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Abstract

This study extends the literature on the asymmetric effect of oil price fluctuations on emerging and frontier stock markets via a quantile-on-quantile approach that allows to capture normal and extreme states in each respective market. We find that oil risk exposures are heterogeneous across the emerging and frontier stock markets and indeed display quantile-specific characteristics. Observing uniform patterns of oil risk exposures within groups of countries that include both importers and exporters, we argue that oil price risk serves as a systematic risk proxy, capturing the market's concerns regarding global growth expectations, rather than a simple import/export commodity. Our findings suggest that signals from the oil market, either via measures of trading activity in oil futures or changes in basis values, could be utilized by policy makers to improve models of stock market volatility

JEL Classification: C22, G12, Q40

Keywords: Stock returns; Oil prices; Quantile regression; Emerging markets

1. Introduction

The relationship between oil prices and stock markets is a renewable phenomenon, which the literature finds worthy of further investigation. The early literature has examined this linkage since, on the supply side, oil is a feedstock that affects companies' earnings and hence their stock prices. On the demand side, oil prices affect consumers' disposable income, spending, and thereby the demand for goods and services produced by those companies. In recent years and particularly following the global crisis of 2017/2018, oil seems to have taken a broader role as a systematic driver of economic and financial variables, as noted by Bernanke (2016) that stock and oil markets tend to move together recently as they both react to a common factor reflecting softening of global aggregate demand. Furthermore, recent research suggests possible asymmetric effects of supply and demand related oil shocks on stock markets (Ready, 2016; Basher et al., 2018), presenting further challenges for models of oil-stock market relationship. This paper extends the literature to emerging and frontier stock markets from a novel perspective by focusing on the quantile relationships between oil and stock markets, hence providing further insight to the effects of oil shocks on financial returns.

Earlier studies consider the oil-stock relationship to be linear without taking into account possible asymmetries in the reaction of stock markets to positive and negative oil shocks. Focusing the attention on the sources of oil price shocks, more recent studies show that oil demand shocks have different impacts on stock markets than oil supply shocks (Killian, 2015, Ready, 2016), while Basher et al. (2018) show that the effect of oil shocks on stock markets are largely regime specific, based on high and low market volatility states. Clearly, an equal size shock could affect markets differently, depending on whether the market is in a normal, bearish or bullish state, as investors' trades in response to oil related shocks would be affected by the current state of the market. In this regard, the quantile-to-quantile approach presents a valuable opening, allowing us to study the oil-stock market

relationship over the entire market distributions representing various market states, without the limitation of two (in some cases three) market states as dictated by regime switching models.

The relationship between oil prices and the stock market takes on a higher dimension when the stock markets are classified as emerging or frontier. In the oil-producing emerging economies, oil is usually the primary source of export revenues and this relationship is direct and intense. However, in the case of oil-importing emerging countries, the relationship is less passionate and usually moves in the opposite direction. Further, the emerging economies depend heavily on commodity exports, which are highly volatile and in turn, leads to a volatile relationship between oil and stocks, which is not the case for developed markets. Moreover, the sensitivity of the emerging markets is exacerbated by the limited availability of hedging instruments that can protect corporate profits in the case of high oil price gyrations. To that end, modeling the relationship between oil price fluctuations and stock markets in emerging nations can present additional challenges for both investors in their risk management strategies and for policy makers in mitigating the possible negative effects of oil shocks on their economies and monetary policies.

This study extends the mixed literature on the asymmetric effect of oil price shocks on stock market returns to 44 emerging and frontier stock markets, including a diverse set of oil exporting and importing countries. Unlike other studies in the literature that focus on either developed markets or a limited number of emerging stock markets including those in the BRICS, Eastern Europe or Asia-Pacific region, we examine the quantile-level relationships between oil and stock markets and provide a comparative analysis of a large set of emerging and frontier stock markets. In contrast with the standard quantile regression methodology that is unable to capture the dependence in its entirety, we adopt a quantile-on-quantile (QQ) approach and examine the relationship between various quantiles of stock market and oil

returns that represent normal, bull and bear states. From an investment perspective, the analysis is of particular interest to active managers who focus on emerging stock markets as the findings can be used in market timing strategies for developing stock markets conditional on oil market movements and distribution. The findings are also of interest to local investors in these markets as they help to make inferences regarding the potential role of oil serving as a hedge or diversifier for stock market risks in those countries, with the objective of achieving diversification benefits and risk reductions. From a policy making perspective, the results can provide a basis for mitigating oil price shocks on the stock markets so that appropriate mechanisms can be put in place in order to control and protect against volatility in emerging stock markets.

We show that oil risk exposures are heterogeneous across the emerging and frontier stock markets and indeed display quantile-specific characteristics. Oil risk exposures of emerging and frontier stock markets are generally significant and positive at low quantiles or bearish markets, consistently across most of the stock markets examined. At the same time, we observe a larger scale oil effect in several emerging markets, particularly at low oil return quantiles regardless of the stock market state, while several other emerging markets, particularly those in eastern European countries, exhibit strong and positive oil risk exposures during bull market states as well. Observing uniform patterns of oil risk exposures within groups of countries that include both importers and exporters, we argue that oil price risk serves as a systematic risk proxy, capturing the market's concerns regarding global growth expectations, rather than a simple import/export commodity.

The findings overall indicate the presence of asymmetric oil risk exposures for most developing stock markets, while the risk exposures are necessarily explained by import/export characteristics of the host countries.

effect is not uniform across the emerging nations. Our findings are in line with the notion that oil price risk serves as a systematic risk proxy, capturing the market's concerns regarding global growth expectations. Given this, a significant policy implication is that signals from the oil market, either via measures of trading activity in oil futures or changes in basis values, could be utilized by policy makers to improve models of stock market volatility. Furthermore, the information captured by oil price fluctuations can be used to explain possible asymmetries in the reaction of developing stock markets to global shocks.

The remainder of this paper is organized as follows. Section 2 briefly discusses the literature on the relationship between oil and stock markets and the burgeoning literature on quantile-based models. Section 3 explains the data and methodology, while Section 4 presents the empirical findings. Finally, Section 5 concludes the paper.

2. Literature review

The relationship between energy and stock markets has been examined in numerous studies from different angles and in different contexts. The literature does not provide strong consensus on whether oil price shocks have positive, negative or insignificant impacts on stock returns. One can thus classify the strands of the literature on this basis. In the first strand, various studies examining the relationship at the aggregate and sectoral level over different periods for developed and emerging markets, document evidence of a negative effect of oil returns on stock returns (e.g., Kaul and Jones, 1996; Sadorsky, 1999; Papapetrou, 2001; Shimon and Raphael, 2006; Basher and Sadorsky, 2006; Hammoudeh and Choi, 2007; Nandha and Haff, 2008; Kilian and Park, 2009; Issac and Ratti, 2009, among others). The second strand, on the other hand, finds a significant positive relationship between oil prices and stock returns (e.g., El-Sharif, Brown, Nixon and Russel, 2005; Narayan and Narayan, 2010; Zhang and Chen, 2011; Arouri and Rault, 2001).

