.6	0.0	0.0	0.0	0.1	0.1	0.4	11.37
BR	0.8	0.0	1.8	0.8	1.4	0.7	0.5	0.1	1.5	2.1	0.2	0.2	0.6	0.3	0.4	84.0	0.0	0.7	0.9	0.7	0.1	0.6	0.1	0.6	0.5	0.1	0.3	15.96
CL	2.2	0.2	1.3	0.2	1.9	0.5	0.5	0.0	1.4	1.7	0.3	0.0	0.5	0.2	0.2	0.0	85.4	0.0	0.1	1.3	0.3	0.2	0.1	0.0	0.1	0.5	0.8	14.60
PE	0.9	0.1	0.6	0.2	0.1	0.2	1.5	0.0	1.3	0.1	0.2	0.0	0.0	0.7	0.1	0.7	0.0	92.1	0.0	0.1	0.1	0.3	0.0	0.0	0.4	0.0	0.1	7.94
CO	1.2	0.3	0.0	1.8	2.4	0.7	0.2	0.0	0.1	0.5	0.0	0.2	0.1	0.2	0.2	0.9	0.5	0.0	86.0	0.2	0.0	0.3	1.7	1.5	0.8	0.3	0.0	14.01
RM	3.3	1.6	0.0	0.1	3.9	5.5	0.0	1.5	4.0	0.6	0.0	0.1	0.4	0.3	0.1	0.4	0.8	0.0	0.1	50.6	8.1	8.2	0.1	1.9	2.4	1.5	4.6	49.39
MN	0.2	1.2	0.3	0.5	0.0	0.5	0.1	0.1	9.0	0.1	0.7	0.7	0.7	2.2	0.5	0.1	0.2	0.1	0.0	11.2	70.1	0.4	0.6	0.3	0.0	0.0	0.2	29.94
CR	1.6	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.6	0.5	0.8	0.7	0.0	0.5	0.2	0.2	0.2	12.5	0.4	77.1	1.4	0.0	2.5	0.1	0.1	22.86
RU	0.0	0.2	0.5	0.1	2.1	0.3	0.0	2.1	0.1	1.0	0.9	0.1	0.7	2.6	0.0	0.1	0.0	0.0	1.6	0.0	0.7	1.5	81.8	0.6	0.7	0.5	1.7	18.19
SV	0.1	0.1	0.8	0.0	1.2	0.4	0.3	0.0	1.2	0.2	0.4	0.2	5.2	1.1	0.0	0.6	0.0	0.0	1.4	3.0	0.3	0.0	0.5	80.8	1.5	0.6	0.1	19.24
TK	0.4	0.4	0.0	0.0	0.5	2.2	0.1	0.6	4.9	1.2	0.4	0.3	1.5	4.2	0.1	0.4	0.1	0.4	0.6	3.4	0.0	2.3	0.6	1.3	72.1	0.6	1.3	27.91
BH	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.0	0.6	0.4	0.6	0.1	0.1	0.5	0.0	0.3	2.7	0.0	0.1	0.5	0.7	0.7	91.8	0.1	8.23
HG	0.1	0.1	0.2	0.7	0.3	0.0	1.1	0.4	0.2	0.0	0.1	0.1	1.9	2.7	0.3	0.3	0.7	0.1	0.0	7.2	0.2	0.1	1.7	0.1	1.4	0.1	80.0	19.99
To others	25.9	15.6	18.3	8.86	54.8	19.6	9.15	11.9	68.6	17.4	10.6	41.2	67.6	47.7	9.12	13.7	12.4	6.36	11.6	69.9	24	18	16.2	14.7	25.3	5.89	15.9	*Total*
Including own	124.5	110.9	115.8	107.6	160.4	115.0	107.0	107.8	184.7	116.1	108.6	141.2	182.6	151.6	106.9	111.5	110.2	104.8	109.2	190.3	118.1	113.1	114.1	110.2	122.7	103.5	111.8	*spillover*
Net	-1.4	-4.7	-2.5	-1.3	5.55	-4.5	-2.1	-4.1	16.1	-1.3	-2.0	-0.0	15	3.91	-2.2	-2.2	-2.2	-1.6	-2.4	20.5	-5.9	-4.9	-2.0	-4.5	-2.6	-2.3	-4.1	*24.45%*

Notes: Spillovers matrix was computed through LASSO-VAR(1). Spillovers measures consider a KPPS *10*-weeks-ahead forecast error variance decomposition. Source: Authors' elaboration.

Appendix 1. Firms sample.

Country	Firm	Code	Ticker	Sector	Industry	Sub-industry
Hong Kong	CNOOC Limited	HK01EN	883 HK	Energy	Oil & Gas	Oil & Gas Producers
Hong Kong	CLP Holdings Limited.	HK02EN	2 HK	Utilities	Utilities	Electric Utilities
Hong Kong	The Hong Kong and China Gas Company Limited.	HK03EN	3 HK	Utilities	Utilities	Gas & Water Utilities
Hong Kong	China Petroleum & Chemical Corporation.	HK04EN	386 HK	Energy	Oil & Gas	Oil & Gas Producers
Hong Kong	Power Assets Holdings Limited.	HK05EN	6 HK	Utilities	Utilities	Electric Utilities
Hong Kong	PetroChina Company Limited.	HK06EN	857 HK	Energy	Oil & Gas	Oil & Gas Producers
China	China Yangtze Power Co., Ltd.	CH01EN	600900 CH	Utilities	Utilities	Electric Utilities
China	EVE Energy Co., Ltd.	CH02RE	300014 CH	Energy	Renewable Energy	Renewable Energy
China	China Petroleum & Chemical Corporation.	CH03EN	600028 CH	Energy	Oil & Gas	Oil & Gas Producers
China	PetroChina Company Limited.	CH04EN	601857 CH	Energy	Oil & Gas	Oil & Gas Producers
China	Xinjiang Goldwind Science & Technology Co., Ltd.	CH05RE	002202 CH	Energy	Renewable Energy	Renewable Energy
China	SDIC Power Holdings Co., Ltd.	CH06EN	600886 CH	Utilities	Utilities	Electric Utilities
China	GD Power Development Co.,Ltd.	CH07EN	600795 CH	Utilities	Utilities	Electric Utilities
China	Huaneng Power International, Inc.	CH08EN	600011 CH	Utilities	Utilities	Electric Utilities
China	Huadian Power Internatioanal Corporation Limited.	CH09EN	600027 CH	Utilities	Utilities	Electric Utilities
China	China Oilfield Services Limited.	CH10EN	601808 CH	Energy	Oil & Gas	Oil & Gas Services & Equip
China	Shenergy Company Limited.	CH11EN	600642 CH	Utilities	Utilities	Electric Utilities
China	Shenzhen Energy Group Co., Ltd.	CH12EN	000027 CH	Utilities	Utilities	Electric Utilities
China	Offshore Oil Engineering Co., Ltd.	CH13EN	600583 CH	Energy	Oil & Gas	Oil & Gas Services & Equip
China	Guangdong Meiyan Jixiang Hydropower Co., Ltd.	CH14EN	600868 CH	Utilities	Utilities	Electric Utilities
China	Guangxi Guiguan Electric Power Co.,Ltd.	CH15EN	600236 CH	Utilities	Utilities	Electric Utilities
China	Guangdong Electric Power Development Co.,Ltd.	CH16EN	000539 CH	Utilities	Utilities	Electric Utilities
China	Shanghai Dazhong Public Utilities (Group) Co., Ltd.	CH17EN	600635 CH	Utilities	Utilities	Gas & Water Utilities
China	COFCO Biotechnology Co., Ltd.	CH18RE	000930 CH	Energy	Renewable Energy	Renewable Energy
China	Datang Huayin Electric Power Co., Ltd.	CH19EN	600744 CH	Utilities	Utilities	Electric Utilities
China	Jilin Electric Power Co., Ltd.	CH20EN	000875 CH	Utilities	Utilities	Electric Utilities
China	Inner Mongolia Mengdian Huaneng Thermal Power Corporation Ltd.	CH21EN	600863 CH	Utilities	Utilities	Electric Utilities
China	Henan Ancai Hi-Tech Co., Ltd.	CH22EN	600207 CH	Energy	Oil & Gas	Oil & Gas Producers
China	Shanghai Electric Power Company Limited.	CH23EN	600021 CH	Utilities	Utilities	Electric Utilities
China	Jinneng Holding Shanxi Electric Power Co., Ltd.	CH24EN	000767 CH	Utilities	Utilities	Electric Utilities
China	Guangdong Shaoneng Group Co., Ltd.	CH25EN	000601 CH	Utilities	Utilities	Electric Utilities
China	Changchun Gas Co., Ltd.	CH26EN	600333 CH	Utilities	Utilities	Gas & Water Utilities
China	Guanghui Energy Co., Ltd.	CH27EN	600256 CH	Energy	Oil & Gas	Oil & Gas Producers
China	Huadian Energy Co., Ltd.	CH28EN	600726 CH	Utilities	Utilities	Electric Utilities
China	Sichuan Chuantou Energy Co., Ltd.	CH29EN	600674 CH	Utilities	Utilities	Electric Utilities
China	Shenzhen Guangju Energy Co., Ltd.	CH30EN	000096 CH	Energy	Oil & Gas	Oil & Gas Producers
China	Sinopec Oilfield Service Corporation.	CH31EN	600871 CH	Energy	Oil & Gas	Oil & Gas Services & Equip
China	An Hui Wenergy Co., Ltd.	CH32EN	000543 CH	Utilities	Utilities	Electric Utilities
Taiwan	Formosa Petrochemical Corp.	TW01EN	6505 TT	Energy	Oil & Gas	Oil & Gas Producers
Taiwan	United Renewable Energy Co., Ltd.	TW02RE	3576 TT	Energy	Renewable Energy	Renewable Energy
Taiwan	The Great Taipei Gas Co., Ltd.	TW03EN	9908 TT	Utilities	Utilities	Gas & Water Utilities
Taiwan	National Petroleum Co., Ltd.	TW04EN	9937 TT	Energy	Oil & Gas	Oil & Gas Producers
Taiwan	Shin Hai Gas Corporation.	TW05EN	9926 TT	Utilities	Utilities	Gas & Water Utilities
Taiwan	Shin Shin Natural Gas Co., Ltd.	TW06EN	9918 TT	Utilities	Utilities	Gas & Water Utilities
Taiwan	Mosel Vitelic, Inc.	TW07RE	2342 TT	Energy	Renewable Energy	Renewable Energy
Taiwan	Taiwan Land Development Corporation.	TW08RE	2841 TT	Energy	Renewable Energy	Renewable Energy
Taiwan	Shan-Loong Transportation Co., Ltd.	TW09EN	2616 TT	Energy	Oil & Gas	Oil & Gas Producers
Taiwan	Hsin-Kao Gas Company Ltd.	TW10EN	9931 TT	Utilities	Utilities	Gas & Water Utilities
Taiwan	Luxe Electric Co Ltd.	TW11RE	1529 TT	Energy	Renewable Energy	Renewable Energy
South Korea	Korea Gas Corporation.	KS01EN	036460 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	Mi Chang Oil Industrial Co., Ltd.	KS02EN	003650 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	Yesco Holdings Co., Ltd.	KS03EN	015360 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	Korea Electric Power Corporation.	KS04EN	015760 KS	Utilities	Utilities	Electric Utilities
South Korea	SGC Energy Co.,Ltd.	KS05EN	005090 KS	Utilities	Utilities	Electric Utilities
South Korea	Incheon City Gas Co., Ltd.	KS06EN	034590 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	Hankook Shell Oil Co., Ltd.	KS07EN	002960 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	SK Innovation Co., Ltd.	KS08EN	096770 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	Daesung Holdings Co., Ltd.	KS09EN	016710 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	Samchully Co., Ltd.	KS10EN	004690 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	SK Inc.	KS11EN	034730 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	Busan City Gas	KS12EN	015350 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	SK Gas Ltd.	KS13EN	018670 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	Kukdong Oil & Chemicals Co., Ltd.	KS14EN	014530 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	Hanjin Heavy Industries & Construction Holdings Co.,Ltd.	KS15EN	003480 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	Seoul City Gas Co. Ltd.	KS16EN	017390 KS	Utilities	Utilities	Gas & Water Utilities
South Korea	S-Oil Corporation.	KS17EN	010950 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	SK Discovery Co.,Ltd.	KS18EN	006120 KS	Utilities	Utilities	Elec & Gas Marketing & Trad.
South Korea	E1 Corp.	KS19EN	017940 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	OCI Company Ltd.	KS20RE	010060 KS	Energy	Renewable Energy	Renewable Energy
South Korea	S-Oil Corp.	KS21EN	010955 KS	Energy	Oil & Gas	Oil & Gas Producers
South Korea	SK Discovery Corp Ltd	KS22EN	006125 KS	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	The Hub Power Co. Ltd.	PK01EN	HUBC PA	Utilities	Utilities	Electric Utilities
Pakistan	Oil & Gas Development Co. Ltd.	PK02EN	OGDC PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	Pakistan Petroleum Ltd.	PK03EN	PPL PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	Pakistan Oilfields Ltd.	PK04EN	POL PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	Pakistan State Oil Co. Ltd.	PK05EN	PSO PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	Mari Petroleum Co. Ltd.	PK06EN	MARI PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	Kot Addu Power Co. Ltd.	PK07EN	KAPCO PA	Utilities	Utilities	Electric Utilities
Pakistan	Sui Northern Gas Pipelines Ltd.	PK08EN	SNGP PA	Utilities	Utilities	Gas & Water Utilities
Pakistan	Attock Refinery Ltd.	PK09EN	ATRL PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	K-Electric Ltd.	PK10EN	KEL PA	Utilities	Utilities	Electric Utilities
Pakistan	Attock Petroleum Ltd.	PK11EN	APL PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	Sui Southern Gas Co. Ltd.	PK12EN	SSGC PA	Utilities	Utilities	Gas & Water Utilities
Pakistan	Shell Pakistan Ltd.	PK13EN	SHEL PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	National Refinery Ltd.	PK14EN	NRL PA	Energy	Oil & Gas	Oil & Gas Producers
Pakistan	Pakistan Refinery Ltd.	PK15EN	PRL PA	Energy	Oil & Gas	Oil & Gas Producers

