Examining the Explanatory Power of Political Risk on Oil Equity Returns

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1 Abstract

This study investigates the impact that political risk in the main country of operation has on oil equities. Following Fama and French's methodology when possible, we construct a factor to measure political risk, using returns from the 68 largest global oil producers and political risk classification based on global political stability indices. We then compare the performance of a 3-factor model to a 4-factor model which uses our factor as well as the 3 standard Fama-French factors, and analyzing the individual explanatory power of the added factor. Results showed that the political risk factor provided uncorrelated returns with significant explanatory power at the $\alpha = 0.05$ level, provided an improvement in the variance in returns explained by the model by over 10% when compared to the original 3-factor model, which we consider significant, and made these improvements without overfitting. In the long term, the total risk premium of the political risk factor turned out to be positive when the model was back-tested over the last 10 years, demonstrating that through multiple market cycles, companies in politically risky operating jurisdictions provided higher returns. Finally, we examined the predictive power of our model, finding it had no significant predictive capability, with the political risk factor providing no significant predictive improvement.

2 Introduction

Factor models have remained a consistent risk management tool for quantitative hedge funds, but they remain very generalized, as they are all geared for the management of large, broad market focused portfolios. As an example, the Fama-French three factor model, an improvement of the 1-factor CAPM, still uses very generalized factors based on company size and book value. For funds with less capital, who may want to narrow their scope to capture alpha within a specific sector, we believe that the standard 3-factor model leaves much to be desired. While this factor model is functional when applied to specific sectors, many sectors carry unique risks, that if measured, could lead to significant improvements in performance when using a factor model in this scope. As a smaller fund ourselves, this research is relevant to AlgoGators' risk management strategy, as the application of sector specific factors when examining our risk exposure could yield valuable insights.

As there is limited literature on systematically incorporating political risk as a quantifiable factor within sector-focused models, we want to investigate a sector that is clearly impacted by the factor we will investigate. Around 74.1% of the world's proven oil reserves are in historically politically unstable areas (the Middle East, Africa, and parts of South America), which grows to around 80% when Russia, which is currently incredibly politically risky for western investors, is considered (BP, 2021). This concentration of resources in unstable jurisdictions forces large oil producers (and younger companies) to expose themselves to an elevated amount of political risk as they replace depleted assets, which itself has an outsized impact on the oil industry due to the high cost of land and drilling/refinery equipment placed at risk. This risk has had a proven impact on investor psychology, as Bøe et al. found that "The protection of property rights and the political stability in a host country increase the probability of investment" (2018). Since the probability of investment conversely lowers as political stability decreases, it would follow that investing in more politically risky jurisdictions would come with a positive risk premium, which we hypothesize. We also hypothesize that factoring for political risk will provide sufficient additional explanatory capability on returns within the oil and gas sector.

3 Methodology

The purpose of this research is to determine the statistical significance and impact of the creation of a political risk factor on a sector-specific factor model within the oil and gas sector.

3.1 Data Collection

We collected monthly price and balance sheet data (market cap, book value) for a list of the 68 largest global oil producing companies over the last 10 years, effectively representing the majority of the world's exchange tradeable oil production. The data was collected through the Yahoo Finance API. We also collected the risk free rate to be used in construction of the market risk factor, which was collected via FRED's API package.

3.2 Factor Construction

We created the base factor model in accordance with some of Fama and French's conventions, but were limited in our level of adherence due to the significantly smaller data pool from only focusing on one sector. Fama-French factors are constructed using the 6 value-weight portfolios formed on size and book-to-market (Fama and French, 1993). However, these portfolios use thousands of stocks, and with only 68 stocks without uniform size distribution, it would be impossible to construct the required portfolios. The factors are constructed as follows, using four portfolios consisting of stocks in the top and bottom thirds of size and book-to-market (2 portfolios per factor):

- Market Factor (MKT): Calculated the same as Fama-French, through measuring the difference between excess value-weighted return from every stock measured and the one-month Treasury bill rate.
- Small Minus Big (SMB): Calculated by taking the difference between the return of the large portfolio and small portfolio.
- High Minus Low (HML): Calculated by taking the difference between the return of the high book-to-market portfolio and low book-to-market portfolio.

