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Geopolitical Risk Versus Supply- and Demand-Induced Oil Shocks

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Amid ongoing geopolitical events and their associated impact on energy markets, this study probes into the predictive capability of geopolitical risk (GPR) for various components of oil shocks. It also evaluates whether incorporating GPR in oil shock-model improves the forecast accuracy of global oil shocks, focusing exclusively on out-of-sample analysis. The findings indicate that (i) GPR induces a negative shock to oil supply, (ii) GPR generates a positive shock to oil consumption demand, and (iii) GPR causes a negative shock to oil inventory demand. These predictive effects are consistent across different oil shock dynamics and at different forecasting horizons, underscoring the significance of integrating GPR into oil shock models to enhance their accuracy and reliability.

I. Introduction

The genesis of global production and oil market linkages could be traced to the industrial revolution of the 19th century, when the iron and steel sector produced new building materials, railroads connected nations, and the discovery of oil produced a new fuel source. Following the discovery of the Spindletop geyser, the oil industry saw exponential growth, leading to the chartering of over 1,500 oil-related businesses and the emergence of oil as the primary fuel and production input of the 20th century¹. More importantly, the global importance attached to oil has equally underscored its role in global politics as a critical focus for war and conflict (see Tklare, 2014; Yergin, 2011). Consequently, the desire to control valuable oil and gas assets has been a major source of long-standing historical tensions around the world, ranging from the East and South China Seas to Nigeria, South Sudan, Crimea/Ukraine, and Iraq, among others, and has catapulted to various wars including the Gulf War, Middle East Wars and Russia-Ukraine War, among others. On the flip side, as demonstrated by various superpowers against Russia in her ongoing war with Ukraine, oil has been a component of significant sanctions imposed on some erring countries. The outcomes of these conflicts typically lead to a decrease in global oil supply or demand, which affects the stability of oil prices and overall prices of goods and services.

Exploring different economic/market conditions, a number of studies have examined the predictability of geopoliti-

cal risk for oil price volatility. In general, it is suggested that geopolitical risk is helpful in forecasting oil price volatility and its associated tail risks (Liu et al., 2019; Qian et al., 2022; Salisu et al., 2021; Wu et al., 2023). As noted by Montgomery (2022), oil price shocks are usually exacerbated by a variety of circumstances including war and revolution, periods of rapid economic expansion in key importing countries, and issues peculiar to exporting countries, such as political unrest or a dearth of investment in the oil sector. These 'narrow' causes are essentially related to large shifts in either supply or demand. Accordingly, this current study differs from Qian et al. (2022) who investigate the relationship between geopolitical risk and oil price volatility during expansion and recession periods, as well as Wu et al. (2023) who study the impact of geopolitical risk on oil price fluctuation along the oil-exporting and oil-importing dichotomy, by examining the intensity of geopolitical risk on supply- and demand-induced oil price shocks. The contention is that shocks associated with oil fundamentals do not always heightened in response to geopolitical events. They occasionally even vary in the opposite direction, and this occurrence can be explained by demand and supply transmission mechanisms. This assertion is further supported by the different reactions of oil fundamentals to geopolitical tensions, as illustrated by the graphs in the appendix. Essentially, oil shocks are categorized into demand and supply shocks, with demand shocks further partitioned into oil

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1 <https://www.history.com/topics/industrial-revolution/oil-industry>

consumption demand and oil inventory demand shocks (see Baumeister & Hamilton, 2019).

The study's analysis leads to two key conclusions. First, geopolitical risks propagate a negative shock on oil supply. Second, their effect on demand is more complex, as geopolitical risks stimulate a positive shock to oil consumption demand but a negative shock to oil inventory demand during the examined period.

Following this introduction, the rest of the paper is structured as follows: Section II documents the preliminary analyses and the adopted methodology; Section III reports and discusses the results; and Section IV concludes.