Pakistan	Kohinoor Energy Ltd.	PK16EN	KOHE PA	Utilities	Utilities	Electric Utilities
Sri Lanka	Lanka IOC PLC	SL01EN	LIOC SL	Energy	Oil & Gas	Oil & Gas Producers
Sri Lanka	Vallibel Power Erathna.	SL02EN	VPEL SL	Utilities	Utilities	Electric Utilities
Sri Lanka	Vidullanka.	SL03EN	VLL SL	Utilities	Utilities	Electric Utilities
Sri Lanka	Resus Energy.	SL04EN	HPWR SL	Utilities	Utilities	Electric Utilities
Thailand	PTT Public Company Limited.	TH01EN	PTT TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	PTT Exploration and Production Public Company Limited.	TH02EN	PTTEP TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	Thai Oil Public Company Limited.	TH03EN	TOP TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	Electricity Generating Public Company Limited.	TH04EN	EGCO TB	Utilities	Utilities	Electric Utilities
Thailand	IRPC PCL.	TH05EN	IRPC TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	Ratchaburi Group.	TH06EN	RATCH TB	Utilities	Utilities	Electric Utilities
Thailand	Bangchak Corporation Public Company Limited.	TH07EN	BCP TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	Esso Thailand.	TH08EN	ESSO TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	Super Energy Corporation Public Company Limited.	TH09EN	SUPER TB	Utilities	Utilities	Electric Utilities
Thailand	Siamgas & Petrochemicals.	TH10EN	SGP TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	SPCG.	TH11EN	SPCG TB	Utilities	Utilities	Electric Utilities
Thailand	Rojana Industrial Park Public Company Limited.	TH12EN	ROJNA TB	Utilities	Utilities	Electric Utilities
Thailand	Eastern Power Group Public Company Limited.	TH13EN	EP TB	Utilities	Utilities	Electric Utilities
Thailand	Seven Utilities And Power Public Company Limited.	TH14EN	7UP TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	SUSCO.	TH15EN	SUSCO TB	Energy	Oil & Gas	Oil & Gas Producers
Thailand	Sahacogen Chonburi Public Company Limited.	TH16EN	SCG TB	Utilities	Utilities	Electric Utilities
Thailand	Eternal Energy Public Company Limited.	TH17EN	EE TB	Utilities	Utilities	Electric Utilities
Thailand	Solartron.	TH18RE	SOLAR TB	Energy	Renewable Energy	Renewable Energy
Indonesia	PT Perusahaan Gas Negara.	IJ01EN	PGAS IJ	Utilities	Utilities	Gas & Water Utilities
Indonesia	PT Medco Energi Internasional.	IJ02EN	MEDC IJ	Energy	Oil & Gas	Oil & Gas Producers
Indonesia	PT Elnusa.	IJ03EN	ELSA IJ	Energy	Oil & Gas	Oil & Gas Producers
Indonesia	PT Petrosea.	IJ04EN	PTRO IJ	Energy	Oil & Gas	Oil & Gas Producers
Indonesia	PT Energi Mega Persada Tbk.	IJ05EN	ENRG IJ	Energy	Oil & Gas	Oil & Gas Producers
Indonesia	PT Rukun Raharja Tbk.	IJ06EN	RAJA IJ	Energy	Oil & Gas	Oil & Gas Producers
Indonesia	PT Radiant Utama Interinsco Tbk.	IJ07EN	RUIS IJ	Energy	Oil & Gas	Oil & Gas Services & Equip
India	NTPC Ltd.	IN01EN	NTPC IB	Utilities	Utilities	Electric Utilities
India	Power Grid Corporation of India Limited.	IN02EN	PWGR IB	Utilities	Utilities	Electric Utilities
India	Reliance Industries Ltd.	IN03EN	RIL IB	Energy	Oil & Gas	Oil & Gas Producers
India	Oil and Natural Gas Corporation Limited.	IN04EN	ONGC IB	Energy	Oil & Gas	Oil & Gas Producers
India	Reliance Infrastructure Ltd.	IN05EN	RELI IN	Utilities	Utilities	Electric Utilities
India	Hindustan Petroleum Corporation Limited.	IN06EN	HPCL IN	Energy	Oil & Gas	Oil & Gas Producers
Singapore	Capallianz Holdings Ltd.	SP01EN	CAPL SP	Energy	Oil & Gas	Oil & Gas Producers
Singapore	Sembcorp Marine Ltd.	SP02EN	SMM SP	Energy	Oil & Gas	Oil & Gas Producers
Malaysia	Petronas Dagangan Berhad markets petroleum.	MK01EN	PETD MK	Energy	Oil & Gas	Oil & Gas Producers
Malaysia	Petronas Gas Berhad.	MK02EN	PTG MK	Energy	Oil & Gas	Oil & Gas Producers
Malaysia	Tenaga Nasional Berhad.	MK03EN	TNB MK	Utilities	Utilities	Electric Utilities
Malaysia	Dialog Group.	MK04EN	DLG MK	Energy	Oil & Gas	Oil & Gas Producers
Malaysia	YTL Power International Bhd.	MK05EN	YTLP MK	Utilities	Utilities	Electric Utilities
Malaysia	YTL Corporation Berhad.	MK06EN	YTL MK	Utilities	Utilities	Electric Utilities
Philippines	Aboitiz Ventures Inc.	PM01EN	AEV PM	Utilities	Utilities	Electric Utilities
Philippines	Manila Electric Company.	PM02EN	MER PM	Utilities	Utilities	Electric Utilities
Philippines	San Miguel Corporation.	PM03EN	SMC PM	Energy	Oil & Gas	Oil & Gas Producers
Philippines	Aboitiz Power Corporation.	PM04EN	AP PM	Utilities	Utilities	Electric Utilities
Philippines	First Gen Corporation.	PM05EN	FGEN PM	Utilities	Utilities	Electric Utilities
Philippines	Lopez Holdings Corp.	PM06EN	LPZ PM	Utilities	Utilities	Electric Utilities
Philippines	Petron Corporation.	PM07EN	PCOR PM	Energy	Oil & Gas	Oil & Gas Producers
Philippines	First Philippine Holdings Corporation.	PM08EN	FPH PM	Utilities	Utilities	Electric Utilities
Vietman	PetroVietnam Drilling & Well Services JSC.	VM01EN	PVD VM	Energy	Oil & Gas	Oil & Gas Producers
Vietman	Pha Lai Thermal Power JSC.	VM02EN	PPC VM	Utilities	Utilities	Electric Utilities
Vietman	Vinh Son Song Hinh Hydropower JSC.	VM03EN	VSH VM	Utilities	Utilities	Electric Utilities
Vietman	Thac Mo Hydro Power JSC.	VM04RE	TMP VM	Energy	Renewable Energy	Renewable Energy
Vietman	PetroVietnam Low Pressure Gas Distribution JSC.	VM05EN	PGD VM	Utilities	Utilities	Gas & Water Utilities
Vietman	Thac Ba Hydropower JSC.	VM06RE	TBC VM	Energy	Renewable Energy	Renewable Energy
Vietman	Can Don Hydro Power JSC.	VM07RE	SJD VM	Energy	Renewable Energy	Renewable Energy
Vietman	Petrolimex Gas JSC.	VM08EN	PGC VM	Energy	Oil & Gas	Oil & Gas Producers
Vietman	Ba Ria Thermal Power JSC.	VM09EN	BTP VM	Utilities	Utilities	Electric Utilities
Vietman	Khanh Hoa Power JSC.	VM10EN	KHP VM	Utilities	Utilities	Engineering & Construction
Vietman	An Pha Petroleum Group JSC.	VM11EN	ASP VM	Utilities	Utilities	Gas & Water Utilities
Mongolia	Tavantolgoi JSC (TTL)	MG01EN	TTL MO	Energy	Oil & Gas	Oil & Gas Producers
Mongolia	Sharyn Gol JSC	MG02EN	SHG MO	Energy	Oil & Gas	Oil & Gas Producers
Mongolia	Baganuur JSC	MG03EN	BAN MO	Energy	Oil & Gas	Oil & Gas Producers
Mongolia	Shivee Ovoo JSC	MG04EN	SHV MO	Energy	Oil & Gas	Oil & Gas Producers
Mongolia	HBOil JSC	MG05EN	HBO MO	Energy	Oil & Gas	Oil & Gas Producers
Argentina	Transener Cía. de Transp. de Energía Eléctr. en Alta Tensión	AR01EN	TRAN AR	Energy	Oil & Gas	Oil & Gas Producers
Argentina	Pampa Energia SA.	AR02EN	PAMP AR	Utilities	Utilities	Electric Utilities
Argentina	Transportadora de Gas del Sur S.A.	AR03EN	TGSU2 AR	Energy	Oil & Gas	Oil & Gas Producers
Argentina	Sociedad Comercial del Plata S.A.	AR04EN	COME AR	Energy	Oil & Gas	Oil & Gas Producers
Argentina	Central Puerto SA.	AR05EN	CEPU AR	Utilities	Utilities	Electric Utilities
Argentina	YPF S.A.	AR06EN	YPFD AR	Energy	Oil & Gas	Oil & Gas Producers
Argentina	Empresa Distribuidora y Comercializadora Norte S.A.	AR07EN	EDN AR	Utilities	Utilities	Electric Utilities
Argentina	Transportadora de Gas del Norte SA.	AR08EN	TGNO4 AR	Utilities	Utilities	Gas & Water Utilities
Argentina	Endesa Costanera.	AR09EN	CECO2 AF	Utilities	Utilities	Electric Utilities
Brazil	Petroleo Brasileiro S.A.	BR01EN	PETR4 BS	Energy	Oil & Gas	Oil & Gas Producers
Brazil	Petroleo Brasileiro S.A.	BR02EN	PETR3 BS	Energy	Oil & Gas	Oil & Gas Producers
Brazil	Ultrapar Participacoes S.A.	BR03EN	UGPA3 BS	Energy	Oil & Gas	Oil & Gas Producers
Brazil	Equatorial Energia SA.	BR04EN	EQTL3 BS	Utilities	Utilities	Electric Utilities
Brazil	Eneva S.A.	BR05EN	ENEV3 BS	Utilities	Utilities	Electric Utilities
Brazil	Cosan SA.	BR06EN	CSAN3 BS	Energy	Oil & Gas	Oil & Gas Producers
Brazil	Companhia Energetica de Minas Gerais- CEMIG.	BR07EN	CMIG4 BS	Utilities	Utilities	Electric Utilities
Brazil	Centrais Eletricas Brasileiras S.A.	BR08EN	ELET3 BS	Utilities	Utilities	Electric Utilities
Brazil	Energisa SA.	BR09EN	ENGI11 BS	Utilities	Utilities	Electric Utilities
Brazil	Engie Brasil Energia S.A.	BR10EN	EGIE3 BS	Utilities	Utilities	Electric Utilities
Brazil	Companhia Paranaense de Energia-Copel.	BR11EN	CPLE6 BS	Utilities	Utilities	Electric Utilities
Brazil	Transmissora Alianca de Energia Eletrica SA.	BR12EN	TAEE11 BS	Utilities	Utilities	Electric Utilities

Brazil	Centrais Eletricas Brasileiras S.A.	BR13EN	ELET6 BS	Utilities	Utilities	Electric Utilities
Brazil	CPFL Energia S.A.	BR14EN	CPFE3 BS	Utilities	Utilities	Electric Utilities
Brazil	EDP - Energias do Brasil SA.	BR15EN	ENBR3 BS	Utilities	Utilities	Electric Utilities
Brazil	Rio Paranapanema Energia S.A.	BR16EN	GEPA4 BS	Utilities	Utilities	Electric Utilities
Brazil	Companhia de Transmissao de Energia Eletrica Paulista.	BR17EN	TRPL4 BS	Utilities	Utilities	Electric Utilities
Brazil	Companhia Energetica de Minas Gerais- CEMIG.	BR18EN	CMIG3 BS	Utilities	Utilities	Electric Utilities
Chile	Colbun S.A.	CL01EN	COLBUN CC	Utilities	Utilities	Electric Utilities
Chile	Empresas Copec SA.	CL02EN	COPEC CC	Energy	Oil & Gas	Oil & Gas Producers
Chile	AES Andes S.A.	CL03EN	AESGENER CC	Utilities	Utilities	Electric Utilities
Chile	Enel Americas SA.	CL04EN	ENELAM CC	Utilities	Utilities	Electric Utilities
Chile	Enel Generacion Chile SA.	CL05EN	ENELGXCH CC	Utilities	Utilities	Electric Utilities
Chile	Antarchile S.A.	CL06EN	ANTAR CC	Energy	Oil & Gas	Oil & Gas Producers
Peru	Enel Generacion Peru S.A.A.	PE01EN	ENGEPEC1 PE	Utilities	Utilities	Electric Utilities
Peru	ENGIE Energia Peru S.A.A.	PE02EN	ENGIEC1 PE	Utilities	Utilities	Electric Utilities
Peru	Enel Distribucion Peru S.A.A.	PE03EN	ENDISPC1 PE	Utilities	Utilities	Electric Utilities
Peru	Refineria La Pampilla S.A.A.	PE04EN	RELAPAC1 PE	Energy	Oil & Gas	Oil & Gas Producers
Peru	Luz del Sur S.A.A.	PE05EN	LUSURC1 PE	Utilities	Utilities	Electric Utilities
Colombia	Ecopetrol SA.	CO01EN	ECOPETL CB	Energy	Oil & Gas	Oil & Gas Producers
Colombia	Interconexion Electrica S.A.	CO02EN	ISA CB	Utilities	Utilities	Electric Utilities
Colombia	Grupo Energia Bogota SA.	CO03EN	GEB CB	Utilities	Utilities	Gas & Water Utilities
Colombia	Celsia S.A.	CO04EN	CELSIA CB	Utilities	Utilities	Electric Utilities
Romania	Conpet SA Ploiesti	RM01EN	COTE RE	Energy	Oil & Gas	Oil & Gas Producers
Romania	Transelectrica SA	RM02EN	TEL RE	Utilities	Utilities	Electric Utilities
Montenegro	Elektroprivreda Crne Gore ad Niksic	MN01EN	EPCG ME	Utilities	Utilities	Electric Utilities
Montenegro	Jugopetrol ad Podgorica	MN02EN	JGPK ME	Energy	Oil & Gas	Oil & Gas Producers
Czech Republic	CEZ AS	CR01EN	CEZ CP	Utilities	Utilities	Electric Utilities
Russia	Federal Grid Co Unified Energy System PJSC	RU01EN	FEES RM	Utilities	Utilities	Electric Utilities
Russia	Gazprom Neft PJSC	RU02EN	GAZP RM	Energy	Oil & Gas	Oil & Gas Producers
Russia	RusHydro PJSC	RU03EN	HYDR RM	Utilities	Utilities	Electric Utilities
Russia	Inter RAO UES PJSC	RU04EN	IRAO RM	Utilities	Utilities	Elec & Gas Marketing & Trading
Russia	LUKOIL PJSC	RU05EN	LKOH RM	Energy	Oil & Gas	Oil & Gas Producers
Russia	Novatek PJSC	RU06EN	NVTK RM	Energy	Oil & Gas	Oil & Gas Producers
Russia	Rosneft Oil Co PJSC	RU07EN	ROSN RM	Energy	Oil & Gas	Oil & Gas Producers
Russia	Surgutneftegas PJSC	RU08EN	SNGS RM	Energy	Oil & Gas	Oil & Gas Producers
Russia	Surgutneftegas PJSC (Pref)	RU09EN	SNGSP RM	Energy	Oil & Gas	Oil & Gas Producers
Russia	Tatneft PJSC	RU10EN	TATN RM	Energy	Oil & Gas	Oil & Gas Producers
Russia	Tatneft PJSC (Pref)	RU11EN	TATNP RM	Energy	Oil & Gas	Oil & Gas Producers
Slovenia	Petrol dd Ljubljana	SV01EN	PETG SV	Energy	Oil & Gas	Oil & Gas Producers
Turkey	Aygaz A.S.	TK01EN	AYGAZ TI	Energy	Oil & Gas	Oil & Gas Producers
Turkey	Tupras Turkiye Petrol Rafinerileri A.S.	TK02EN	TUPRS TI	Energy	Oil & Gas	Oil & Gas Producers
Bosnia-Herzegovina	Elektrokrajina	BH01EN	EKBLRA BK	Utilities	Utilities	Electric Utilities
Bosnia-Herzegovina	Hidroelektrane Na Drini	BH02EN	HEDRRA BK	Utilities	Utilities	Electric Utilities
Bosnia-Herzegovina	Rite Gacko	BH03EN	RITERA BK	Utilities	Utilities	Electric Utilities
Hungary	MOL Hungarian Oil & Gas PLC	HG01EN	MOL HB	Energy	Oil & Gas	Oil & Gas Producers

Source: Bloomberg.