Bernanke (2016) argues that an underlying common demand factor accounts for much of the positive relationship, and that more of this relationship can be explained if shifts in market risk preferences are also accounted for. Reboredo and Rivera-Castro (2013), for example, find a positive interdependence between oil price shocks and the stock returns at both the aggregate and the sectoral levels in the post global financial crisis period. This finding is indeed supported by several earlier studies including Sadorsky (2001) who provides empirical support for a significant positive relationship between oil prices and stock returns in the case of oil and gas firms. In other studies, Gogineni (2007) and Yurtsever and Zahor (2007) show that, under a number of hypotheses, oil prices are positively interlinked with stock prices, if oil price shocks reflect changes in aggregate demand. Finally, the third strand reports no significant relationship between oil prices and stock returns (e.g., Huang, et al., 1996; Blanchard and Gali, 2007; Henriques and Sadorsky, 2008; Lescaroux and Mignon, 2008; Apergis and Miller, 2009; Miller and Ratti, 2009; Sukcharoen et al., 2014).

The more recent research in this literature finds evidence that the oil-stock relationship is in fact time-varying and nonlinear and that this relationship may be affected by particular events such as the recent global financial crisis (e.g., Miller and Rati, 2009; Reboredo, 2010; Filips et al., 2011; Daskalaki and Skiadopoulos, 2011; Wen et al. (2012); Chang and Yu, 2013; Reboredo and Rivera-Castro, 2014; and Zhang and Li, 2014). These studies use nonlinear models to analyze the impact of changes in oil prices on stock returns, but there is no convincing enough literature that shows how positive/negative oil price shocks or inter-quantile oil price changes affect different equity return quantiles particularly for emerging markets. Sim and Zhou (2015) is the first study to use the quantile-on-quantile regression method to estimate the effect of oil price shock quantiles on stock return quantiles for the United States. They document an asymmetric relationship between oil prices and equities such that negative oil price shocks have a positive effect on the stock market when the market

is in a positive state, while the effect is not as strong in the case of positive oil price shocks. Focusing on BRICS countries, U.K., U.S. and the European Monetary Union and using copula functions, Reboredo and Ugolini (2016) confirm this finding and show that downside spillover effects across the oil and stock markets are larger than they are on the upside, while small positive and negative oil price movements have no impact on any stock return quantiles. Their research also suggests that the oil price effect has strengthened following the global financial crisis.

In another related work, Zhu et al. (2016) examine extreme dependence between the Asia-Pacific stock markets and the oil market by employing the quantile regression analysis. They document an asymmetric and heterogeneous pattern in the dependence structure where dependence increases dramatically after a crisis (structural break). They also observe significantly greater dependence at the lower tails than the upper tails, while the relationship is positive at the low quantiles. Our study follows this approach and extends the literature to a large number of emerging and frontier markets with different macroeconomic and market conditions.

3. Data and Methodology

3.1. Data

We utilize weekly data for 44 emerging and frontier stock markets as classified by Morgan Stanley Capital International, including Argentina, Bahrain, Bangladesh, Brazil, Bulgaria, China, Chile, Colombia, Croatia, Czech Republic Egypt, Estonia, Greece, Hungary, India, Indonesia, Kazakhstan, Kenya, Korea, Kuwait, Lithuania, Malaysia, Mauritius, Mexico, Morocco, Nigeria, Oman, Pakistan, Philippines Poland, Qatar, Romania, Russia, Serbia, Slovenia, South Africa, Sri Lanka, Taiwan, Thailand, Tunisia, Turkey, United Arab Emirates (UAE), Ukraine and Vietnam. The MSCI country stock market indices are used to obtain the stock market returns. As shown in Table 1, the sample period begins on different

dates for most countries, but ends on Dec. 16, 2016 for all markets. Finally, the Brent crude oil price is used to calculate oil returns as this type of oil is the benchmark for a large percentage of global oil consumption (Degiannakis et al., 2014).

3.2. Quantile-on-quantile correlations

The relationship between the oil and stock markets is examined via the quantile-on-quantile (QQ) approach, recently applied to the U.S market in Sim and Zhou (2015). The QQ approach, as a generalization of the standard quantile regression, is a combination of quantile regression and nonparametric estimation, allowing one to examine how the conditional quantiles of a variable relate to the conditional quantiles of another variable. In the framework of this study, the QQ approach is utilized to examine the relationship between the quantiles of the Brent oil returns and the quantiles of stock market returns for 44 emerging and frontier markets. The model begins with the following nonparametric quantile regression specification

$$R_t = \beta^{\theta}(P_t) + u_t^{\theta} \tag{1}$$

where R_t (P_t) is the stock market (Brent oil) return in period t, θ is the θ-th quantile of the conditional distribution of the stock market returns and u_t^{θ} is a quantile error term whose conditional θ-th quantile is equal to zero. The $\beta^{\theta}(\cdot)$ is assumed to be an unknown function as we have no prior information on how the stock and oil markets are linked.

This standard quantile regression model allows the effect of oil returns to vary across the different quantiles of stock returns; however, this regression is unable to capture the dependence in its entirety as the term $\beta^{\theta}(\cdot)$ is indexed on the stock return quantile θ only and not the oil return quantile. Following the literature on the asymmetric effects of oil price shocks, we posit that large (or small) positive/negative oil shocks may have a differential impact on the stock market, and that stock returns may also react asymmetrically to negative and positive oil market shocks. Therefore, in order to get a comprehensive insight, we focus on the relationship between the θ-th quantile of the stock market returns and the τ-th quantile

of the oil returns, denoted by P^{τ}. This is done by examining Eq. (1) in the neighborhood of P^{τ} via a local linear regression. As $\beta^{\theta}(\cdot)$ is unknown, this function is approximated through a first order Taylor expansion around a quantile P^{τ}, such that

$$\beta^{\theta}(P_t) \approx \beta^{\theta}(P^{\tau}) + \beta^{\theta'}(P^{\tau})(P_t - P^{\tau}) \tag{2}$$

where $\beta^{\theta'}$ is the partial derivative of $\beta^{\theta}(P_t)$ with respect to P, is also called the marginal effect or response, and is similar in interpretation to the coefficient (slope) in a linear regression model. Next, renaming $\beta^{\theta}(P^{\tau})$ and $\beta^{\theta'}(P^{\tau})$ as $\beta_0(\theta,\tau)$ and $\beta_1(\theta,\tau)$, respectively, we rewrite Eq. (2) as

$$\beta^{\theta}(P_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(P_t - P^{\tau}) \tag{3}$$