II. Preliminary Analyses and Methodology

The datasets which comprise of weekly data (January 1885 to May 2023) on three disaggregated oil shocks series including oil-specific consumption demand shock, oil inventory demand shock, as well as oil supply shock (see Baumeister & Hamilton, 2019)², and a measure of global geopolitical risk (Caldara & Iacoviello, 2022)³ are subjected to some preliminary analyses (see Table 1) such as the persistence test, heteroskedasticity and serial correlation biases, to ascertain our choice of technique. The persistence test provides evidence of high degree of persistence in the predictor series following its significance value at 1 percent level. Moreover, the presence of some other biases such as serial correlation and heteroskedasticity is examined as their presence may further affect the forecast results if not circumvented. Hence, these statistical features are tested with the ARCH, and Q-statistic & Q²-statistic tests, respectively. The null hypothesis for the autocorrelation is there is no serial dependence, while for heteroscedasticity is that there is no conditional heteroscedasticity. Evidence of serial correlation bias is observed at first and second order of the Q-statistic for both the oil shock series and the GPR. Similarly, the heteroscedasticity bias is also prominent for all the series hence, the choice of the technique (the Feasible Quasi Generalised Least Squares – FQGLS) which has been considered adequate to solve these biases (see Westerlund & Narayan, 2015, 2012).

A priori, the nexus between geopolitical risk (GPR) and oil shocks operates through both demand and supply channels. Heightened geopolitical tension in oil-producing regions, for example, limits the supply, thereby causing demand to exceed supply. This has far-reaching implications for various global economic fundamentals, including inflation, output, and other indicators. Consequent upon the foregoing, a bivariate model resting on the FQGLS technique of Westerlund and Narayan (2015, 2012) is formulated to examine the linkage between oil shocks and geopolitical tension. The estimation model follows:

$$Os_t = \alpha + \gamma gpr_{t-1} + \pi(gpr_t - \rho_0 gpr_{t-1}) + \mu_t \quad (1)$$

such that Os_t is the concerned oil shock, α is the constant intercept, gpr denotes geopolitical risk index and μ_t is the zero-mean idiosyncratic error term. The slope coefficient γ connotes the response of oil market to geopolitical crises, thus we focus on the signs and statistical significance of the gamma-adjusted coefficients of the model.

Furthermore, the approach of Lewellen (2004) and Westerlund and Narayan (2015) is adopted to address issues relating to the endogeneity bias resulting from the correlation between the predictor series and the error term as well as any potential persistence effect, as modeled in equation (1). In addition, to resolve the issue of conditional heteroscedasticity effect in the error term, Westerlund and Narayan (2015) suggest pre-weighting all the data with the inverse of the standard deviation obtained from a typical GARCH-type model (i.e. $\frac{1}{\hat{\sigma}_t}$) and estimating the resulting equation with the OLS.

Finally, the forecast accuracy of the predictive model using both the relative mean square error (RMSE) and the Clark & West (2007) test, is assessed. The evaluation covers both in-sample and out-of-sample forecasts, based on a 90:10 data split. This approach allows for comparing the performance of the GPR-based model for oil shocks against the benchmark historical average model, which does not account for these dynamics.

III. Results and Discussions

The findings are offered for both predictability of geopolitical risk (GPR) for oil shocks as well as examining whether including GPR variable(s) in a typical oil shock model improves the forecast accuracy of oil shock compared to the benchmark model that excludes same. It is found that geopolitical risk effectively predicts both oil demand and oil supply shocks given the statistical significance of the GPR coefficients. Nonetheless, the effects are mixed across these shocks. While increased geopolitical tendency triggers a negative shock for oil supply, it propagates a positive shock for oil consumption demand. On the contrary, the effect is negative for oil inventory. These findings conform to *a priori*, considering that GPR tends to disrupt oil production and supply. Additionally, oil supply has historically been employed as a sanctioning tool against major oil-producing countries such as Russia, involving in some actions that are capable of causing geopolitical tensions. In such cases, demand is likely to surpass supply, creating a positive relationship between oil demand and geopolitical dynamics. Moreover, increased demand relative to supply triggers inventory depletion, explaining the observed negative impact of GPR on oil inventory demand shocks.