Appendix 2. Descriptive statistics: energy stock returns by firms.

Country	Code	Obs.	Mean	Median	Std. Dev.	Min	Max	Skewness	Kurtosis	Shapiro-Wilk	ADF test
Hong Kong	HK01EN	585	0.0382	-0.0009	4.8807	-21.8072	21.9828	0.0511	5.6748	5.918***	-24.957***
Hong Kong	HK02EN	585	0.0775	0.0951	1.9065	-9.6573	11.8184	0.0663	6.9276	6.370***	-24.396***
Hong Kong	HK03EN	585	0.1138	0.2050	2.2985	-13.1939	7.0642	-0.5134	5.3508	5.599***	-23.351***
Hong Kong	HK04EN	585	0.0222	-0.0537	3.7515	-11.6022	18.4366	0.3834	4.7178	4.554***	-23.936***
Hong Kong	HK05EN	585	0.0433	0.0955	2.5660	-13.4033	12.2959	-0.6282	7.4263	7.551***	-25.059***
Hong Kong	HK06EN	585	-0.1396	-0.3870	4.0099	-15.3577	17.1343	0.3098	3.9922	3.257***	-23.858***
China	CH01EN	585	0.1858	0.0134	2.4568	-11.2546	14.6288	0.2037	6.3906	6.280***	-24.265***
China	CH02RE	585	0.9191	0.5778	8.0478	-34.6392	38.1720	0.2325	5.5015	6.346***	-24.121***
China	CH03EN	585	-0.0889	-0.0582	3.4009	-21.2392	11.4055	-0.3201	6.7054	6.744***	-23.476***
China	CH04EN	585	-0.1428	-0.2013	3.1123	-20.6516	14.6601	0.1539	10.493	9.106***	-23.876***
China	CH05RE	585	0.1958	-0.0133	5.9875	-26.3405	33.5157	0.5370	6.8950	7.158***	-25.789***
China	CH06EN	585	0.2381	0.0345	3.8533	-37.3876	17.4997	-1.2131	19.4501	8.949***	-22.326***
China	CH07EN	585	0.0175	0.0000	4.0340	-32.7412	21.9903	-0.3764	17.9020	10.114***	-22.646***
China	CH08EN	585	-0.0025	-0.1409	4.2032	-24.2431	32.4480	0.5522	12.2863	8.497***	-24.492***
China	CH09EN	585	0.0514	-0.2047	4.7555	-35.8453	24.5463	0.0002	12.7370	9.170***	-24.614***
China	CH10EN	585	0.1330	-0.1151	5.4243	-38.3992	24.0060	-0.2380	8.9984	7.727***	-23.330***
China	CH11EN	585	0.0417	0.0000	3.8799	-27.6193	23.3128	-0.2018	15.8929	9.886***	-24.227***
China	CH12EN	585	0.2552	0.0000	5.3453	-36.9494	31.4579	-0.1847	17.9889	10.571***	-21.639***
China	CH13EN	585	0.0233	0.1292	5.3506	-41.0765	20.4919	-0.5670	11.4856	8.344***	-24.610***
China	CH14EN	585	0.2203	-0.0412	6.9655	-40.8946	52.5057	1.0035	15.1043	10.189***	-22.922***
China	CH15EN	585	0.1658	0.0193	4.6856	-33.7989	34.1409	-0.0934	15.5420	9.588***	-23.933***
China	CH16EN	585	0.0249	0.0000	4.2821	-35.1768	36.6573	0.3227	22.0135	10.099***	-26.674***
China	CH17EN	585	0.1104	-0.0428	6.1823	-32.2167	37.4084	0.6385	11.5267	9.386***	-22.371***
China	CH18RE	585	0.2193	0.1180	6.4173	-37.9098	35.6090	0.3574	10.0389	8.979***	-22.583***
China	CH19EN	585	0.2511	0.0000	6.7723	-41.0133	44.0328	0.8824	11.8934	9.409***	-21.434***
China	CH20EN	585	0.1653	-0.0415	5.7818	-37.1290	30.2190	0.4821	10.1629	9.223***	-22.061***
China	CH21EN	585	0.0877	-0.0596	4.9831	-40.1573	22.5929	-0.7103	13.9145	9.052***	-24.890***
China	CH22EN	585	0.3124	0.0000	7.8087	-39.8209	60.9121	1.1799	14.5304	9.489***	-23.063***
China	CH23EN	585	0.2073	0.0000	5.2577	-33.4612	28.1869	0.6055	11.6465	9.695***	-21.925***
China	CH24EN	585	0.1028	0.0000	5.6196	-40.2877	50.2238	0.5132	20.0235	9.980***	-22.438***
China	CH25EN	585	0.1426	0.0000	5.5800	-34.0097	21.7972	0.0037	7.4873	7.708***	-21.412***
China	CH26EN	585	0.0699	0.0278	6.4266	-29.8347	61.6453	1.9640	20.7974	9.790***	-25.626***
China	CH27EN	585	0.0876	-0.0877	5.3954	-29.5352	20.9930	-0.1846	6.6312	7.295***	-24.442***
China	CH28EN	585	0.0635	-0.2210	5.8937	-41.0144	31.1778	0.2766	12.9520	9.757***	-22.768***
China	CH29EN	585	0.2569	0.3937	4.0443	-25.3888	25.9322	-0.2019	13.4035	9.185***	-24.306***
China	CH30EN	585	0.2412	-0.0683	6.4085	-37.3747	48.3619	1.0617	16.1419	10.124***	-23.455***
China	CH31EN	585	0.0439	0.0000	6.4403	-45.4640	36.6446	-0.2862	15.2545	10.058***	-24.888***
China	CH32EN	585	0.0815	0.2142	4.6276	-28.4048	21.5211	-0.3923	7.3673	7.108***	-23.833***
Taiwan	TW01EN	585	0.1011	0.0000	3.5199	-16.0257	14.9129	-0.0669	5.7459	6.217***	-26.499***
Taiwan	TW02RE	585	-0.0020	-0.0934	6.4211	-25.1263	23.8989	0.2683	5.1566	6.510***	-22.037***
Taiwan	TW03EN	585	0.1429	0.1317	1.5184	-10.2701	8.0071	-0.3797	9.2465	7.787***	-24.488***
Taiwan	TW04EN	585	0.0857	0.0000	1.9305	-12.5615	9.0174	-0.3969	9.3553	8.260***	-23.478***
Taiwan	TW05EN	585	0.1984	0.1247	1.9635	-9.8668	12.5086	0.2950	8.2311	7.665***	-27.602***
Taiwan	TW06EN	585	0.1143	0.0831	2.0714	-11.1399	12.2597	-0.0190	7.4744	7.160***	-28.821***
Taiwan	TW07RE	585	0.1130	-0.6895	8.3568	-27.3713	40.1649	1.1429	7.1682	8.566***	-23.215***
Taiwan	TW08RE	585	0.0854	-0.0454	3.9105	-25.7627	38.0126	1.5766	23.186	10.270***	-24.854***
Taiwan	TW09EN	585	0.1587	0.1791	2.0186	-15.3411	6.2576	-1.4476	11.334	8.886***	-24.223***
Taiwan	TW10EN	585	0.2153	0.1461	2.3183	-10.4635	14.7486	0.2498	8.7613	8.258***	-25.473***
Taiwan	TW11RE	585	0.1049	0.2820	7.6402	-27.7944	31.9441	0.5575	5.4580	6.999***	-25.693***
South Korea	KS01EN	585	0.0675	-0.2324	5.0823	-32.2520	31.0772	0.2299	8.2793	7.113***	-25.220***
South Korea	KS02EN	585	0.1588	0.0437	3.5425	-34.1903	15.6913	-1.4262	19.4888	9.226***	-25.903***
South Korea	KS03EN	585	0.0894	0.0449	2.7962	-18.1952	16.1361	0.4470	11.1837	8.892***	-23.266***
South Korea	KS04EN	585	0.0204	0.0186	4.1929	-22.8226	13.8197	-0.1298	5.1162	4.870***	-24.419***
South Korea	KS05EN	585	0.1291	-0.0677	5.4340	-26.3805	32.5340	0.3129	6.5051	6.214***	-24.239***
South Korea	KS06EN	585	0.0465	0.0474	2.3025	-12.3573	9.2168	-0.2458	6.0461	6.791***	-25.013***
South Korea	KS07EN	585	0.1880	0.0189	3.4794	-14.1547	17.5366	0.4313	5.4611	6.119***	-24.077***
South Korea	KS08EN	585	0.2788	0.2603	6.1877	-32.0831	35.5706	0.3770	7.6918	7.198***	-25.482***
South Korea	KS09EN	585	0.3302	0.0745	4.8058	-22.1527	25.1488	0.6441	7.4583	7.909***	-22.401***
South Korea	KS10EN	585	0.0033	-0.1103	3.5547	-15.7328	16.9688	0.5181	5.5380	6.176***	-22.475***
South Korea	KS11EN	585	0.4228	0.1886	5.5065	-33.4817	25.5292	0.2060	6.7943	6.576***	-25.426***
South Korea	KS12EN	585	0.2314	0.0821	3.6516	-19.6493	48.8172	4.4124	63.2873	11.597***	-28.039***
South Korea	KS13EN	585	0.2453	0.0302	4.5371	-21.6615	29.2869	0.6929	7.4207	7.154***	-23.441***
South Korea	KS14EN	585	0.3216	0.1813	5.3236	-36.7543	67.8273	3.6715	55.3425	11.489***	-27.087***
South Korea	KS15EN	585	-0.0203	-0.5948	5.9729	-22.7168	24.6837	0.6363	5.0733	6.382***	-23.496***
South Korea	KS16EN	585	0.1509	0.1307	3.6716	-15.7095	16.4102	0.3825	6.2630	7.344***	-23.706***
South Korea	KS17EN	585	0.2092	0.0552	5.4449	-25.4673	28.3723	0.3484	6.1427	6.260***	-25.642***
South Korea	KS18EN	585	0.2611	0.0000	6.6295	-23.4500	62.4839	2.8651	26.2655	10.576***	-26.392***
South Korea	KS19EN	585	0.0039	-0.1624	3.8423	-22.7189	22.4038	0.3030	8.5777	7.837***	-23.771***
South Korea	KS20RE	585	0.1402	-0.0060	7.0583	-33.1345	34.9050	0.0622	5.7308	5.829***	-23.984***
South Korea	KS21EN	585	0.0895	-0.0308	4.1179	-18.9956	21.6573	0.1815	6.3101	6.570***	-22.827***
South Korea	KS22EN	585	0.5081	0.0360	8.1381	-30.2944	85.5560	4.4296	45.3368	11.737***	-27.892***
Pakistan	PK01EN	585	0.1363	0.0539	3.6626	-19.8776	15.0376	-0.1294	6.4358	6.716***	-23.340***
Pakistan	PK02EN	585	-0.0535	-0.0968	3.8308	-17.9723	24.4471	0.3327	7.6149	7.068***	-22.585***
Pakistan	PK03EN	585	0.0156	-0.0855	3.9505	-21.4350	16.0060	-0.0328	6.7243	7.036***	-22.719***