By substituting Eq. (3) in Eq. (1), the following equation is obtained

$$S_t = \underbrace{\beta_0(\theta,\tau) + \beta_1(\theta,\tau)(P_t - P^{\tau})}_{(*)} + u_t^{\theta} \tag{4}$$

where the term (*) is the *θ-th* conditional quantile of the stock market returns. Unlike the standard conditional quantile function, Eq. (4) captures the overall dependence structure between the *θ-th* quantile of stock market returns and the *τ-th* quantile of oil returns as the parameters β_0 and $\beta_1$are doubly indexed in θ and τ. In the estimation of Eq. (4), P_t and P^{τ} are replaced by their empirical counterparts $\hat{P}_t$ and $\hat{P}^{\tau}$, respectively and the local linear regression estimates of the parameters $\hat{\beta}_0$ and $\hat{\beta}_1$ are obtained by solving

$$\min_{b_0,b_1} \sum_{i=1}^{n} \rho_{\theta}\left[S_t - \hat{\beta} - \hat{\beta}_1\left(\hat{P}_t - \hat{P}^{\tau}\right)\right] K\left(\frac{F_n(\hat{P}_t)-\tau}{h}\right) \tag{5}$$

where $\rho_{\theta}(u)$ is the quantile loss function, defined as $\rho_{\theta}(u) = u\big(\theta - I(u<0)\big)$ and I is the usual indicator function. $K(\cdot)$ denotes the kernel function and h is the bandwidth parameter of the kernel. Because of its computational simplicity and efficiency, the Gaussian kernel is used to weight the observations in the neighborhood of P^{τ}. Specifically, in our analysis, these weights are inversely related to the distance between the empirical distribution function of $\hat{P}_t$, denoted by $F_n\left(\hat{P}_t\right) = \frac{1}{n}\sum_{k=1}^{n} I(\hat{P}_k < \hat{P}_t)$, and the value of the distribution function that

corresponds with the quantile P^{τ}, denoted by τ. The bandwidth parameter h is selected using the cross-validation regression approach with a local linear regression.

4. Empirical results

4.1. Summary statistics and preliminary analysis

Table 1 presents the descriptive statistics for the weekly log returns along with the sample period and the number of observations for each market. The end point for country return series is December 16, 2016 while the starting points are governed by data availability. We observe positive mean returns in most stock markets in the sample with the exception of several eastern European countries (Bulgaria, Greece, Lithuania, Serbia and Ukraine) and Gulf Arab stock markets (Bahrain, Kuwait, Oman and UAE). It is possible that the prolonged Eurozone uncertainty had negative spillover effects on some of the more vulnerable eastern European markets, while the oil slump experienced since the global financial crisis had a negative impact on the Gulf Arab stock markets. On the other hand, some of the major developing nations including Argentina, Brazil, Russia and Turkey experience the greatest volatility in their stock markets, possibly due to a combination of political instability in these nations and geopolitical risks. Finally, most of the stock markets in the sample exhibit negative skewness and significantly large kurtosis, implying a greater likelihood of experiencing negative returns as well as the presence of extreme movements. The notion of whether the large crashes experienced in most emerging stock markets are related to oil price shocks is yet to be explored.

Table 2 provides the Pearson correlation estimates between Brent oil returns and stock market indices during the whole sample period as well as during the pre/post global financial crisis period. Interestingly, all stock markets display positive correlations with oil returns during the whole sample period, irrespective of whether these countries are classified as net importers or net exporters. We observe that the oil-stock market correlations are significantly

higher during the global financial crisis period (December 2007 to June 2009) than at other times. Given that these correlations were quite low, and in some cases negative, before the global financial crisis period, one can argue that a structural break has occurred in the relationship between oil and stock markets due to the global financial crisis. It is possible that oil market fundamentals have acted as a proxy for global systematic risk for most developing stock markets following the financial crisis, acting as an indicator of global economic growth expectations or as a proxy for investor sentiment globally. Nevertheless, how the oil-stock market relationship plays out across various quantiles will provide valuable insights into these preliminary observations.

4.2. Quantile dependence between oil and stock market returns

Before we proceed with the analysis of quantile dependence, we first examine the time-variation in the correlations in order to detect possible structural changes in correlation patterns. Figure 1 provides the rolling Pearson correlation estimates with a window size of 32 weeks. Consistent with the preliminary analysis presented in Table 2, a positive trend in the oil-stock market correlations is observed for most markets during the financial crisis period, while the trend turns negative in the aftermath of the crisis. The positive trend in the correlations is particularly persistent in the case of Brazil, Chile, Colombia, Mexico, Russia and Thailand, while several countries including Bulgaria, Croatia, Lithuania, Mauritius, Romania, Slovenia and Ukraine generally experience declining and generally low correlations with oil returns. At the same time, we observe a notable uptick in oil-stock market correlations around the global financial crisis period when oil prices surged to historical high levels before crashing significantly in mid-2008. We also note a general structural change in correlation patterns during the 2012-2016 period as the Eurozone economies continued to struggle to contain recessionary concerns, pushing interest rates to negative territory. These observations, overall, indicate that the relationship between oil and stock markets can be

highly sensitive to extreme market conditions, which can be successfully captured by quantile based models.

Figure 2 presents the plots of quantile-on-quantile estimates for the slope parameter, $\beta_1(\theta,\tau)$ described in Eq. (3). As explained earlier, these estimates are similar to the slope term in a linear regression model, reflecting the sensitivity of each stock market to oil market fluctuations. However, given that $\beta_1(\theta,\tau)$ is doubly indexed in θ and τ, β_1 estimates reported in the figures measure the relationship between the θ-th quantile of stock market returns and the τ-th quantile of oil returns. The plots are color-coded in such a way that represents the degree of sensitivity (red indicating higher sensitivity), with the stock return quantiles placed on the y-axis and the oil return quantiles on the x-axis.

A common theme reflected by the estimates presented in Figure 2 is that risk exposures of emerging and frontier stock markets with respect to oil price fluctuations indeed display quantile-specific characteristics. Consistent with the reported findings for developed markets, we observe that oil risk exposures are generally significant at low quantiles, for both stock and oil returns, across most emerging and frontier stock markets. This indicates that stock markets become particularly sensitive to oil price fluctuations during periods of large stock market downturns coupled with large oil price drops. Risk exposures with respect to oil returns during crash market states are particularly high (and positive) in the case of eastern European stock markets including Bulgaria, Croatia, Czech Republic, Hungary, Russia, Serbia, Slovenia and Turkey. Considering that all of these countries with exception of Russia are all net importers and thus should be expected to benefit from low oil prices, the strong positive oil risk exposures during crash states in both markets reflects the nature of oil as a risk proxy for global growth projections, rather than just an import or export commodity. This argument is further confirmed with positive and strong oil risk exposures during crash market states observed for Latin American countries including Colombia, Chile, Mexico as well as

Gulf Arab nations of Oman, Qatar, and UAE, suggesting that oil risk serves as a proxy for global economic uncertainty, with the risk exposure getting stronger during crash states in both stock and oil markets.

While oil sensitivity is largely confined to crash states in stock and oil markets for most countries, we also observe a larger scale oil effect in several developing nations including Bahrain, Bangladesh, Kenya, Kuwait, Malaysia, Nigeria and Pakistan, particularly at low oil return quantiles regardless of the stock market state. This suggests that these developing nations are particularly affected by downturns in the oil market, suggesting the presence of asymmetric spillovers from the oil market into these stock markets. Clearly, policy makers will have to take the asymmetry in these stock markets' sensitivities to oil price fluctuations in their volatility forecasting models, perhaps utilizing regime based specifications or quantile based estimations. Nevertheless, given that stock and oil market dependence is particularly strong during crash market states, it can be argued that oil is an unlikely safe haven for investors in most emerging nations.