Moreover, the analysis tests whether incorporating GPR into the oil shock model significantly enhances its forecast

² <https://sites.google.com/site/cjsbaumeister/datasets?authuser=0>

³ <https://www.matteoiacoviello.com/gpr.htm>

Table 1. Persistence, Conditional Heteroscedasticity & Autocorrelation Tests

Persistence		ARCH			Q-Statistic			Q ² -Statistic		
		K=2	K=4	K=6	K=2	K=4	K=6	K=2	K=4	K=6
OCDS	-	3.30**	46.37***	35.87***	28.02***	140.52***	186.44***	6.33**	175.23***	196.43***
OIDS	-	2.07	35.23***	33.15***	32.96***	209.65***	267.71***	4.02	135.06***	180.28***
OSS	-	0.81	26.90***	18.39***	25.81***	146.27***	181.39***	1.67	103.89***	106.03***
GPR	0.87***	77.43***	38.77***	25.80***	1.32	7.35	13.32***	139.58***	139.89***	140.00***

Note: OCDS and OIDS – oil consumption demand shock and oil inventory demand shock – denote oil demand shocks. OSS is oil supply shock. GPR denotes geopolitical risk. The reported figures are F-statistics for the ARCH test and Ljung–Box Q-statistics for the autocorrelation test, considered at three different lag lengths (k = 2, 4, and 6). Statistical significance of tests at 1%, 5%, and 10% levels, denoted by ***, **, and *, respectively, indicates the rejection of the null hypotheses.

Table 2. Predictability of GPR for Oil Shocks

Predictability Results						
	OCDS		OSS		OIDS	
	0.0051***		-0.0047***		-0.0019***	
	(0.0006)		(0.0001)		(0.0001)	
	[8.1620]		[-53.8183]		[-28.1976]	
Out-of-Sample Forecast Analysis						
	C-W	RMSE	C-W	RMSE	C-W	RMSE
h= 4-week	0.0408	1.0002	0.0078**	0.9985	0.0052**	0.9996
	[1.2747]		[1.8292]		[1.7320]	
h=8-week	0.0422*	1.0001	0.0077**	0.9986	0.0031	1.0005
	[1.3163]		[1.8512]		[1.0198]	
h=16-week	0.0488*	0.9999	0.0073**	0.9986	0.0007	1.0016
	[1.5570]		[1.8145]		[0.2258]	

Note: Here, ***, **, and * imply statistical significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses denote standard errors while those reported in square brackets are *t*-statistics.

accuracy compared to the benchmark model, which excludes GPR, using both RMSE and the Clark & West (2007) test. The augmented model with GPR is deemed superior if the RMSE ratio (calculated as the RMSE of the augmented model divided by that of the benchmark) is below one, and the C-W test produces a positive and statistically significant result. Since statistical significance cannot be inferred from the RMSE, the C-W test requires rejecting the null hypothesis of a zero coefficient, which occurs if the *t*-statistic exceeds +1.282 at the 10% significance level, +1.645 at the 5% level, or +2.00 at the 1% level. A rejection of the null, coupled with an RMSE ratio below one, indicates that the augmented model provides more accurate forecasts of global oil shocks than the historical benchmark. This analysis focuses exclusively on out-of-sample forecasts across three horizons: 4, 8, and 16 weeks.

Based on the RMSE results and the statistical significance of the corresponding Clark & West (2007) test presented in Table 2, it is demonstrated that incorporating the GPR enhances the forecast accuracy for both oil supply shocks and demand shocks. While the improvement is consistent for oil supply shocks across multiple forecast horizons, it is specific to longer (8- and 16-week) and shorter (4-week) horizons for oil consumption demand and oil inventory demand, respectively. These findings align with previous studies on GPR and oil market fundamentals (e.g., Liu et al., 2019; Qian et al., 2022; Salisu et al., 2021), although none have focused explicitly on distinct oil shocks as this study does.

IV. Conclusion

This study examines the predictability of geopolitical risk (GPR) for oil market shocks following the classification of Baumeister & Hamilton (2019). The various analyses

show that GPR significantly predicts both oil supply and oil consumption (including oil inventory) demand shocks. While it propagates a negative shock to oil supply, the influence is mixed for oil consumption demand and oil inventory demand shocks. It is further shown that inclusion of GPR in a typical oil shock model improves the latter's forecast accuracy, as evidenced by the lower mean square error of the GPR-based model compared to that of the benchmark model. Thus, the findings stress the significance of integrating GPR in forecasting global oil shocks. Given the differing results for oil supply and demand shocks, this study underscores the importance of employing distinct intervention strategies to address the impact of GPR on oil shocks effectively. Similarly, the superpowers and their allies should explore alternative methods for sanctioning major oil producers during geopolitical crises, as the resulting negative consequences such as global inflation due to limited supply often impact the entire global economy, including those not directly involved in the aggression.