Pakistan	PK04EN	585	0.0863	0.1423	3.9810	-23.3817	13.3006	-0.4725	6.8162	6.913***	-21.318***
Pakistan	PK05EN	585	0.1286	0.0141	4.5259	-17.3724	18.2259	0.2288	5.0478	5.846***	-21.589***
Pakistan	PK06EN	585	0.6032	-0.0032	5.7001	-22.7086	26.9910	0.8491	7.0204	8.457***	-19.483***
Pakistan	PK07EN	585	-0.0388	-0.0838	4.1368	-20.1437	30.2746	0.9574	13.2366	9.273***	-22.426***
Pakistan	PK08EN	585	0.1737	-0.1296	5.9798	-27.7220	19.7580	0.1520	4.5872	5.678***	-22.571***
Pakistan	PK09EN	585	0.2256	-0.0105	6.1834	-27.7274	24.7649	0.0888	4.5365	5.222***	-22.685***
Pakistan	PK10EN	585	0.1684	-0.2902	6.0445	-18.4470	33.3543	0.8748	5.9803	7.120***	-23.257***
Pakistan	PK11EN	585	0.0535	-0.0333	3.8026	-22.5035	14.1214	-0.5161	6.9788	7.163***	-22.592***
Pakistan	PK12EN	585	0.1076	-0.3216	5.8995	-22.3533	21.5089	0.1865	4.2846	4.953***	-23.456***
Pakistan	PK13EN	585	0.1104	-0.2105	5.6054	-22.4682	35.0615	0.9151	8.5075	8.191***	-21.497***
Pakistan	PK14EN	585	0.3069	-0.0955	6.3982	-27.7989	32.9847	0.5216	6.8378	8.005***	-20.979***
Pakistan	PK15EN	585	0.2494	-0.6877	7.1588	-24.5431	36.0176	0.8207	5.8487	7.339***	-21.099***
Pakistan	PK16EN	585	-0.0002	-0.0707	4.4412	-22.8854	20.4871	0.0674	8.2306	8.586***	-25.638***
Sri Lanka	SL01EN	585	0.0365	-0.3137	4.5650	-15.4346	29.0896	0.9112	6.9555	7.313***	-21.594***
Sri Lanka	SL02EN	585	0.0667	-0.0233	4.5299	-19.3275	56.3584	3.7224	46.4120	11.132***	-25.495***
Sri Lanka	SL03EN	585	0.1455	-0.0325	4.1396	-14.2933	21.7005	1.0314	7.6639	8.280***	-26.305***
Sri Lanka	SL04EN	585	0.0752	-0.2208	4.9194	-35.6614	40.6692	1.1006	18.0847	9.745***	-30.646***
Thailand	TH01EN	585	0.1828	0.0607	4.1619	-26.2226	20.4661	0.0777	8.2162	7.341***	-24.975***
Thailand	TH02EN	585	0.0813	-0.0547	4.7108	-34.5602	24.8172	-0.4629	10.9584	8.201***	-23.175***
Thailand	TH03EN	585	0.1834	0.3282	4.8008	-25.9016	30.4687	0.0376	7.7926	6.979***	-23.707***
Thailand	TH04EN	585	0.2047	0.2104	3.1315	-21.1138	19.5677	-0.2184	10.7276	8.132***	-22.901***
Thailand	TH05EN	585	0.1030	-0.0554	4.9029	-22.6838	34.4971	0.8074	9.6620	7.941***	-23.815***
Thailand	TH06EN	585	0.1157	-0.0089	2.8832	-21.7066	22.7463	0.5118	15.8251	8.979***	-26.913***
Thailand	TH07EN	585	0.2042	0.2564	4.3968	-30.8072	22.3347	-0.2169	9.3702	7.701***	-22.981***
Thailand	TH08EN	585	0.2216	0.0650	5.7857	-32.4305	35.5246	0.4848	8.0812	7.579***	-21.769***
Thailand	TH09EN	585	0.8235	0.0000	8.3769	-33.7571	45.7843	0.9612	7.7197	8.517***	-23.907***
Thailand	TH10EN	585	0.3565	0.3916	5.6139	-26.8566	30.6398	-0.0986	6.3231	6.312***	-24.250***
Thailand	TH11EN	585	0.3704	0.0498	5.4068	-26.3521	41.9887	1.5412	15.4676	10.081***	-22.587***
Thailand	TH12EN	585	0.0233	-0.1905	4.9765	-25.5112	30.5031	0.4677	7.9677	7.410***	-24.071***
Thailand	TH13EN	585	0.3681	0.1509	4.6434	-19.4724	27.5012	0.7212	8.3523	8.100***	-22.074***
Thailand	TH14EN	585	0.4518	-0.5431	10.6120	-27.7273	95.8014	2.8843	20.5566	10.782***	-24.086***
Thailand	TH15EN	585	0.5285	-0.0787	6.0418	-28.1220	49.5311	1.6974	14.6899	9.769***	-21.527***
Thailand	TH16EN	585	0.0313	0.0000	3.1423	-16.9352	32.5916	1.9329	26.9679	10.526***	-22.514***
Thailand	TH17EN	585	0.0897	-0.4217	6.8888	-26.6256	39.5213	1.2375	8.7789	9.209***	-26.536***
Thailand	TH18RE	585	0.3661	-0.3730	8.3934	-47.9114	64.7740	1.5398	15.2776	9.956***	-22.953***
Indonesia	IJ01EN	585	-0.0800	0.1579	5.9799	-33.9336	30.2622	-0.2446	7.6187	7.560***	-21.818***
Indonesia	IJ02EN	585	0.2318	-0.5126	7.5272	-34.8063	45.6562	0.7723	7.7976	8.055***	-21.363***
Indonesia	IJ03EN	585	0.1675	-0.4265	7.1930	-31.1243	52.0809	1.4771	12.2897	9.466***	-22.059***
Indonesia	IJ04EN	585	0.3082	0.0000	7.7492	-29.5794	42.0689	1.2331	8.4068	9.066***	-21.978***
Indonesia	IJ05EN	585	-0.1216	-0.2725	9.0446	-49.3783	57.3487	1.1463	12.2412	10.003***	-22.147***
Indonesia	IJ06EN	585	0.5877	-1.0174	9.1717	-32.1486	61.1807	1.6431	9.9901	9.469***	-22.048***
Indonesia	IJ07EN	585	0.1673	-0.0856	6.7168	-21.3982	47.3455	2.1022	15.3786	10.449***	-26.340***
India	IN01EN	585	-0.1018	-0.3267	3.8978	-22.1985	17.7564	-0.1592	5.4527	5.186***	-24.099***
India	IN02EN	585	0.0904	0.0093	3.2963	-21.8411	12.8655	-0.2832	7.2222	6.460***	-25.192***
India	IN03EN	585	0.2404	0.2075	4.2654	-17.1531	18.6373	0.0230	4.4155	3.764***	-24.443***
India	IN04EN	585	-0.0863	-0.2074	4.5775	-23.2540	17.4856	-0.1226	5.2103	5.306***	-24.257***
India	IN05EN	585	-0.2661	0.0215	8.8993	-42.9359	47.2642	0.4494	7.9309	8.018***	-20.420***
India	IN06EN	585	0.2286	-0.1155	5.2743	-28.7803	30.0224	0.2464	5.9749	5.684***	-23.782***
Singapore	SP01EN	585	0.0431	0.0454	3.4687	-18.9947	14.1906	-0.2375	6.3160	6.551***	-22.686***
Singapore	SP02EN	585	-0.3213	-0.3668	5.3255	-27.6031	28.7838	0.3357	8.5437	8.244***	-22.761***
Malaysia	MK01EN	585	0.1567	0.0356	3.1280	-14.2338	16.8445	0.1680	6.7642	7.393***	-24.275***
Malaysia	MK02EN	585	0.0822	-0.0571	2.7570	-9.9075	12.6092	0.4441	4.9820	5.998***	-24.967***
Malaysia	MK03EN	585	0.0854	-0.0979	2.7728	-12.2814	18.6453	0.9575	10.1300	8.371***	-24.100***
Malaysia	MK04EN	585	0.3696	0.0465	3.5766	-18.6251	13.1650	0.0358	5.5770	6.799***	-27.463***
Malaysia	MK05EN	585	-0.1448	0.0092	3.4666	-21.0978	13.2559	-0.2188	6.0418	6.005***	-22.815***
Malaysia	MK06EN	585	-0.0657	-0.2370	4.1095	-21.3612	21.9366	0.2730	7.3757	7.492***	-25.487***
Philippines	PM01EN	585	0.3262	-0.0011	4.6612	-16.7005	33.2544	1.0603	9.8367	8.755***	-25.111***
Philippines	PM02EN	585	0.1176	-0.0396	3.8556	-15.7667	19.2229	0.1843	6.4518	7.144***	-23.973***
Philippines	PM03EN	585	0.2018	-0.0887	4.2437	-24.7892	25.7417	0.4574	10.8969	9.275***	-20.925***
Philippines	PM04EN	585	0.2204	0.0897	3.5306	-15.9153	20.5127	0.5893	6.5350	6.760***	-26.998***
Philippines	PM05EN	585	0.2741	0.1338	4.4799	-14.7623	21.0632	0.5061	5.1693	5.675***	-24.284***
Philippines	PM06EN	585	0.1072	-0.0238	5.0079	-16.0055	32.4899	0.9862	8.4658	8.252***	-23.600***
Philippines	PM07EN	585	0.0191	-0.3261	5.3133	-20.1947	50.6427	2.2926	20.4129	10.042***	-22.770***
Philippines	PM08EN	585	0.1326	0.1487	3.4268	-17.3486	12.7058	-0.0950	5.1823	5.602***	-21.815***
Vietman	VM01EN	585	0.0239	-0.0094	5.8252	-19.8227	30.0087	0.2059	5.2348	5.482***	-24.144***
Vietman	VM02EN	585	0.1078	-0.0155	4.9784	-16.8679	21.8350	0.2266	4.5317	4.634***	-25.851***
Vietman	VM03EN	585	0.0437	0.0000	3.5492	-23.8492	22.4481	0.0166	10.8363	8.753***	-24.958***
Vietman	VM04RE	585	0.1701	0.0446	3.9636	-15.1739	18.1561	-0.1554	4.8087	5.451***	-28.000***
Vietman	VM05EN	585	0.0948	-0.0989	4.9048	-25.5966	28.7167	0.4217	8.9729	8.343***	-24.280***
Vietman	VM06RE	585	0.0462	0.0000	3.3253	-16.4901	12.5505	-0.2058	5.5992	5.973***	-30.915***
Vietman	VM07RE	585	0.0938	0.0048	3.3814	-19.9764	15.8204	-0.5148	8.9097	8.992***	-24.087***
Vietman	VM08EN	585	0.1649	0.0000	4.7597	-15.2492	20.0625	0.5451	5.6370	7.515***	-22.288***
Vietman	VM09EN	585	0.1013	-0.0746	5.0648	-17.5571	21.3334	0.7770	6.0906	8.079***	-24.511***
Vietman	VM10EN	585	-0.0478	-0.0406	3.5850	-21.1995	18.0530	0.2813	8.9599	8.739***	-27.518***
Vietman	VM11EN	585	0.0128	-0.1624	5.9894	-19.4315	27.5140	0.9776	6.5561	8.132***	-25.885***
Mongolia	MG01EN	585	0.5342	-0.0688	8.8406	-37.3328	69.4733	2.1897	18.0098	10.691***	-22.036***

Mongolia	MG02EN	585	0.1744	0.0000	9.3886	-30.7432	96.3662	3.2726	30.2942	11.024***	-23.921***
Mongolia	MG03EN	585	0.0420	-0.1662	8.8619	-22.1458	63.0646	2.2230	14.6068	10.004***	-23.250***
Mongolia	MG04EN	585	0.1881	0.0000	9.6385	-31.0736	67.1575	2.0296	12.5744	10.242***	-23.187***
Mongolia	MG05EN	585	-0.1055	0.0000	6.9659	-37.6430	49.5050	1.1381	14.2795	10.454***	-24.557***
Argentina	AR01EN	585	0.3805	-0.1659	8.8320	-63.5494	40.3742	-0.1025	8.8862	7.391***	-25.336***
Argentina	AR02EN	585	0.3768	0.2457	6.9615	-48.3529	30.1950	-0.2884	8.1124	6.920***	-24.730***
Argentina	AR03EN	585	0.3843	-0.1088	6.7711	-39.4318	28.6395	-0.1994	6.2935	6.082***	-24.050***
Argentina	AR04EN	585	0.2440	-0.1283	7.7112	-48.7941	27.6385	-0.1355	6.8167	6.668***	-25.353***
Argentina	AR05EN	585	0.3754	0.0027	7.3577	-55.3329	32.5712	-0.4385	10.1309	8.123***	-24.257***
Argentina	AR06EN	585	-0.0218	0.1820	7.5578	-52.2785	61.7665	0.0513	15.4067	8.986***	-24.017***
Argentina	AR07EN	585	0.3166	-0.2733	8.5099	-60.1875	55.3597	0.2848	11.1244	8.490***	-24.400***
Argentina	AR08EN	585	0.5446	-0.1316	9.0532	-54.5180	46.5670	0.1670	7.6753	7.553***	-23.239***
Argentina	AR09EN	585	0.1457	-0.5118	9.3493	-44.6882	57.5617	1.1088	9.7906	9.189***	-24.469***
Brazil	BR01EN	585	0.0110	0.1536	7.6342	-42.9901	40.9102	0.1423	7.6594	7.399***	-23.394***
Brazil	BR02EN	585	-0.0103	-0.0218	7.5896	-43.8948	36.1331	-0.0380	7.3298	7.112***	-23.539***
Brazil	BR03EN	585	0.0376	0.1490	5.0769	-33.8850	23.3308	-0.3269	8.6557	7.635***	-22.699***
Brazil	BR04EN	585	0.2974	0.4153	4.4429	-23.1956	23.8787	-0.4232	6.7299	6.408***	-23.134***
Brazil	BR05EN	585	-0.1874	0.0631	7.4172	-40.3168	28.1538	-0.7313	7.6841	7.713***	-22.952***
Brazil	BR06EN	585	0.2022	0.1842	5.6464	-29.4058	28.1089	-0.0900	5.9022	5.647***	-25.364***
Brazil	BR07EN	585	-0.0119	0.2552	6.5732	-28.7986	34.4180	0.1224	6.2253	6.368***	-22.236***
Brazil	BR08EN	585	0.1078	-0.2557	8.1672	-38.5587	36.2300	0.4485	6.0005	6.740***	-22.594***
Brazil	BR09EN	585	0.1573	0.0000	4.8485	-24.0646	21.3266	-0.3203	7.2616	7.700***	-23.536***
Brazil	BR10EN	585	0.0258	-0.0094	4.0079	-13.8098	15.0078	0.0386	3.9147	2.887***	-22.697***
Brazil	BR11EN	585	0.0489	0.1326	5.4685	-26.1350	20.8603	-0.1031	5.0881	5.112***	-22.672***
Brazil	BR12EN	585	0.0656	0.0000	4.1215	-19.8255	12.9905	-0.3083	5.1382	5.423***	-22.231***
Brazil	BR13EN	585	0.0927	-0.3847	7.5102	-41.0060	29.9756	-0.0109	6.1494	6.198***	-23.058***
Brazil	BR14EN	585	0.0061	0.1032	4.6463	-28.3158	26.6150	-0.4485	9.0597	7.753***	-23.410***
Brazil	BR15EN	585	-0.0132	0.0826	4.4302	-24.7559	18.5439	-0.1596	5.3843	4.972***	-23.434***
Brazil	BR16EN	585	-0.0924	0.0000	4.5579	-24.8064	25.5478	0.1607	8.9177	9.010***	-28.011***
Brazil	BR17EN	585	0.0100	0.0739	4.4125	-32.1708	16.8379	-0.7461	9.3041	7.428***	-23.445***
Brazil	BR18EN	585	0.0768	0.2271	6.5470	-31.3483	35.9330	0.2332	7.4808	7.150***	-21.296***
Chile	CL01EN	585	0.0162	-0.1245	3.8590	-20.3002	17.8359	0.0548	5.8497	5.857***	-25.495***
Chile	CL02EN	585	0.0495	0.1133	4.2813	-32.5473	20.7473	-0.3567	9.7503	7.287***	-24.856***
Chile	CL03EN	585	-0.0931	0.0000	3.9267	-26.7384	17.0543	-0.4121	7.8934	6.913***	-25.868***
Chile	CL04EN	585	0.0090	0.0436	4.2069	-32.4863	36.5761	0.3098	18.8867	9.229***	-26.474***
Chile	CL05EN	585	-0.1505	-0.2028	3.5334	-15.6063	16.5876	0.1267	5.4457	5.782***	-24.523***
Chile	CL06EN	585	-0.0040	-0.0882	3.8896	-19.1263	21.6970	0.3256	6.5302	6.313***	-24.335***
Peru	PE01EN	585	0.1818	0.0677	3.5901	-20.1127	16.5410	0.0582	6.6622	7.011***	-23.309***
Peru	PE02EN	585	0.0703	0.0000	2.3431	-7.7447	11.2246	0.5608	6.1034	7.807***	-19.457***
Peru	PE03EN	585	0.1513	0.0000	3.1369	-24.1615	20.1150	0.0236	12.8402	8.965***	-22.741***
Peru	PE04EN	585	-0.1077	-0.5238	6.7965	-23.6405	50.1014	1.7486	13.6806	9.093***	-24.140***
Peru	PE05EN	585	0.2042	0.0855	3.8066	-23.8751	29.9857	0.3710	18.5704	10.486***	-21.472***
Colombia	CO01EN	585	0.0592	0.2423	5.7742	-42.1184	34.5717	-0.3747	14.3147	9.125***	-23.334***
Colombia	CO02EN	585	0.1077	0.1134	4.6989	-35.0766	25.7781	-0.4254	12.0929	8.644***	-24.183***
Colombia	CO03EN	585	0.0819	0.1614	3.4837	-21.6286	15.3209	-0.3929	7.6736	7.264***	-26.236***
Colombia	CO04EN	585	-0.0333	0.0277	4.1715	-26.2419	21.4743	-0.5171	8.7663	7.509***	-24.624***
Romania	RM01EN	585	0.2188	0.0000	4.2623	-17.6525	21.0214	0.5561	7.1161	8.056***	-23.484***
Romania	RM02EN	585	0.1337	0.0303	3.9995	-14.8857	16.4246	-0.0054	5.3071	6.621***	-24.341***
Montenegro	MN01EN	585	0.0970	-0.0264	6.7147	-27.3290	42.5595	1.1170	9.9095	9.442***	-30.184***
Montenegro	MN02EN	585	0.0667	0.0000	3.6919	-27.0142	15.0207	-0.8360	12.7349	9.151***	-27.675***
Czech Republic	CR01EN	585	-0.0587	0.0712	3.5207	-20.5877	16.9212	-0.1008	6.7200	6.361***	-26.208***
Russia	RU01EN	585	0.0002	0.0000	6.7094	-32.5581	50.0000	0.4241	11.4422	8.662***	-23.101***
Russia	RU02EN	585	-0.0028	-0.1018	4.9299	-23.3063	20.3338	0.1085	5.3291	5.637***	-23.971***
Russia	RU03EN	585	-0.0703	-0.0772	5.4023	-27.4379	34.5178	0.1608	8.2074	7.486***	-23.412***
Russia	RU04EN	585	0.0295	-0.2328	5.9839	-28.5514	26.9758	0.0779	7.1863	7.540***	-23.208***
Russia	RU05EN	585	0.1729	0.1628	4.6648	-32.6067	28.5562	-0.1976	11.1534	8.271***	-25.233***
Russia	RU06EN	585	0.3394	0.1469	5.0123	-31.1920	35.4591	0.5278	10.6789	8.170***	-27.876***
Russia	RU07EN	585	0.1283	0.0271	5.3954	-34.3488	36.9316	-0.0707	11.5870	8.489***	-24.932***
Russia	RU08EN	585	0.0239	0.0539	5.2896	-29.9657	35.7079	0.2108	10.6840	8.473***	-23.655***
Russia	RU09EN	585	0.1250	0.1171	4.6312	-24.7345	20.4051	-0.6368	7.5736	7.800***	-24.551***
Russia	RU10EN	585	0.2622	0.0770	5.8531	-35.7163	53.5339	0.7862	18.1908	9.155***	-26.413***
Russia	RU11EN	585	0.3420	0.4560	5.6126	-38.4826	46.7378	0.0473	15.8986	8.972***	-25.297***
Slovenia	SV01EN	585	0.0382	0.0398	3.0347	-16.0297	15.6794	0.1009	6.4210	6.325***	-24.139***
Turkey	TK01EN	585	0.0092	0.1414	5.1358	-26.5766	23.9069	-0.1469	5.9313	6.048***	-25.621***
Turkey	TK02EN	585	0.0408	0.1181	5.3520	-26.0969	21.4428	-0.2295	5.5368	5.737***	-27.143***
Bosnia-Herzegovina	BH01EN	585	-0.1090	-0.1848	7.2505	-25.4409	72.7252	3.5713	37.8331	11.875***	-19.349***
Bosnia-Herzegovina	BH02EN	585	-0.0015	-0.1198	5.3721	-21.3938	41.1011	1.2584	14.8134	10.780***	-25.853***
Bosnia-Herzegovina	BH03EN	585	0.0807	-0.2043	9.8434	-34.6907	104.1982	3.1541	31.6141	11.367***	-22.585***
Hungary	HG01EN	585	0.0139	-0.0523	4.7626	-28.4657	27.6560	-0.0977	8.6828	7.614***	-26.263***