Interestingly, several emerging nations, particularly eastern European countries including Croatia, Greece, Russia, Serbia, Romania, Ukraine, Poland and Turkey exhibit strong and positive oil risk exposures during bull market states as well. This finding suggests that bull runs in oil prices have significant spillover effects on these stock markets, interestingly, despite the fact that these are mainly oil importing nations, with the exception of Russia. A similar pattern is also observed for India, Kenya, Korea, and South Africa, with strong and positive oil exposures observed at high quantiles of both oil and stock market returns. Considering that these countries represent a mixed group of oil importers and exporters, one can argue that oil represents more than just a commodity, but instead serves as a systematic risk proxy, reflecting global growth expectations. One possible explanation is that oil market volatility in the positive direction reflects investors' favorable global growth

expectations, thus creating a positive investment trend, fueled by increased risk appetite, and fund flows into emerging markets, thus creating a positive effect in stock market returns.

A significant implication of the findings presented above is that policy makers can utilize signals from the oil market via measures of trading activity in oil futures (e.g. Chan et al., 2015) or changes in basis values for various oil futures contracts in order to improve stock market forecasting models. Clearly, if fluctuations in oil prices contain information regarding changes in global risk appetite, this would have significant implications over fund flows in and out of emerging financial markets. This is particularly an important consideration for policy makers in emerging nations that are exposed to "hot money" flows as foreign investors can inflict significant damage on local financial markets and currency rates.

The argument that oil represents more than just a commodity, but instead an indicator of global growth expectations, is further confirmed by the results for net energy exporters of UAE, Qatar, and Kuwait wherein one would expect a significant and positive relationship between high oil prices and strong stock market performance. The plots, however, suggest otherwise, indicating weak and in some cases insignificant links to oil returns at high quantiles. To that end, the findings do not necessarily support the trade channel to explain the oil-stock market relationship (Chen and Chen, 2007; Lizardo and Mollick, 2010), but instead, suggest that oil price uncertainty can potentially serve as a systematic, global risk proxy while oil risk is asymmetric for most developing stock markets. Nevertheless, the findings provide insight to the information captured by oil price fluctuations, which can be of interest to policy makers in emerging nations.

5. Conclusion

This study extends the burgeoning literature on the asymmetric effect of oil price shocks on stock market returns to a large number of emerging and frontier stock markets. Unlike other studies in the literature that focus on either developed markets or a limited

number of emerging stock markets like those in BRICS, we focus on the quantile-specific risk exposures of stock markets with respect to oil price fluctuations, providing new insight to the effects of asymmetric oil price risks on developing nations. In contrast with the standard quantile regression methodology that is unable to capture the dependence in its entirety, we adopt a quantile-on-quantile (QQ) approach and examine the relationship between the θ-*th* quantile of stock market returns and the τ-*th* quantile of oil returns that represent normal, bull and bear states in each respective market.

Our findings suggest that oil risk exposures are heterogeneous across the emerging and frontier stock markets and indeed display quantile-specific characteristics. We observe that oil risk exposures are generally significant at low quantiles, for both stock and oil returns, across most emerging and frontier stock markets, indicating that stock markets become particularly sensitive to oil price fluctuations during periods of large stock market downturns coupled with large oil price drops. While oil sensitivity is largely confined to bear states in stock and oil markets for most countries, we also observe a larger scale oil effect in several developing nations, particularly at low oil return quantiles regardless of the stock market state. Interestingly, several emerging nations, particularly those in eastern European countries, exhibit strong and positive oil risk exposures during bull market states as well. The evidence overall suggest the presence of asymmetric spillovers from the oil market into developing stock markets.

Observing uniform patterns of oil risk exposures within groups of countries that include both importers and exporters, our findings are in line with the notion that oil price risk serves as a systematic risk proxy, capturing the market's concerns regarding global growth expectations, rather than a simple import/export commodity. A significant implication of this result is that signals from the oil market, either via measures of trading activity in oil futures or changes in basis values, could be utilized by policy makers to improve models of stock

market volatility. Furthermore, the information captured by oil price fluctuations can be used to explain possible asymmetries in the reaction of developing stock markets to global shocks.

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Table 1. Descriptive statistics for weekly returns.