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Appendix

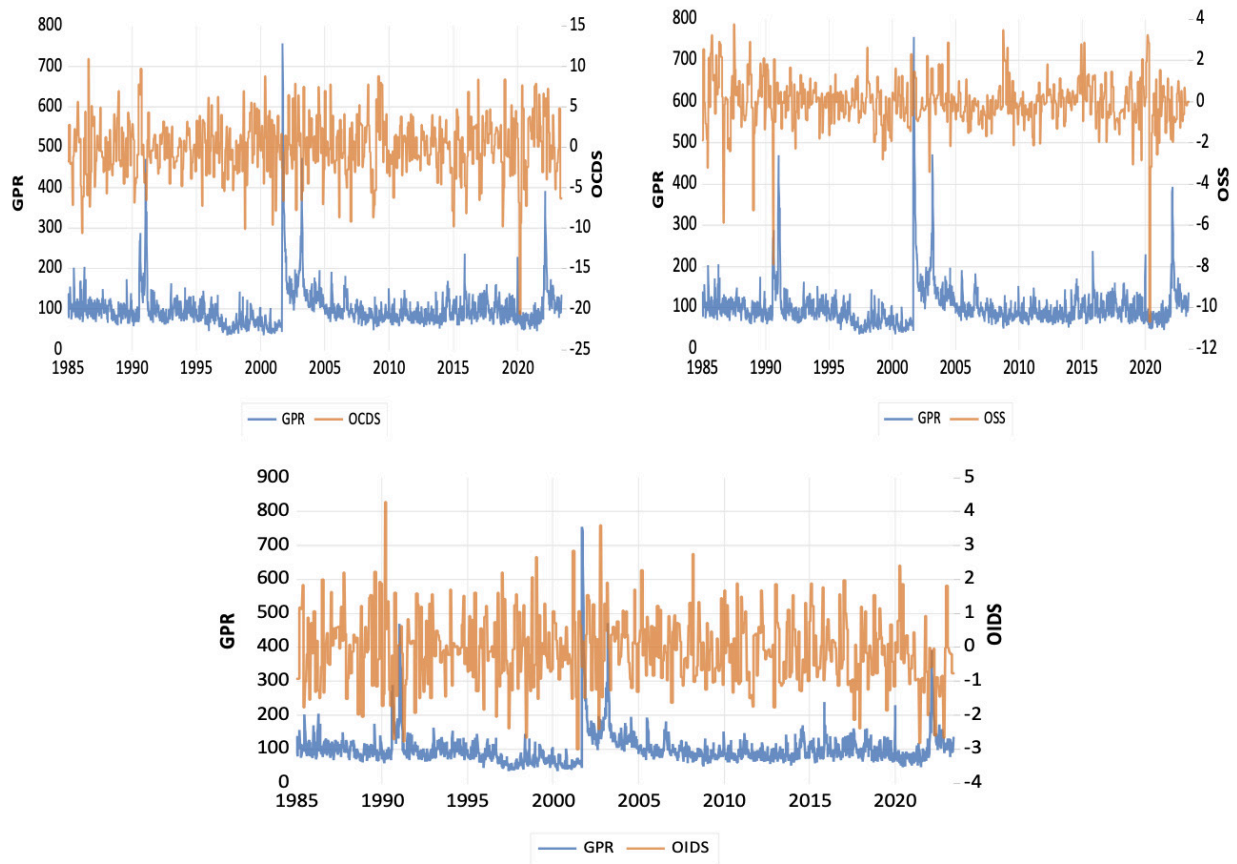


Figure 1. Graphical illustrations of reactions of oil market to plethora of geopolitical events

Note: [Table 1](#) offers the definitions of GPR, OCDS, OSS and OIDS.