Note: ADF corresponds to Augmented Dickey-Fuller test. This test only considers the random walk specification. Superscripts ***, **, * indicate statistical significance at 1%, 5%, and 10%, respectively. Source: Authors' elaboration.

Appendix 3. Global and local statistics for the spillovers effects at country-level

Country	Energy stock returns without PCA control					Energy stock returns with PCA control				
	Centrality	Betweenness	Closeness	Authority	Eccentricity	Centrality	Betweenness	Closeness	Authority	Eccentricity
HK	159	6.659	0.013	0.899	2	34	80.236	0.024	0.162	3
CH	43	0.654	0.012	0.075	2	19	2.746	0.020	0.149	3
TW	118	5.367	0.013	0.552	2	20	25.763	0.022	0.109	3
KS	171	9.115	0.013	1.000	2	4	1.296	0.015	0.004	4
PK	40	0.484	0.012	0.052	2	85	66.638	0.026	0.870	2
SL	0	0.000	0.001	0.000	0	27	2.309	0.018	0.157	3
TH	145	0.792	0.013	0.785	2	7	28.407	0.019	0.015	3
IJ	121	4.516	0.013	0.581	2	15	2.407	0.021	0.074	3
IN	105	3.246	0.012	0.457	2	102	109.728	0.027	0.971	3
SP	165	4.757	0.013	0.955	2	21	56.202	0.022	0.029	3
MK	150	8.163	0.013	0.821	2	6	1.634	0.018	0.027	3
PM	107	3.420	0.013	0.471	2	68	18.125	0.020	0.677	3
VM	40	1.022	0.013	0.065	2	98	52.516	0.024	1.000	3
MG	0	0.000	0.001	0.000	0	70	29.457	0.023	0.610	3
AR	75	1.192	0.012	0.267	2	8	1.613	0.019	0.010	3
BR	133	0.702	0.013	0.689	2	8	0.242	0.019	0.009	3
CL	163	4.907	0.013	0.938	2	11	2.670	0.022	0.042	2
PE	59	0.844	0.012	0.186	2	3	0.000	0.017	0.001	4
CO	166	6.038	0.013	0.953	2	10	21.470	0.019	0.039	3
RM	100	18.661	0.013	0.385	2	101	130.291	0.025	0.631	3
MN	23	0.000	0.011	0.027	2	39	1.228	0.019	0.261	4
CR	122	10.572	0.013	0.596	2	28	3.402	0.019	0.115	3
RU	164	1.105	0.013	0.944	2	18	18.757	0.020	0.076	3
SV	72	16.472	0.013	0.252	2	18	5.338	0.022	0.097	2
TK	114	0.465	0.013	0.540	2	35	32.123	0.023	0.231	2
BH	2	0.000	0.010	0.000	2	3	0.000	0.015	0.011	4
HG	135	0.846	0.013	0.710	2	22	21.402	0.020	0.102	3

Notes: Global and local measures are based spillovers effects computed from LASSO-VAR(1). Spillovers measures consider a KPPS *10*-weeks-ahead forecast error variance decomposition. Centrality degree corresponds to the number of links related to each node (vertex), both incoming and outgoing from each node. Betweenness is a measure that quantifies the number of times a node acts as a bridge along the path between two nodes (the shortest length). Closeness computes the shortest paths between all nodes and assigns a score to each based on the sum of their paths. Authority Score measures the relative importance of each node. Eccentricity is the distance from a particular node *i* to the furthest node *j* (with respect to *i*). Source: Authors' elaboration.

Appendix 4. Global and local statistics for the spillovers effects at firms-level.

	Energy stock returns (before PCA)					Residual stock returns (after PCA)				
Code	Centrality	Betweenness	Closeness	Authority	Eccentricity	Centrality	Betweenness	Closeness	Authority	Eccentricity
HK01EN	94	1945.94	0.001	0.033	4	8	307.24	0.001	0.000	5
HK02EN	26	313.57	0.000	0.001	4	12	481.57	0.001	0.001	6
HK03EN	23	196.65	0.000	0.000	4	18	938.26	0.001	0.000	6
HK04EN	49	2667.11	0.001	0.037	4	17	1078.57	0.001	0.000	5
HK05EN	22	221.53	0.000	0.000	4	14	684.28	0.001	0.000	6
HK06EN	88	5527.32	0.001	0.033	4	30	2584.52	0.001	0.000	5
CH01EN	41	4.99	0.000	0.155	6	9	150.67	0.001	0.000	7
CH02RE	64	0.24	0.000	0.267	6	17	1292.63	0.001	0.000	5
CH03EN	65	5365.58	0.000	0.362	5	44	2361.79	0.001	0.000	5
CH04EN	66	545.88	0.000	0.342	5	43	323.38	0.001	0.000	6
CH05RE	81	80.84	0.000	0.522	6	13	945.56	0.001	0.000	6
CH06EN	63	19.86	0.000	0.280	6	22	336.55	0.001	0.000	6
CH07EN	125	73.53	0.000	0.886	6	48	1249.72	0.001	0.000	5
CH08EN	101	30.63	0.000	0.632	6	54	2710.27	0.001	0.000	5
CH09EN	120	81.65	0.000	0.781	6	70	1225.77	0.001	0.000	6
CH10EN	88	3524.33	0.000	0.569	5	29	182.01	0.001	0.000	6
CH11EN	136	177.99	0.000	0.955	6	19	598.86	0.001	0.000	5
CH12EN	147	159.06	0.000	1.000	6	18	405.66	0.001	0.000	6
CH13EN	108	960.90	0.000	0.739	5	33	397.23	0.001	0.000	6
CH14EN	95	2.26	0.000	0.466	6	5	146.36	0.001	0.000	6
CH15EN	125	144.25	0.000	0.786	6	9	482.92	0.001	0.000	6
CH16EN	107	88.46	0.000	0.613	6	20	622.39	0.001	0.000	6
CH17EN	112	162.87	0.000	0.658	6	16	312.92	0.001	0.000	6
CH18RE	101	8.01	0.000	0.573	6	13	701.05	0.001	0.000	6
CH19EN	96	1.37	0.000	0.543	6	4	105.73	0.001	0.000	7
CH20EN	105	12.30	0.000	0.562	6	14	818.10	0.001	0.000	6
CH21EN	124	103.27	0.000	0.816	6	36	491.07	0.001	0.000	5
CH22EN	75	8.03	0.000	0.396	6	0	0.00	0.000	0.000	0
CH23EN	103	4.00	0.000	0.605	6	15	1303.79	0.001	0.000	5
CH24EN	114	11.43	0.000	0.709	6	17	1339.27	0.001	0.000	6
CH25EN	100	9.28	0.000	0.533	6	4	94.93	0.001	0.000	6
CH26EN	58	1.16	0.000	0.239	6	8	84.13	0.001	0.000	6
CH27EN	84	344.59	0.000	0.460	5	4	61.93	0.001	0.000	7
CH28EN	111	10.97	0.000	0.649	6	11	179.85	0.001	0.000	6
CH29EN	108	105.08	0.000	0.636	6	13	475.47	0.001	0.000	7
CH30EN	108	162.98	0.000	0.652	6	14	119.18	0.001	0.000	6
CH31EN	65	5.94	0.000	0.266	6	8	351.35	0.001	0.000	7
CH32EN	105	126.95	0.000	0.606	6	17	395.03	0.001	0.000	7
TW01EN	66	1826.39	0.001	0.002	4	5	372.43	0.001	0.000	5
TW02RE	11	231.28	0.000	0.000	4	24	1097.96	0.001	0.000	6
TW03EN	30	815.57	0.000	0.000	4	2	0.00	0.001	0.000	7
TW04EN	12	25.77	0.000	0.000	4	2	0.00	0.001	0.000	7
TW05EN	32	1195.22	0.000	0.000	4	18	515.71	0.001	0.000	6
TW06EN	25	8.63	0.000	0.000	4	18	731.27	0.001	0.000	6
TW07RE	11	57.29	0.000	0.000	4	36	803.37	0.001	0.002	6
TW08RE	18	579.51	0.000	0.000	4	5	220.13	0.001	0.000	6
TW09EN	33	340.23	0.001	0.000	4	5	372.26	0.001	0.000	5
TW10EN	19	2.00	0.000	0.000	4	2	0.00	0.001	0.000	6
TW11RE	6	241.42	0.000	0.000	5	38	1576.98	0.001	0.001	6
KS01EN	38	864.57	0.001	0.000	4	7	218.55	0.001	0.000	7
KS02EN	40	423.07	0.000	0.000	4	15	1700.64	0.001	0.000	6
KS03EN	45	554.54	0.000	0.000	4	8	224.40	0.001	0.000	6
KS04EN	28	152.82	0.000	0.000	4	7	303.91	0.001	0.000	6
KS05EN	25	41.95	0.000	0.000	4	5	83.11	0.001	0.000	6
KS06EN	55	1281.75	0.000	0.001	4	16	452.33	0.001	0.000	7
KS07EN	32	493.91	0.000	0.000	4	5	400.36	0.001	0.001	6
KS08EN	87	807.72	0.001	0.002	4	26	1087.62	0.001	0.000	5
KS09EN	21	58.59	0.000	0.000	4	3	49.01	0.001	0.000	5
KS10EN	29	98.56	0.000	0.000	4	7	228.11	0.001	0.000	5
KS11EN	35	371.68	0.001	0.000	4	3	9.74	0.001	0.000	6
KS12EN	38	2055.81	0.000	0.000	4	15	764.19	0.001	0.000	6
KS13EN	30	145.85	0.000	0.000	4	11	150.59	0.001	0.000	6
KS14EN	13	37.88	0.000	0.000	4	5	128.92	0.001	0.000	6
KS15EN	26	97.34	0.000	0.000	4	23	2295.26	0.001	0.000	6
KS16EN	32	285.90	0.000	0.000	4	7	299.09	0.001	0.000	6
KS17EN	64	724.19	0.001	0.002	4	44	1104.57	0.001	0.000	5
KS18EN	37	217.03	0.000	0.000	4	56	388.64	0.001	0.000	7
KS19EN	44	373.18	0.000	0.000	4	13	770.82	0.001	0.000	5