	n	Mean	S.D.	Min	Max	Skewness	Kurtosis	JB	Q(1)	Q(5)	ARCH(1)	ARCH(5)	Starting Period
Brent Oil	1511	0.07	4.98	-45.12	22.14	-0.74	5.91	2344.57***	0.68	4.62	46.50***	95.83***	01/08/1988
Argentina	1511	0.21	7.10	-63.64	73.28	0.08	17.48	19294.13***	12.43***	33.00***	135.98***	296.30***	01/08/1988
Bahrain	602	-0.47	2.97	-21.32	10.92	-1.33	9.18	2309.32***	4.23**	24.41***	4.90**	16.05***	06/03/2005
Bangladesh	367	-0.03	3.22	-17.58	18.46	0.14	6.50	658.36***	0.30	3.23	46.37***	66.51***	12/04/2009
Brazil	1511	0.18	6.36	-78.77	26.35	-1.50	17.43	19756.34***	3.76*	7.49	10.92***	44.85***	01/08/1988
Bulgaria	602	-0.26	4.12	-41.60	17.72	-2.12	19.21	9782.81***	11.25***	61.30***	23.24***	59.43***	06/03/2005
China	1250	-0.04	4.46	-24.34	22.54	-0.20	2.87	441.02***	0.27	13.48**	36.78***	93.39***	01/01/1993
Chile	1511	0.18	3.32	-34.66	19.13	-0.85	9.64	6054.16***	1.41	10.56*	151.85***	163.74***	01/08/1988
Colombia	1250	0.14	3.93	-29.02	15.04	-0.66	4.65	1220.47***	7.97***	38.64***	11.65***	73.83***	01/01/1993
Croatia	759	0.02	3.35	-23.98	19.53	-0.42	8.15	2136.51***	1.73	8.99	54.52***	87.59***	05/31/2002
Czech Republic	1146	0.07	3.80	-29.81	21.63	-0.56	5.64	1587.41***	0.30	9.44*	52.39***	172.35***	12/30/1994
Egypt	1146	0.14	4.29	-50.27	15.51	-1.81	18.76	17501.16***	2.43	11.61**	6.24**	10.06*	12/30/1994
Estonia	759	0.12	3.75	-25.22	17.25	-0.51	6.04	1196.69***	3.20*	13.75**	6.56**	142.26***	05/31/2002
Greece	1511	-0.10	5.11	-38.35	20.73	-0.57	4.50	1361.56***	1.57	7.17	30.20***	58.84***	01/08/1988
Hungary	1146	0.15	5.05	-43.45	22.73	-1.00	8.10	3338.89***	0.03	17.37***	20.68***	67.90***	12/30/1994
India	1250	0.12	3.81	-21.88	18.37	-0.33	2.23	284.26***	6.31**	17.58***	29.96***	101.30***	01/01/1993
Indonesia	1511	0.13	5.97	-64.50	50.70	-0.24	21.03	27946.57***	2.65	43.80***	119.74***	237.63***	01/08/1988
Kazakhstan	576	-0.03	5.74	-32.28	35.58	0.18	6.12	909.97***	0.23	1.86	14.54***	90.62***	12/02/2005
Kenya	759	0.29	3.63	-17.56	21.34	0.14	5.11	836.67***	2.38	6.99	37.43***	76.17***	05/31/2002
Korea	1511	0.09	4.79	-52.71	28.64	-0.91	14.23	13001.16***	12.44***	27.01***	45.28***	156.88***	01/08/1988
Kuwait	602	-0.09	3.09	-21.37	16.75	-0.92	8.70	1999.32***	0.22	13.42**	102.08***	147.93***	06/03/2005
Lithuania	446	-0.09	3.28	-17.34	29.01	0.46	17.94	6062.82***	1.40	20.96***	0.93	18.92***	05/30/2008
Malaysia	1511	0.08	3.70	-42.80	34.16	-0.97	24.80	39069.04***	0.01	19.60***	11.61***	316.95***	01/08/1988
Mauritius	759	0.23	2.76	-22.34	12.63	-0.43	8.93	2562.28***	6.95***	21.10***	11.41***	69.42***	05/31/2002
Mexico	1511	0.25	4.28	-31.68	28.19	-0.50	6.98	3144.74***	0.24	24.64***	34.70***	152.29***	01/08/1988
Morocco	1146	0.09	2.37	-14.28	9.16	-0.35	3.02	463.84***	2.89*	11.09**	31.45***	98.95***	12/30/1994
Nigeria	759	0.03	4.45	-31.83	18.20	-0.73	6.04	1231.97***	0.12	12.70**	32.98***	53.73***	05/31/2002
Oman	602	-0.08	2.89	-22.31	13.52	-1.34	11.19	3346.96***	0.06	9.99*	25.14***	62.00***	06/03/2005
Pakistan	1250	0.03	4.19	-27.25	18.79	-0.79	4.56	1220.55***	30.79***	45.91***	194.45***	253.25***	01/01/1993
Philippines	1511	0.10	3.85	-27.88	16.19	-0.60	4.80	1545.69***	1.48	35.32***	21.85***	71.41***	01/08/1988
Poland	1250	0.13	5.31	-29.57	25.85	-0.29	4.37	1015.64***	1.45	16.99***	173.26***	245.52***	01/01/1993
Qatar	602	0.00	3.44	-22.76	12.87	-0.88	6.32	1090.81***	4.22**	6.56	14.64***	94.37***	06/03/2005
Romania	576	-0.03	4.66	-34.67	20.08	-1.39	8.79	2057.41***	5.57**	30.93***	3.39*	75.10***	12/02/2005
Russia	1146	0.16	6.88	-31.70	44.90	-0.11	5.70	1559.59***	4.43**	17.18***	101.85***	206.91***	12/30/1994
Serbia	446	-0.41	5.33	-44.38	22.19	-1.51	13.68	3684.58***	8.56***	25.94***	22.00***	43.54***	05/30/2008
Slovenia	759	0.02	3.16	-22.02	11.39	-0.95	5.86	1208.26***	2.69	18.55***	40.42***	57.91***	05/31/2002

South Africa	1250	0.12	3.95	-18.85	27.60	-0.17	3.99	838.14***	1.52	9.59*	159.01***	248.04***	01/01/1993
Sri Lanka	1250	0.05	3.80	-14.15	35.18	1.43	12.53	8642.01***	26.78***	37.82***	1.28	16.68***	01/01/1993
Taiwan	1511	0.08	4.32	-22.16	24.06	-0.04	3.28	679.66***	0.00	22.99***	144.05***	281.13***	01/08/1988
Thailand	1511	0.08	4.70	-29.16	27.72	-0.19	5.54	1952.36***	0.36	23.98***	123.46***	223.50***	01/08/1988
Tunisia	654	0.06	2.32	-13.83	15.50	-0.05	6.91	1313.62***	0.02	2.36	2.15	11.10**	06/04/2004
Turkey	1511	0.08	7.12	-73.77	38.61	-0.79	10.11	6615.73***	0.29	15.14***	77.49***	91.99***	01/08/1988
UAE	602	-0.09	4.60	-32.68	20.72	-1.24	7.59	1611.06***	5.85**	9.89*	3.21*	65.62***	06/03/2005
Ukraine	550	-0.59	5.28	-32.53	22.42	-0.62	3.84	378.66***	18.61***	35.86***	7.75***	23.88***	06/02/2006
Vietnam	524	-0.09	4.50	-19.35	20.83	0.17	2.68	161.55***	13.60***	19.27***	27.89***	84.92***	12/01/2006