KS20RE	29	328.82	0.000	0.000	4	4	48.14	0.001	0.000	6
KS21EN	76	1541.28	0.001	0.002	3	26	618.49	0.001	0.000	6
KS22EN	31	232.16	0.000	0.000	4	51	54.22	0.001	0.000	7
PK01EN	75	478.92	0.000	0.000	5	14	100.50	0.001	0.000	6
PK02EN	66	1240.26	0.000	0.001	5	29	1796.68	0.001	0.000	6
PK03EN	71	1388.96	0.000	0.001	5	21	766.15	0.001	0.000	6
PK04EN	66	4442.52	0.001	0.001	5	11	768.50	0.001	0.000	6
PK05EN	106	657.63	0.000	0.000	5	16	652.43	0.001	0.000	5
PK06EN	52	211.83	0.000	0.000	5	0	0.00	0.000	0.000	0
PK07EN	73	300.77	0.000	0.000	4	12	223.77	0.001	0.000	7
PK08EN	84	48.71	0.000	0.000	5	25	608.48	0.001	0.000	5
PK09EN	96	16.59	0.000	0.000	5	30	1271.86	0.001	0.000	6
PK10EN	45	0.00	0.000	0.000	5	3	0.00	0.001	0.000	7
PK11EN	76	293.91	0.000	0.000	5	8	185.99	0.001	0.000	6
PK12EN	87	1618.87	0.000	0.000	4	30	1225.47	0.001	0.000	5
PK13EN	61	14.27	0.000	0.000	5	4	0.00	0.001	0.000	6
PK14EN	82	0.00	0.000	0.000	5	27	808.68	0.001	0.000	6
PK15EN	73	0.32	0.000	0.000	5	14	820.73	0.001	0.000	5
PK16EN	16	27.39	0.000	0.000	4	0	0.00	0.000	0.000	0
SL01EN	16	0.00	0.000	0.000	6	19	1130.61	0.001	0.000	5
SL02EN	38	95.63	0.000	0.000	6	5	415.00	0.001	0.000	6
SL03EN	34	151.05	0.000	0.000	5	38	5190.76	0.001	0.000	5
SL04EN	23	80.06	0.000	0.000	5	2	0.00	0.001	0.000	7
TH01EN	114	1747.68	0.001	0.003	4	28	779.73	0.001	0.000	6
TH02EN	98	6280.83	0.001	0.003	4	18	71.02	0.001	0.000	6
TH03EN	59	303.76	0.001	0.001	4	30	539.10	0.001	0.000	5
TH04EN	42	200.39	0.000	0.000	4	23	580.96	0.001	0.001	5
TH05EN	50	231.93	0.001	0.001	4	28	2029.42	0.001	0.000	5
TH06EN	48	524.80	0.000	0.000	4	24	639.43	0.001	0.000	6
TH07EN	49	126.84	0.000	0.001	4	19	791.50	0.001	0.000	5
TH08EN	42	1369.95	0.000	0.000	4	6	283.96	0.001	0.000	6
TH09EN	22	77.50	0.000	0.000	4	8	104.82	0.001	0.000	6
TH10EN	41	474.53	0.001	0.000	4	4	48.44	0.001	0.000	6
TH11EN	23	53.89	0.000	0.000	4	1	0.00	0.001	0.000	6
TH12EN	33	1031.65	0.000	0.000	4	2	0.00	0.001	0.000	7
TH13EN	25	308.11	0.000	0.000	4	7	516.13	0.001	0.000	6
TH14EN	31	1.54	0.000	0.000	4	7	60.81	0.001	0.000	6
TH15EN	26	672.80	0.000	0.000	4	1	0.00	0.001	0.000	7
TH16EN	14	0.06	0.000	0.000	4	3	0.00	0.001	0.000	6
TH17EN	35	256.23	0.000	0.000	4	14	347.08	0.001	0.000	5
TH18RE	31	221.74	0.000	0.000	4	6	134.43	0.001	0.000	6
IJ01EN	25	1073.88	0.001	0.000	4	2	0.00	0.001	0.000	6
IJ02EN	22	35.68	0.000	0.000	4	2	0.00	0.001	0.000	6
IJ03EN	32	2444.48	0.001	0.000	4	6	153.19	0.001	0.000	7
IJ04EN	12	0.00	0.000	0.000	5	10	697.76	0.001	0.000	6
IJ05EN	20	499.38	0.000	0.000	4	4	53.22	0.001	0.000	6
IJ06EN	15	9.33	0.000	0.000	4	4	63.09	0.001	0.000	7
IJ07EN	12	1197.31	0.000	0.000	4	12	589.96	0.001	0.000	6
IN01EN	33	169.73	0.000	0.000	4	10	362.62	0.001	0.000	6
IN02EN	29	93.60	0.000	0.000	4	8	413.82	0.001	0.000	5
IN03EN	39	178.21	0.001	0.000	4	12	671.82	0.001	0.000	5
IN04EN	38	1005.49	0.000	0.000	4	10	476.51	0.001	0.000	6
IN05EN	24	51.21	0.000	0.000	4	5	21.09	0.001	0.000	7
IN06EN	28	296.27	0.000	0.000	5	14	918.02	0.001	0.000	6
SP01EN	112	1446.10	0.001	0.003	3	5	64.73	0.001	0.000	6
SP02EN	38	82.00	0.001	0.001	4	4	43.57	0.001	0.000	6
MK01EN	22	8.96	0.000	0.000	4	7	318.12	0.001	0.000	6
MK02EN	24	790.33	0.000	0.000	4	20	2137.13	0.001	0.001	5
MK03EN	26	104.85	0.001	0.000	4	2	0.00	0.001	0.000	6
MK04EN	25	257.99	0.000	0.000	4	6	96.20	0.001	0.000	6
MK05EN	27	175.13	0.000	0.000	4	15	150.10	0.001	0.000	6
MK06EN	17	3.55	0.000	0.000	4	15	182.44	0.001	0.000	6
PM01EN	28	2533.66	0.000	0.000	4	26	580.50	0.001	0.000	6
PM02EN	15	715.41	0.000	0.000	4	7	0.00	0.001	0.000	7
PM03EN	20	36.52	0.000	0.000	4	8	298.19	0.001	0.000	7
PM04EN	24	921.02	0.000	0.000	5	24	165.27	0.001	0.000	7
PM05EN	22	23.08	0.000	0.000	5	35	1409.34	0.001	0.000	6
PM06EN	22	247.83	0.000	0.000	4	17	160.05	0.001	0.000	7
PM07EN	14	448.52	0.000	0.000	4	7	44.23	0.001	0.000	7
PM08EN	32	392.45	0.000	0.000	4	18	1269.10	0.001	0.000	6
VM01EN	41	5228.04	0.001	0.008	4	15	1029.39	0.001	0.000	6

VM02EN	45	194.91	0.000	0.000	5	21	1269.32	0.001	0.000	6
VM03EN	40	609.05	0.000	0.000	5	2	0.00	0.001	0.000	6
VM04RE	20	48.51	0.000	0.000	5	17	1576.33	0.001	0.000	6
VM05EN	19	157.28	0.000	0.000	4	5	106.66	0.001	0.000	7
VM06RE	23	0.30	0.000	0.000	6	8	77.32	0.001	0.000	6
VM07RE	30	19.27	0.000	0.000	5	1	0.00	0.001	0.000	7
VM08EN	56	1190.61	0.000	0.000	5	23	746.55	0.001	0.000	6
VM09EN	44	23.78	0.000	0.000	5	25	1430.03	0.001	0.000	6
VM10EN	38	127.49	0.000	0.000	5	6	205.20	0.001	0.001	5
VM11EN	38	19.60	0.000	0.000	5	20	1589.32	0.001	0.000	5
MG01EN	22	0.00	0.000	0.000	1	6	211.33	0.001	0.000	6
MG02EN	34	0.00	0.000	0.000	1	0	0.00	0.000	0.000	0
MG03EN	39	0.00	0.000	0.000	1	20	1530.78	0.001	0.000	6
MG04EN	41	0.00	0.000	0.000	1	13	997.42	0.001	0.000	5
MG05EN	2	0.00	0.000	0.000	5	2	0.00	0.001	0.000	6
AR01EN	77	0.00	0.000	0.000	6	12	411.06	0.001	0.001	6
AR02EN	75	0.79	0.000	0.000	5	9	221.59	0.001	0.000	6
AR03EN	62	19.09	0.000	0.000	5	21	691.52	0.001	0.000	6
AR04EN	44	48.01	0.000	0.000	5	12	148.41	0.001	0.000	6
AR05EN	62	0.56	0.000	0.000	5	5	108.43	0.001	0.000	7
AR06EN	66	2465.51	0.000	0.001	5	17	1922.54	0.001	0.001	5
AR07EN	71	0.79	0.000	0.000	5	8	10.06	0.001	0.000	7
AR08EN	64	0.79	0.000	0.000	5	5	237.94	0.001	0.001	6
AR09EN	52	277.49	0.000	0.000	5	12	1277.84	0.001	0.000	5
BR01EN	99	1336.75	0.001	0.002	5	72	105.51	0.001	0.060	6
BR02EN	110	1725.78	0.001	0.003	4	74	272.75	0.001	1.000	6
BR03EN	76	211.54	0.000	0.001	5	1	0.00	0.001	0.000	7
BR04EN	75	155.58	0.000	0.001	5	6	2.17	0.001	0.000	6
BR05EN	31	6.10	0.000	0.000	5	11	894.12	0.001	0.000	5
BR06EN	94	915.29	0.001	0.002	4	13	1400.92	0.001	0.000	5
BR07EN	78	8.85	0.000	0.001	5	63	443.81	0.001	0.000	6
BR08EN	70	3.12	0.000	0.000	5	65	940.36	0.001	0.000	6
BR09EN	42	0.14	0.000	0.000	5	5	293.10	0.001	0.000	7
BR10EN	73	4.92	0.000	0.001	5	20	828.62	0.001	0.000	6
BR11EN	76	9.99	0.000	0.001	5	10	668.59	0.001	0.000	5
BR12EN	57	16.70	0.000	0.000	5	16	759.24	0.001	0.000	6
BR13EN	65	4.69	0.000	0.000	5	63	265.58	0.001	0.000	7
BR14EN	81	161.20	0.000	0.001	4	10	278.00	0.001	0.000	6
BR15EN	78	65.61	0.000	0.001	5	11	240.15	0.001	0.000	6
BR16EN	24	0.00	0.000	0.000	5	8	202.11	0.001	0.000	6
BR17EN	66	49.69	0.000	0.000	5	10	240.42	0.001	0.001	6
BR18EN	79	1.77	0.000	0.001	5	61	271.52	0.001	0.000	6
CL01EN	44	89.40	0.000	0.000	4	6	51.82	0.001	0.000	6
CL02EN	71	429.84	0.001	0.001	4	33	590.28	0.001	0.000	6
CL03EN	32	150.39	0.000	0.000	4	3	71.13	0.001	0.000	7
CL04EN	103	1071.81	0.001	0.002	4	5	122.35	0.001	0.000	6
CL05EN	44	75.25	0.001	0.001	4	9	285.35	0.001	0.000	6
CL06EN	40	372.76	0.001	0.000	4	34	475.57	0.001	0.000	6
PE01EN	30	26.34	0.000	0.000	5	28	1572.61	0.001	0.000	5
PE02EN	11	105.23	0.000	0.000	5	26	2701.04	0.001	0.000	5
PE03EN	32	87.18	0.000	0.000	5	21	530.71	0.001	0.001	6
PE04EN	26	192.04	0.000	0.000	4	14	897.77	0.001	0.000	6
PE05EN	26	47.58	0.000	0.000	5	15	461.96	0.001	0.001	6
CO01EN	100	894.51	0.001	0.003	4	20	782.94	0.001	0.001	5
CO02EN	84	768.22	0.001	0.002	4	29	272.44	0.001	0.002	6
CO03EN	40	107.20	0.000	0.001	4	35	1339.70	0.001	0.002	6
CO04EN	46	212.05	0.001	0.001	4	34	478.25	0.001	0.002	6
RM01EN	13	7.28	0.000	0.000	4	8	335.11	0.001	0.000	6
RM02EN	23	282.17	0.000	0.000	4	17	1361.44	0.001	0.000	6
MN01EN	2	0.00	0.000	0.000	5	2	0.00	0.001	0.000	7
MN02EN	14	0.00	0.000	0.000	4	6	98.93	0.001	0.000	5
CR01EN	38	152.91	0.001	0.000	4	2	0.00	0.000	0.000	8
RU01EN	47	5.75	0.000	0.001	5	24	1823.70	0.001	0.003	5
RU02EN	86	322.22	0.001	0.003	4	13	903.78	0.001	0.000	6
RU03EN	69	87.08	0.001	0.001	4	14	671.08	0.001	0.000	6
RU04EN	46	5.17	0.000	0.001	4	13	727.25	0.001	0.032	6
RU05EN	121	650.00	0.001	0.004	4	17	231.36	0.001	0.001	6
RU06EN	79	222.54	0.001	0.002	4	10	314.12	0.001	0.003	6
RU07EN	107	415.29	0.001	0.003	4	13	336.20	0.001	0.001	6
RU08EN	95	303.46	0.001	0.003	4	13	210.49	0.001	0.000	6
RU09EN	42	21.92	0.000	0.001	4	24	1662.37	0.001	0.001	5

RU10EN	128	1230.53	0.001	0.004	4	34	495.30	0.001	0.001	6
RU11EN	106	684.50	0.001	0.003	4	31	912.75	0.001	0.000	5
SV01EN	15	13.09	0.000	0.000	4	1	0.00	0.001	0.000	7
TK01EN	24	17.37	0.000	0.000	4	34	1026.72	0.001	0.000	5
TK02EN	34	229.01	0.001	0.000	4	25	274.36	0.001	0.000	6
BH01EN	15	0.00	0.000	0.000	1	14	258.67	0.001	0.000	7
BH02EN	6	0.00	0.000	0.000	1	6	354.70	0.001	0.000	7
BH03EN	17	0.00	0.000	0.000	1	16	205.36	0.001	0.000	8
HG01EN	60	953.69	0.001	0.001	4	3	204.00	0.001	0.000	7

Notes: Global and local measures are based on LASSO-VAR(1) model. Centrality degree corresponds to the number of links related to each node (vertex), both incoming and outgoing from each node. Betweenness is a measure that quantifies the number of times a node acts as a bridge along the path between two nodes (the shortest length). Closeness computes the shortest paths between all nodes and assigns a score to each based on the sum of their paths. Authority Score measures the relative importance of each node. Eccentricity is the distance from a particular node *i* to the furthest node *j* (with respect to *i*). Source: Authors' elaboration.

Appendix 5. Global and local statistics for the network at country-level: Granger causality

Country	Energy stock returns without PCA control					Energy stock returns with PCA control				
	Centrality	Betweenness	Closeness	Authority	Eccentricity	Centrality	Betweenness	Closeness	Authority	Eccentricity
HK	51	0.120	0.038	1.000	1	42	3.192	0.037	0.803	2
CH	52	0.160	0.038	0.999	1	50	7.055	0.038	0.919	1
TW	52	0.160	0.038	0.999	1	44	4.565	0.038	0.849	1
KS	51	0.120	0.038	1.000	1	43	2.660	0.038	0.887	1
PK	52	0.160	0.038	0.999	1	40	2.770	0.037	0.934	2
SL	51	0.120	0.038	0.961	1	43	3.887	0.038	1.000	1
TH	51	0.120	0.038	0.961	1	49	5.542	0.038	0.960	1
IJ	52	0.160	0.038	0.999	1	48	5.371	0.038	0.951	1
IN	52	0.160	0.038	0.999	1	34	2.261	0.034	0.581	2
SP	52	0.160	0.038	0.999	1	41	3.488	0.038	0.701	1
MK	52	0.160	0.038	0.999	1	41	2.875	0.038	0.756	1
PM	51	0.120	0.038	1.000	1	29	1.003	0.031	0.513	2
VM	50	0.080	0.038	0.963	1	42	3.556	0.037	0.694	2
MG	52	0.160	0.038	0.999	1	47	5.567	0.038	0.878	1
AR	52	0.160	0.038	0.999	1	51	7.585	0.038	0.987	1
BR	52	0.160	0.038	0.999	1	48	4.683	0.038	0.932	1
CL	51	0.120	0.038	0.961	1	45	3.835	0.037	0.898	2
PE	52	0.160	0.038	0.999	1	42	1.736	0.037	0.835	2
CO	52	0.160	0.038	0.999	1	48	5.799	0.038	0.992	1
RM	52	0.160	0.038	0.999	1	35	0.850	0.036	0.489	2
MN	52	0.160	0.038	0.999	1	46	4.789	0.037	0.896	2
CR	52	0.160	0.038	0.999	1	36	2.073	0.036	0.837	2
RU	52	0.160	0.038	0.999	1	45	3.954	0.038	0.894	1
SV	52	0.160	0.038	0.999	1	47	5.784	0.037	0.966	2
TK	52	0.160	0.038	0.999	1	49	6.680	0.038	0.881	1
BH	52	0.160	0.038	0.999	1	49	6.307	0.038	0.960	1
HG	52	0.160	0.038	0.999	1	46	4.132	0.038	0.870	1

Notes: Global and local measures are based on the Granger network computed through NETS algorithm. Centrality degree corresponds to the number of links related to each node (vertex), both incoming and outgoing from each node. Betweenness is a measure that quantifies the number of times a node acts as a bridge along the path between two nodes (the shortest length). Closeness computes the shortest paths between all nodes and assigns a score to each based on the sum of their paths. Authority Score measures the relative importance of each node. Eccentricity is the distance from a particular node *i* to the furthest node *j* (with respect to *i*). Source: Authors' elaboration.

Appendix 6. Global and local statistics for the network at country-level: Partial autocorrelation

Country	Energy stock returns without PCA control					Energy stock returns with PCA control				
	Centrality	Betweenness	Closeness	Authority	Eccentricity	Centrality	Betweenness	Closeness	Authority	Eccentricity
HK	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
CH	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
TW	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
KS	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
PK	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
SL	25	0.000	0.037	0.964	2	26	0.000	0.038	1.000	1
TH	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
IJ	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
IN	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
SP	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
MK	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
PM	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
VM	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
MG	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
AR	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
BR	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
CL	25	0.000	0.037	0.964	2	26	0.000	0.038	1.000	1
PE	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
CO	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
RM	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
MN	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
CR	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
RU	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
SV	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
TK	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
BH	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1
HG	26	0.040	0.038	1.000	1	26	0.000	0.038	1.000	1

Notes: Global and local measures are based on the contemporaneous network computed through NETS algorithm. Centrality degree corresponds to the number of links related to each node (vertex), both incoming and outgoing from each node. Betweenness is a measure that quantifies the number of times a node acts as a bridge along the path between two nodes (the shortest length). Closeness computes the shortest paths between all nodes and assigns a score to each based on the sum of their paths. Authority Score measures the relative importance of each node. Eccentricity is the distance from a particular node *i* to the furthest node *j* (with respect to *i*). Source: Authors' elaboration.

Appendix 7. Global and local statistics for Granger causality at firms-level.

	Energy stock returns (before PCA)					Residual stock returns (after PCA)				
Code	Centrality	Betweenness	Closeness	Authority	Eccentricity	Centrality	Betweenness	Closeness	Authority	Eccentricity
HK01EN	432	2.75	0.005	0.991	1	418	6.44	0.005	0.964	2
HK02EN	417	2.45	0.005	0.932	1	398	6.18	0.005	0.832	1
HK03EN	415	2.52	0.005	0.936	2	398	6.02	0.005	0.851	2
HK04EN	430	2.70	0.005	0.995	1	395	5.22	0.005	0.888	1
HK05EN	426	2.58	0.005	0.973	1	410	6.35	0.005	0.909	2
HK06EN	428	2.68	0.005	0.982	1	425	7.49	0.005	0.977	1
CH01EN	427	2.67	0.005	0.973	1	419	6.49	0.005	0.955	1
CH02RE	435	2.81	0.005	0.995	1	434	7.90	0.005	0.991	1
CH03EN	429	2.71	0.005	0.972	1	424	7.29	0.005	0.959	1
CH04EN	424	2.52	0.005	0.977	1	431	7.26	0.005	0.986	1
CH05RE	433	2.75	0.005	0.995	1	434	7.98	0.005	1.000	1
CH06EN	429	2.68	0.005	0.991	1	426	7.28	0.005	0.996	1
CH07EN	432	2.71	0.005	0.991	1	425	7.32	0.005	0.996	1
CH08EN	426	2.65	0.005	0.977	1	418	6.78	0.005	0.973	1
CH09EN	428	2.64	0.005	0.977	1	423	7.16	0.005	0.987	1
CH10EN	433	2.75	0.005	1.000	1	424	7.21	0.005	0.991	2
CH11EN	429	2.68	0.005	0.986	1	413	5.89	0.005	0.973	1
CH12EN	434	2.80	0.005	1.000	1	419	6.56	0.005	0.982	1
CH13EN	428	2.66	0.005	0.982	1	424	7.05	0.005	0.982	2
CH14EN	434	2.79	0.005	0.991	1	431	7.74	0.005	0.995	1
CH15EN	430	2.67	0.005	0.995	1	419	6.15	0.005	0.982	1
CH16EN	431	2.76	0.005	0.986	1	423	6.71	0.005	0.982	1
CH17EN	436	2.82	0.005	1.000	1	431	7.59	0.005	0.996	1
CH18RE	431	2.72	0.005	0.991	1	434	7.44	0.005	1.000	1
CH19EN	435	2.80	0.005	1.000	1	433	7.90	0.005	1.000	1
CH20EN	431	2.72	0.005	0.995	1	431	7.52	0.005	0.995	1
CH21EN	431	2.72	0.005	0.995	1	421	6.64	0.005	0.978	1
CH22EN	436	2.82	0.005	1.000	1	435	7.85	0.005	1.000	1
CH23EN	429	2.66	0.005	0.986	1	418	7.02	0.005	0.986	1
CH24EN	432	2.72	0.005	0.991	1	429	7.52	0.005	0.996	1
CH25EN	432	2.72	0.005	0.996	1	431	7.72	0.005	0.986	1
CH26EN	433	2.79	0.005	0.995	1	431	7.46	0.005	0.991	1
CH27EN	434	2.76	0.005	1.000	1	423	7.01	0.005	0.978	1
CH28EN	430	2.69	0.005	0.995	1	433	7.93	0.005	1.000	1
CH29EN	427	2.57	0.005	0.973	1	412	6.22	0.005	0.969	1
CH30EN	433	2.70	0.005	0.995	1	426	6.96	0.005	0.987	1
CH31EN	432	2.73	0.005	0.995	1	434	8.00	0.005	0.995	1
CH32EN	432	2.71	0.005	0.991	1	427	7.37	0.005	0.978	2
TW01EN	428	2.68	0.005	0.968	1	425	7.31	0.005	0.968	1
TW02RE	434	2.76	0.005	0.995	1	434	7.98	0.005	1.000	1
TW03EN	421	2.57	0.005	0.945	1	397	5.40	0.005	0.887	2
TW04EN	427	2.61	0.005	0.968	2	406	6.23	0.005	0.942	2
TW05EN	426	2.59	0.005	0.964	1	399	5.25	0.005	0.910	2
TW06EN	426	2.64	0.005	0.954	1	424	7.25	0.005	0.959	1
TW07RE	433	2.75	0.005	0.991	1	432	7.85	0.005	0.982	1
TW08RE	432	2.75	0.005	0.991	1	418	6.35	0.005	0.991	1
TW09EN	427	2.63	0.005	0.968	1	406	6.11	0.005	0.919	2
TW10EN	428	2.70	0.005	0.968	1	418	6.40	0.005	0.955	1
TW11RE	433	2.78	0.005	0.991	1	431	7.27	0.005	0.986	1
KS01EN	433	2.78	0.005	0.995	1	427	7.34	0.005	0.986	1
KS02EN	435	2.76	0.005	1.000	1	416	6.92	0.005	0.991	1
KS03EN	427	2.59	0.005	0.982	1	408	6.66	0.005	0.941	2
KS04EN	429	2.66	0.005	0.982	1	423	7.10	0.005	0.964	1
KS05EN	429	2.66	0.005	0.986	1	432	7.74	0.005	0.995	1
KS06EN	417	2.38	0.005	0.946	1	416	6.78	0.005	0.923	1
KS07EN	426	2.58	0.005	0.973	1	431	7.58	0.005	0.982	1
KS08EN	435	2.75	0.005	1.000	1	429	7.22	0.005	0.995	1
KS09EN	429	2.69	0.005	0.986	1	433	7.80	0.005	0.995	1
KS10EN	427	2.65	0.005	0.982	1	430	7.78	0.005	0.982	1
KS11EN	432	2.74	0.005	0.986	1	433	7.87	0.005	0.986	1
KS12EN	427	2.59	0.005	0.977	1	414	6.11	0.005	0.978	1
KS13EN	433	2.71	0.005	1.000	1	415	6.49	0.005	0.977	1
KS14EN	429	2.67	0.005	0.977	1	428	7.02	0.005	0.995	1
KS15EN	433	2.73	0.005	0.995	1	432	7.84	0.005	0.982	1
KS16EN	428	2.71	0.005	0.968	1	414	6.78	0.005	0.932	2
KS17EN	433	2.73	0.005	1.000	1	428	6.87	0.005	0.991	1
KS18EN	434	2.79	0.005	0.995	1	429	7.61	0.005	0.995	1
KS19EN	432	2.76	0.005	0.995	1	416	6.64	0.005	0.978	2

KS20RE	432	2.75	0.005	0.986	1	433	7.94	0.005	0.991	1
KS21EN	427	2.68	0.005	0.986	1	410	6.64	0.005	0.941	2
KS22EN	433	2.75	0.005	0.991	1	434	7.81	0.005	0.995	1
PK01EN	426	2.61	0.005	0.973	1	423	7.30	0.005	0.968	1
PK02EN	429	2.59	0.005	0.991	1	426	7.37	0.005	0.977	1
PK03EN	429	2.68	0.005	0.986	1	416	6.69	0.005	0.955	1
PK04EN	432	2.74	0.005	0.986	1	422	7.18	0.005	0.959	1
PK05EN	425	2.60	0.005	0.982	1	421	6.81	0.005	0.959	2
PK06EN	430	2.72	0.005	0.986	1	432	7.63	0.005	0.996	1
PK07EN	432	2.75	0.005	0.986	1	421	6.76	0.005	0.973	2
PK08EN	434	2.77	0.005	1.000	1	428	7.38	0.005	0.991	1
PK09EN	429	2.70	0.005	0.991	1	425	7.43	0.005	0.991	1
PK10EN	429	2.68	0.005	0.977	1	428	7.52	0.005	0.991	1
PK11EN	428	2.62	0.005	0.982	1	425	7.64	0.005	0.987	1
PK12EN	433	2.73	0.005	1.000	1	420	6.56	0.005	0.946	2
PK13EN	430	2.72	0.005	0.982	1	429	7.67	0.005	0.991	2
PK14EN	434	2.73	0.005	1.000	1	420	6.53	0.005	0.969	2
PK15EN	435	2.81	0.005	0.995	1	430	7.73	0.005	0.977	1
PK16EN	432	2.76	0.005	0.991	1	423	7.18	0.005	0.968	1
SL01EN	433	2.75	0.005	0.996	1	430	7.25	0.005	0.986	1
SL02EN	435	2.77	0.005	0.995	1	423	7.09	0.005	0.986	1
SL03EN	426	2.65	0.005	0.973	2	401	6.19	0.005	0.860	2
SL04EN	431	2.72	0.005	0.995	1	430	7.31	0.005	0.991	1
TH01EN	430	2.70	0.005	0.982	1	416	6.78	0.005	0.964	1
TH02EN	432	2.70	0.005	0.986	1	423	6.85	0.005	0.986	1
TH03EN	435	2.79	0.005	1.000	1	423	6.50	0.005	0.991	1
TH04EN	428	2.61	0.005	0.986	1	421	6.47	0.005	0.982	1
TH05EN	433	2.69	0.005	0.995	1	420	6.62	0.005	0.986	1
TH06EN	427	2.63	0.005	0.968	1	421	6.21	0.005	0.982	1
TH07EN	430	2.71	0.005	0.982	1	417	6.61	0.005	0.987	2
TH08EN	436	2.82	0.005	1.000	1	429	7.48	0.005	0.987	1
TH09EN	436	2.82	0.005	1.000	1	434	7.89	0.005	0.995	1
TH10EN	435	2.77	0.005	1.000	1	434	7.76	0.005	0.996	1
TH11EN	431	2.72	0.005	0.982	1	427	7.60	0.005	0.982	1
TH12EN	434	2.79	0.005	0.991	1	422	6.56	0.005	0.982	2
TH13EN	434	2.76	0.005	0.995	1	424	7.12	0.005	0.982	1
TH14EN	434	2.76	0.005	0.995	1	435	7.87	0.005	1.000	1
TH15EN	428	2.59	0.005	0.995	1	432	7.34	0.005	1.000	1
TH16EN	427	2.64	0.005	0.973	1	417	6.27	0.005	0.978	1
TH17EN	432	2.74	0.005	0.995	1	428	7.03	0.005	0.986	1
TH18RE	435	2.80	0.005	0.995	1	436	8.05	0.005	1.000	1
IJ01EN	430	2.72	0.005	0.986	1	430	7.20	0.005	0.986	1
IJ02EN	436	2.82	0.005	1.000	1	435	8.04	0.005	0.995	1
IJ03EN	436	2.82	0.005	1.000	1	432	7.79	0.005	0.991	1
IJ04EN	432	2.64	0.005	0.995	1	434	7.93	0.005	0.991	1
IJ05EN	433	2.75	0.005	0.991	1	434	7.82	0.005	0.995	1
IJ06EN	436	2.82	0.005	1.000	1	433	7.94	0.005	0.996	1
IJ07EN	435	2.79	0.005	1.000	1	433	7.81	0.005	0.991	1
IN01EN	432	2.75	0.005	0.986	1	417	6.38	0.005	0.937	1
IN02EN	423	2.59	0.005	0.977	1	415	5.89	0.005	0.946	1
IN03EN	434	2.78	0.005	0.995	1	421	7.03	0.005	0.950	2
IN04EN	428	2.64	0.005	0.977	1	418	6.38	0.005	0.969	1
IN05EN	434	2.77	0.005	0.991	1	432	7.80	0.005	0.991	1
IN06EN	428	2.64	0.005	0.982	1	425	6.96	0.005	0.986	1
SP01EN	427	2.66	0.005	0.968	1	409	6.38	0.005	0.950	2
SP02EN	432	2.73	0.005	1.000	1	433	7.82	0.005	0.995	1
MK01EN	430	2.61	0.005	0.982	1	416	6.94	0.005	0.945	1
MK02EN	431	2.67	0.005	0.986	1	408	6.39	0.005	0.887	2
MK03EN	427	2.58	0.005	0.977	1	413	6.15	0.005	0.919	2
MK04EN	433	2.77	0.005	0.995	1	415	6.92	0.005	0.928	1
MK05EN	430	2.68	0.005	0.982	1	422	6.60	0.005	0.969	1
MK06EN	431	2.73	0.005	0.991	1	420	7.28	0.005	0.978	2
PM01EN	432	2.76	0.005	0.995	1	420	6.54	0.005	0.991	1
PM02EN	435	2.80	0.005	0.995	1	420	7.09	0.005	0.968	1
PM03EN	428	2.61	0.005	0.991	1	424	6.99	0.005	0.996	1
PM04EN	429	2.66	0.005	0.986	1	417	6.43	0.005	0.964	1
PM05EN	430	2.63	0.005	0.986	1	400	5.87	0.005	0.891	2
PM06EN	429	2.72	0.005	0.982	1	405	5.53	0.005	0.950	2
PM07EN	431	2.69	0.005	0.995	1	427	6.75	0.005	0.991	1
PM08EN	429	2.61	0.005	0.995	1	397	5.33	0.005	0.888	2
VM01EN	434	2.77	0.005	0.995	1	427	7.29	0.005	0.977	1