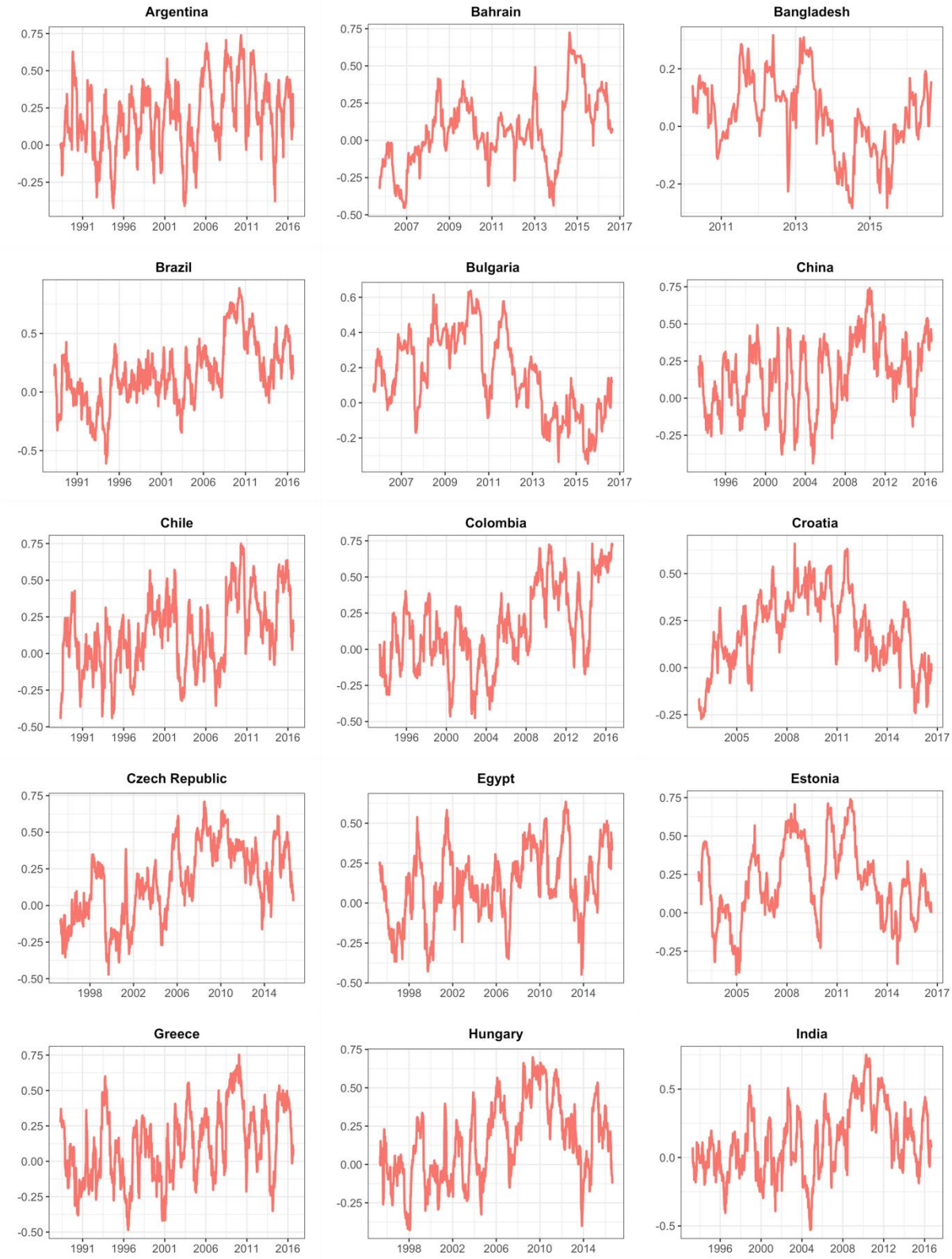
Note: This table reports the descriptive statistics for the weekly oil and stock market returns. The sample period starts at the period given in the last column of the table and ends at 12/16/2016 with *n* observations for each series. In addition to the mean, the standard deviation (S.D.), minimum (min), maximum (max), skewness, and kurtosis statistics, the table reports the Jarque-Bera normality test (JB), the Ljung-Box first [*Q*(1)] and the fifth [*Q*(5)] autocorrelation tests, and the first [ARCH(1)] and the fifth [ARCH(5)] order Lagrange multiplier (LM) tests for the autoregressive conditional heteroskedasticity (ARCH). The asterisks ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 2. Pearson correlation coefficient estimates between the oil and stock market returns.

	Full Sample	Pre-subprime crises period	Subprime crises period	Post-subprime crises period
Argentina	0.18	0.12	0.52	0.28
Bahrain	0.14	-0.23	0.20	0.20
Bangladesh	0.03	--	--	0.03
Brazil	0.14	0.02	0.60	0.43
Bulgaria	0.26	0.08	0.44	0.16
China	0.17	0.08	0.38	0.33
Chile	0.15	0.04	0.39	0.38
Colombia	0.19	0.01	0.44	0.50
Croatia	0.24	0.09	0.46	0.21
Czech Republic	0.20	0.04	0.52	0.33
Egypt	0.18	0.06	0.41	0.26
Estonia	0.26	0.10	0.50	0.20
Greece	0.14	-0.01	0.50	0.33
Hungary	0.20	0.03	0.51	0.33
India	0.15	0.02	0.42	0.29
Indonesia	0.11	0.06	0.43	0.25
Kazakhstan	0.32	0.11	0.46	0.32
Kenya	0.07	-0.03	0.28	0.01
Korea	0.14	0.05	0.43	0.36
Kuwait	0.15	0.00	0.19	0.18
Lithuania	0.28	--	0.48	0.17
Malaysia	0.10	0.03	0.43	0.38
Mauritius	0.19	-0.03	0.41	0.18
Mexico	0.14	0.03	0.40	0.45
Morocco	0.08	-0.02	0.34	0.13
Nigeria	0.09	0.05	0.14	0.07
Oman	0.28	0.13	0.43	0.21
Pakistan	0.06	0.03	0.17	0.08
Philippines	0.10	0.03	0.36	0.22
Poland	0.15	0.02	0.49	0.38
Qatar	0.20	0.05	0.27	0.21
Romania	0.29	0.07	0.30	0.34
Russia	0.26	0.11	0.56	0.57
Serbia	0.28	--	0.29	0.27
Slovenia	0.27	0.08	0.56	0.20
South Africa	0.26	0.11	0.51	0.42
Sri Lanka	0.06	-0.01	0.29	0.11
Taiwan	0.04	-0.05	0.48	0.34
Thailand	0.08	0.00	0.45	0.32
Tunisia	0.12	0.10	0.24	0.04
Turkey	0.06	-0.01	0.41	0.23
UAE	0.24	-0.03	0.44	0.21
Ukraine	0.21	-0.05	0.37	0.17
Vietnam	0.20	-0.15	0.32	0.19

Note: Table reports the Pearson correlation coefficients for the full sample period, pre-, post-, and subprime crises periods. Subprime crises period covers from December 2007 to June 2009. '--' denotes data is not available for the subsample period.

Figure 1. Rolling Pearson correlation estimates



Note: Figure plots the rolling Pearson correlation estimates with a window size of 32 weeks.

Figure 1. (continued)

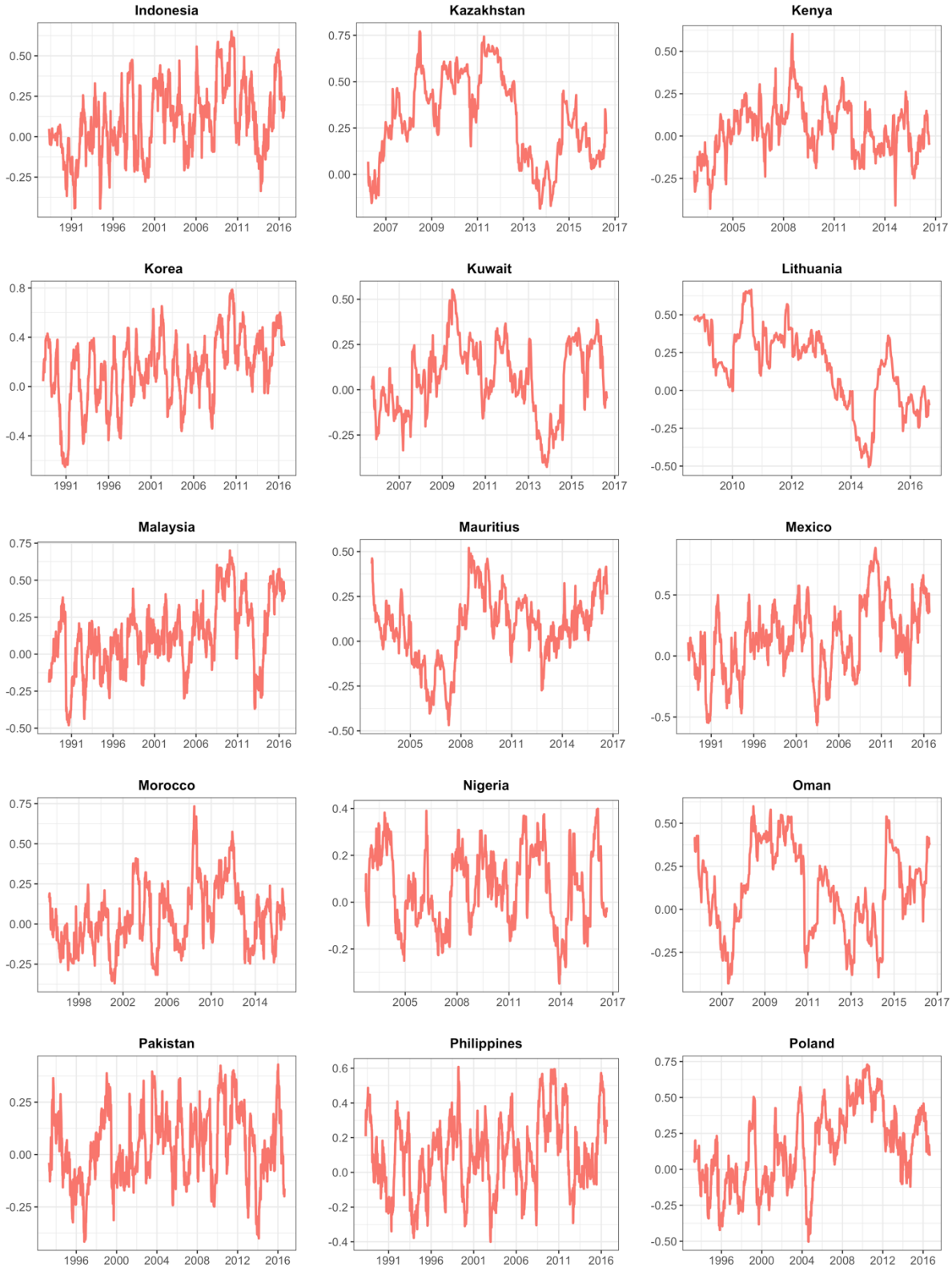


Figure 1. (continued)

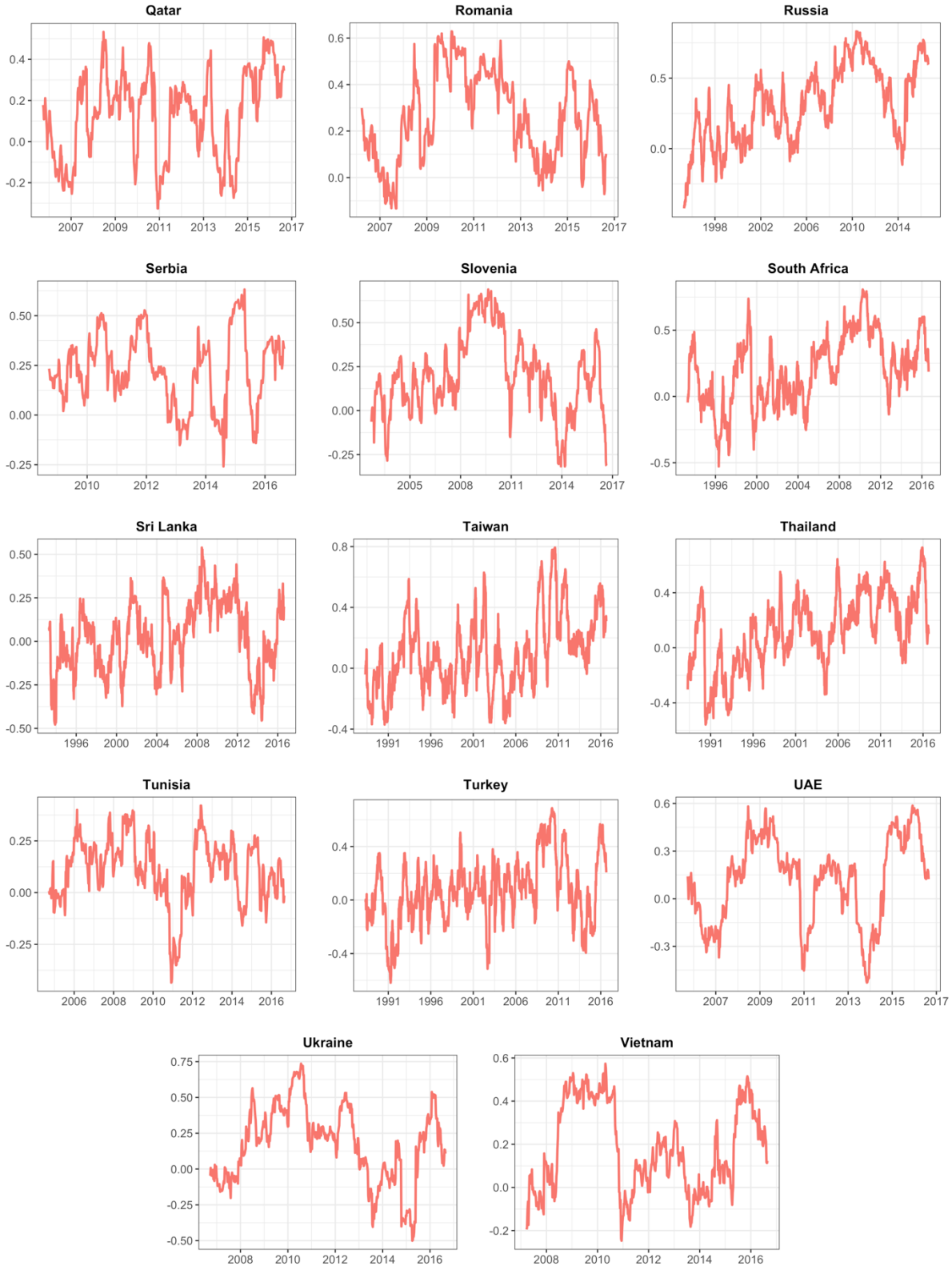


Figure 2. Quantile-on-Quantile estimates for the slope parameter, $\beta_1(\theta,\tau)$.