VM02EN	430	2.72	0.005	0.977	1	420	6.69	0.005	0.964	1
VM03EN	428	2.66	0.005	0.977	1	416	6.22	0.005	0.968	1
VM04RE	430	2.69	0.005	0.986	1	424	7.42	0.005	0.964	1
VM05EN	434	2.76	0.005	0.991	1	428	7.34	0.005	0.982	1
VM06RE	429	2.67	0.005	0.977	1	413	6.78	0.005	0.950	2
VM07RE	427	2.63	0.005	0.973	1	416	6.38	0.005	0.950	2
VM08EN	432	2.76	0.005	0.986	1	400	5.73	0.005	0.851	1
VM09EN	431	2.69	0.005	0.982	1	407	5.89	0.005	0.910	2
VM10EN	428	2.62	0.005	0.973	1	423	6.76	0.005	0.982	1
VM11EN	431	2.68	0.005	0.986	1	424	7.48	0.005	0.968	1
MG01EN	436	2.82	0.005	1.000	1	432	7.78	0.005	0.995	2
MG02EN	434	2.79	0.005	0.995	1	433	7.86	0.005	0.986	1
MG03EN	434	2.79	0.005	1.000	1	431	7.62	0.005	0.978	1
MG04EN	436	2.82	0.005	1.000	1	432	7.90	0.005	0.986	1
MG05EN	434	2.76	0.005	0.995	1	430	7.61	0.005	0.987	1
AR01EN	434	2.79	0.005	0.995	1	427	7.25	0.005	0.987	1
AR02EN	430	2.73	0.005	0.991	1	420	6.84	0.005	0.978	1
AR03EN	435	2.77	0.005	1.000	1	419	7.15	0.005	0.937	2
AR04EN	434	2.71	0.005	0.995	1	428	7.69	0.005	0.973	1
AR05EN	432	2.74	0.005	0.995	1	424	7.24	0.005	0.986	1
AR06EN	432	2.68	0.005	1.000	1	432	7.34	0.005	0.991	1
AR07EN	436	2.82	0.005	1.000	1	429	6.94	0.005	1.000	1
AR08EN	435	2.79	0.005	0.995	1	426	7.36	0.005	0.982	1
AR09EN	433	2.72	0.005	0.995	1	430	7.63	0.005	0.973	1
BR01EN	429	2.67	0.005	0.991	1	426	6.96	0.005	0.973	1
BR02EN	429	2.63	0.005	0.986	1	426	7.12	0.005	0.973	1
BR03EN	430	2.74	0.005	0.991	1	429	7.35	0.005	0.987	1
BR04EN	422	2.45	0.005	0.982	1	420	6.55	0.005	0.978	2
BR05EN	435	2.79	0.005	0.995	1	434	7.93	0.005	0.995	1
BR06EN	428	2.58	0.005	0.991	1	420	6.62	0.005	0.973	1
BR07EN	431	2.70	0.005	1.000	1	412	6.42	0.005	0.982	2
BR08EN	433	2.74	0.005	1.000	1	427	7.52	0.005	0.991	2
BR09EN	429	2.73	0.005	0.977	1	426	7.40	0.005	0.982	1
BR10EN	425	2.51	0.005	0.996	1	403	6.37	0.005	0.881	2
BR11EN	433	2.76	0.005	0.995	1	416	6.57	0.005	0.964	1
BR12EN	427	2.57	0.005	0.991	1	413	6.81	0.005	0.937	2
BR13EN	431	2.66	0.005	0.996	1	428	7.54	0.005	0.996	1
BR14EN	430	2.72	0.005	0.977	1	422	7.10	0.005	0.964	2
BR15EN	429	2.63	0.005	0.982	1	413	6.31	0.005	0.950	2
BR16EN	433	2.67	0.005	0.991	2	431	7.74	0.005	0.986	1
BR17EN	431	2.68	0.005	0.991	1	419	6.47	0.005	0.964	1
BR18EN	429	2.60	0.005	0.995	1	416	6.51	0.005	0.968	1
CL01EN	433	2.76	0.005	0.995	1	420	6.89	0.005	0.936	1
CL02EN	427	2.63	0.005	0.972	1	415	7.12	0.005	0.941	1
CL03EN	432	2.74	0.005	1.000	1	415	6.89	0.005	0.941	1
CL04EN	430	2.65	0.005	0.991	1	418	6.22	0.005	0.969	2
CL05EN	421	2.44	0.005	0.950	1	403	6.07	0.005	0.869	1
CL06EN	423	2.53	0.005	0.982	1	412	6.32	0.005	0.933	1
PE01EN	433	2.75	0.005	0.986	1	422	6.88	0.005	0.973	1
PE02EN	424	2.61	0.005	0.963	1	352	3.90	0.005	0.655	2
PE03EN	427	2.60	0.005	0.968	1	418	6.64	0.005	0.968	2
PE04EN	434	2.79	0.005	0.995	1	433	7.93	0.005	1.000	1
PE05EN	428	2.68	0.005	0.973	1	420	6.32	0.005	0.987	1
CO01EN	432	2.68	0.005	0.995	1	431	7.23	0.005	1.000	1
CO02EN	428	2.65	0.005	0.986	1	424	6.61	0.005	0.991	1
CO03EN	422	2.49	0.005	0.977	1	419	7.14	0.005	0.946	1
CO04EN	433	2.72	0.005	0.995	1	427	7.59	0.005	0.977	1
RM01EN	430	2.69	0.005	0.982	1	415	6.88	0.005	0.936	2
RM02EN	431	2.70	0.005	0.995	1	396	5.24	0.005	0.842	1
MN01EN	430	2.69	0.005	0.996	1	435	7.97	0.005	0.995	1
MN02EN	430	2.70	0.005	0.977	1	421	6.76	0.005	0.973	2
CR01EN	430	2.71	0.005	0.977	1	409	6.07	0.005	0.950	2
RU01EN	434	2.78	0.005	0.995	1	428	7.63	0.005	0.991	1
RU02EN	429	2.69	0.005	0.995	1	426	7.47	0.005	0.964	1
RU03EN	433	2.74	0.005	1.000	1	423	6.85	0.005	0.973	1
RU04EN	429	2.73	0.005	0.995	1	423	7.30	0.005	0.946	1
RU05EN	433	2.72	0.005	1.000	1	423	6.62	0.005	0.978	1
RU06EN	427	2.63	0.005	0.986	1	426	7.28	0.005	0.978	1
RU07EN	434	2.73	0.005	1.000	1	407	5.94	0.005	0.937	1
RU08EN	431	2.71	0.005	0.995	1	415	6.35	0.005	0.987	1
RU09EN	432	2.62	0.005	0.995	1	422	6.76	0.005	0.968	1

RU10EN	433	2.78	0.005	0.995	1	417	6.41	0.005	0.982	1
RU11EN	432	2.73	0.005	0.991	1	410	5.99	0.005	0.982	2
SV01EN	429	2.61	0.005	0.977	1	407	6.63	0.005	0.945	2
TK01EN	430	2.70	0.005	0.995	1	429	7.73	0.005	0.982	1
TK02EN	435	2.80	0.005	1.000	1	426	7.51	0.005	0.968	1
BH01EN	433	2.73	0.005	0.986	1	435	7.98	0.005	1.000	1
BH02EN	430	2.66	0.005	0.986	1	431	7.69	0.005	0.991	1
BH03EN	435	2.79	0.005	1.000	1	435	7.87	0.005	1.000	1
HG01EN	433	2.72	0.005	0.991	1	418	7.07	0.005	0.964	1

Notes: Global and local measures are based on the contemporaneous network computed through NETS algorithm. Centrality degree corresponds to the number of links related to each node (vertex), both incoming and outgoing from each node. Betweenness is a measure that quantifies the number of times a node acts as a bridge along the path between two nodes (the shortest length). Closeness computes the shortest paths between all nodes and assigns a score to each based on the sum of their paths. Authority Score measures the relative importance of each node. Eccentricity is the distance from a particular node *i* to the furthest node *j* (with respect to *i*). Source: Authors' elaboration.

Appendix 8. Global and local statistics for the partial autocorrelation at firms-level.

	Energy stock returns (before PCA)					Residual stock returns (after PCA)				
Code	Centrality	Betweenness	Closeness	Authority	Eccentricity	Centrality	Betweenness	Closeness	Authority	Eccentricity
HK01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
HK02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
HK03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
HK04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
HK05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
HK06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH02RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH04EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CH05RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH06EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CH07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH09EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH11EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH12EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH13EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CH14EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH15EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CH16EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CH17EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH18RE	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CH19EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH20EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH21EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH22EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CH23EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH24EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH25EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH26EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH27EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH28EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH29EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH30EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH31EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CH32EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW01EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
TW02RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW06EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
TW07RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW08RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW09EN	218	0.069	0.005	1.000	1	216	0.009	0.005	0.991	2
TW10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TW11RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS02EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
KS03EN	218	0.069	0.005	1.000	1	217	0.014	0.005	0.995	2
KS04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS09EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS11EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS12EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS13EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS14EN	218	0.069	0.005	1.000	1	217	0.014	0.005	0.995	2
KS15EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS16EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS17EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS18EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS19EN	218	0.069	0.005	1.000	1	217	0.009	0.005	0.995	2

KS20RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS21EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
KS22EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK09EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
PK10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK11EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK12EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK13EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK14EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK15EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PK16EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
SL01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
SL02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
SL03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
SL04EN	218	0.069	0.005	1.000	1	217	0.014	0.005	0.995	2
TH01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH07EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
TH08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH09EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH11EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
TH12EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
TH13EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
TH14EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH15EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH16EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH17EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TH18RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IJ01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IJ02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IJ03EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
IJ04EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
IJ05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IJ06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IJ07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IN01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IN02EN	218	0.069	0.005	1.000	1	217	0.014	0.005	0.995	2
IN03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IN04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
IN05EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
IN06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
SP01EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
SP02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MK01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MK02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MK03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MK04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MK05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MK06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PM01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PM02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PM03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PM04EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
PM05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PM06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PM07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PM08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1

VM02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM04RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM06RE	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
VM07RE	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM09EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
VM11EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MG01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MG02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MG03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MG04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MG05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
AR09EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR03EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
BR04EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
BR05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR09EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR11EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR12EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR13EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR14EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
BR15EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR16EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BR17EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
BR18EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CL01EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CL02EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
CL03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CL04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CL05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CL06EN	217	0.065	0.005	0.995	2	217	0.009	0.005	0.995	2
PE01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PE02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PE03EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
PE04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
PE05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CO01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CO02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CO03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CO04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RM01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RM02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MN01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
MN02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
CR01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU03EN	217	0.065	0.005	0.995	2	218	0.018	0.005	1.000	1
RU04EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU05EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU06EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU07EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU08EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU09EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1

RU10EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
RU11EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
SV01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TK01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
TK02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BH01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BH02EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
BH03EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1
HG01EN	218	0.069	0.005	1.000	1	218	0.018	0.005	1.000	1

Notes: Global and local measures are based on the contemporaneous network computed through NETS algorithm. Centrality degree corresponds to the number of links related to each node (vertex), both incoming and outgoing from each node. Betweenness is a measure that quantifies the number of times a node acts as a bridge along the path between two nodes (the shortest length). Closeness computes the shortest paths between all nodes and assigns a score to each based on the sum of their paths. Authority Score measures the relative importance of each node. Eccentricity is the distance from a particular node *i* to the furthest node *j* (with respect to *i*). Source: Authors' elaboration.