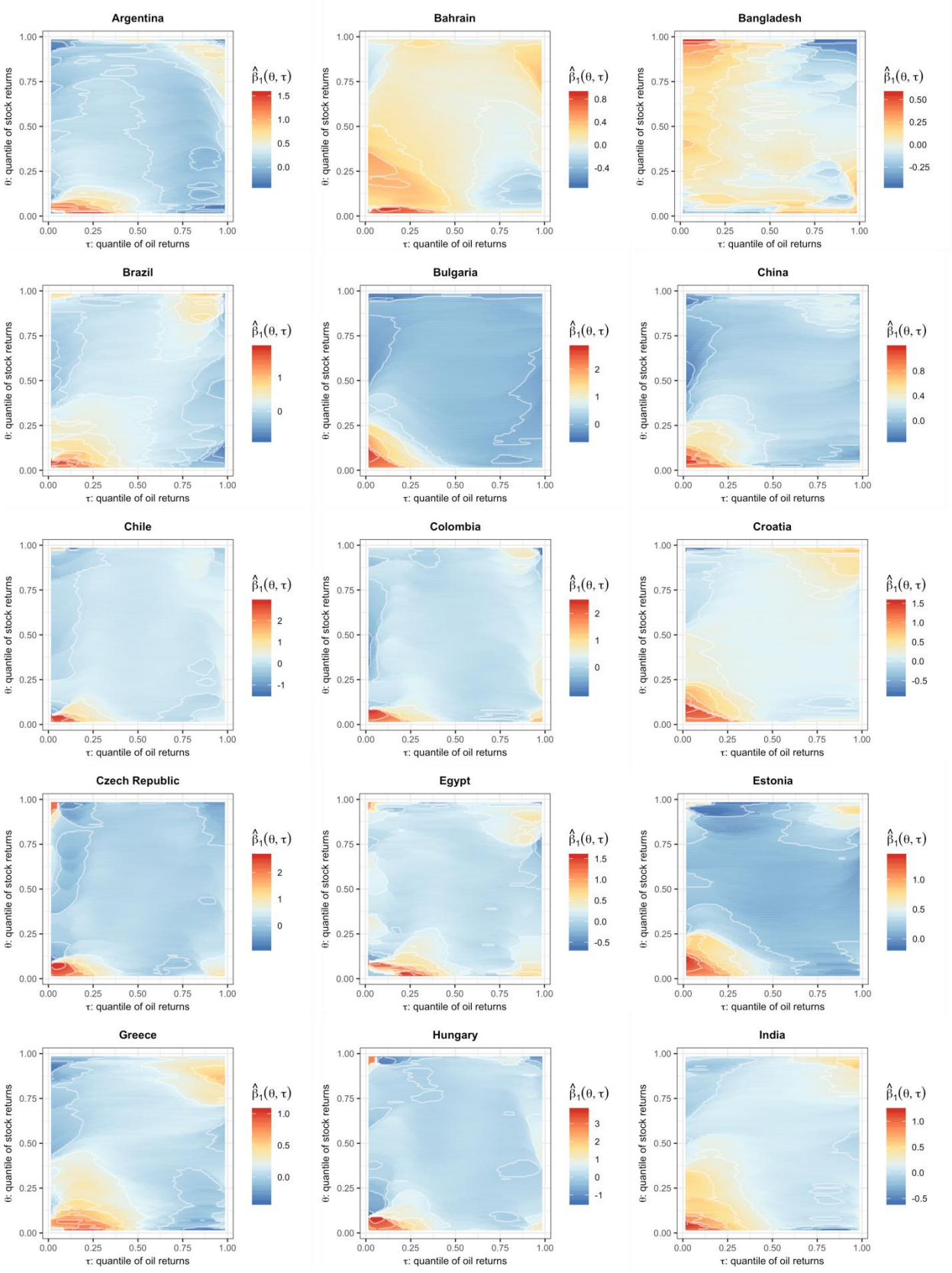


Figure 2. (continued)

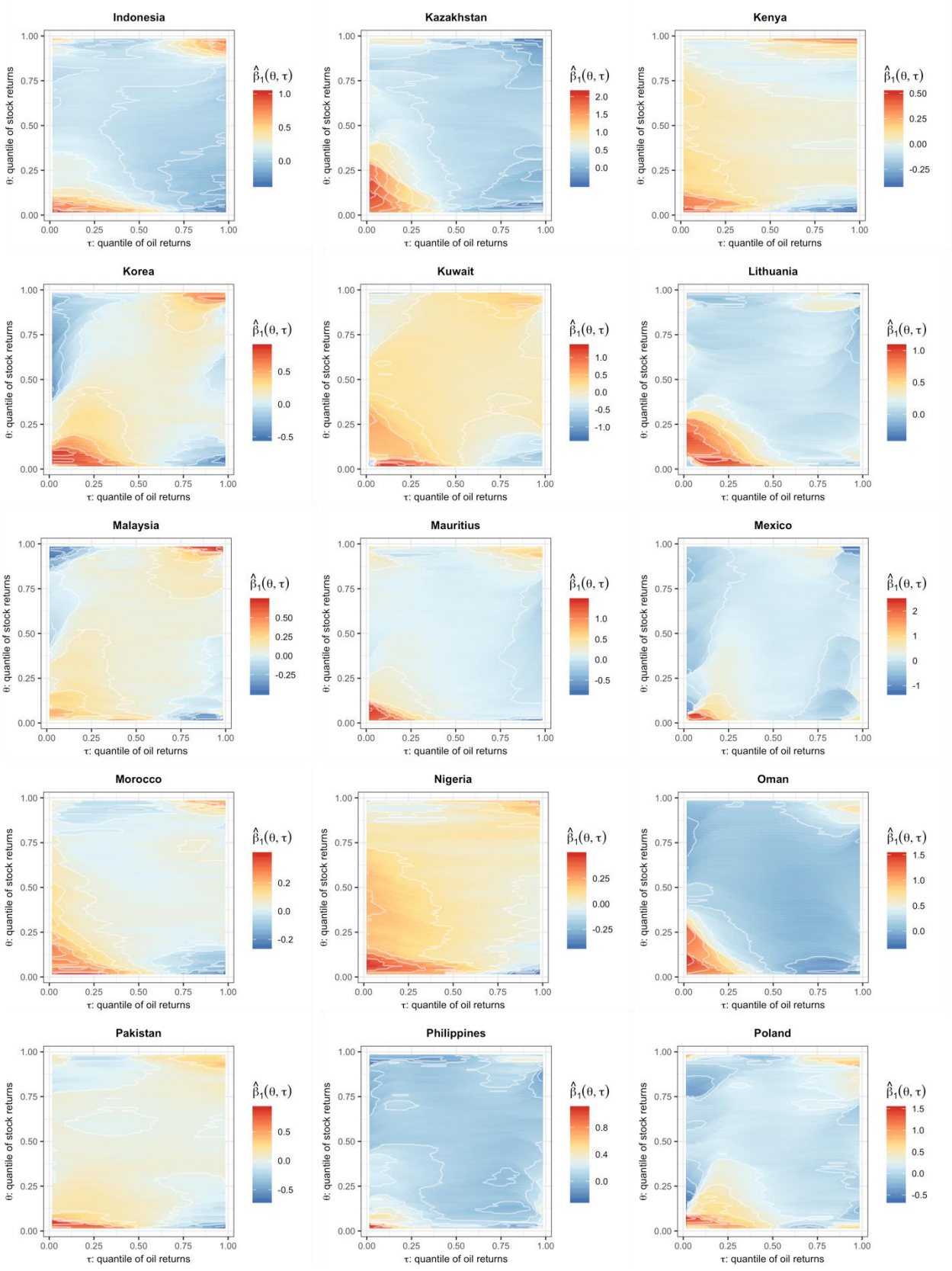


Figure 2. (continued)