To calculate the Political Risk factor (POL), we organized every stock in our universe based on the WGI's Political Stability and Absence of Violence/Terrorism ranking of their main country of operation, which we determined as the country with the given company's largest asset base. Following our methodology for the other factors, two portfolios were then constructed from stocks in the top and bottom thirds of the ranking, with the difference being taken between the return of the high risk and low risk portfolio.

While Fama and French calculate factors and rebalance their portfolios yearly, we will rebalance and recalculate monthly to have enough cross sections for significance within cross-sectional analysis. Additionally, in accordance with how Fama and French handle delisting, we included the (currently frozen) Russian oil producers within our models and stopped including them on the date they were frozen.

3.3 Model Testing

Using these factors, we take time series regressions across the portfolio to get β for each factor, with which we construct the general equation for the 3-factor model of a portfolio/asset at time *t,* where the excess return of each portfolio i is the dependent variable and the calculated factor returns are independent variables (Note: R_f is the risk free rate):

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,mkt}(MKT) + \beta_{i,smb}(SMB) + \beta_{i,hml}(HML) + \varepsilon_i$$

and a similar equation with our political risk factor included:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,mkt}(MKT) + \beta_{i,smb}(SMB) + \beta_{i,hml}(HML) + \beta_{i,pol}(POL) + \varepsilon_i$$

Using these equations, we performed time-series regressions with both models on every stock in our universe to determine the average difference in R-squared between these models, which is the main metric used to evaluate the explanatory power of each model. The significance of this test will be determined by the amount of difference in the variance explained, which we place a threshold of 5% or greater change on.

To find the risk premium that political risk brings to our oil equity returns, we calculated cross-sectional regressions to determine the risk premium (λ) for each factor, as outlined by Fama-MacBeth (1973), using this general equation for each cross section:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,mkt}(\lambda_{mkt}) + \beta_{i,smb}(\lambda_{smb}) + \beta_{i,hml}(\lambda_{hml}) + \beta_{i,pol}(\lambda_{pol}) + \varepsilon_i$$

3.4 Factor Testing

We performed hypothesis testing using a two-sided one sample t-test for each regression coefficient within the cross-sectional regression to assess the statistical significance of each, applying the Holm-Bonferroni correction to account for noise. This helped allow us to attribute the differences in R-squared between models to the political risk factor. To further identify if the factor was providing uncorrelated returns, we computed a Pearson correlation matrix between all the factors, measuring the temporal stability of these correlations across the model construction period by examining variance with rolling correlations.

3.5 GRS Testing

To corroborate our analysis of the explanatory capabilities of the two models, we additionally subjected both models to the Gibbons, Ross, and Shanken test (1989, GRS hereafter), which measures the efficiency of expected returns and describes unexplained variability. The GRS test is an F-test for the hypothesis that all the alphas (from our set of time series regressions) are zero, which if rejected is a demonstration that the model correctly prices the underlying assets.

3.6 Fit Testing

In order to test the 4-factor model for parsimony, we calculated the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted R^2 over the same time-series used in the creation of our models. These criteria penalize regression models for added complexity, which allows us to determine if the model is legitimately benefiting from the factor, or if the inevitable changes in explained variance are a result of overfitting.

3.7 Predictive Testing

While this factor model is primarily intended to be used as a risk management device, for exhaustiveness, we tested the extent to which both models could provide predictive power, and if the political risk factor could improve it. To do so, the models were trained on a sample of the first 36 months of data, whereafter they were used with a 36-month rolling window to predict out of sample monthly returns, with monthly rebalancing of the risk premium. We then analyzed the predictive capability of our models through the calculation of hit ratio, Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE).

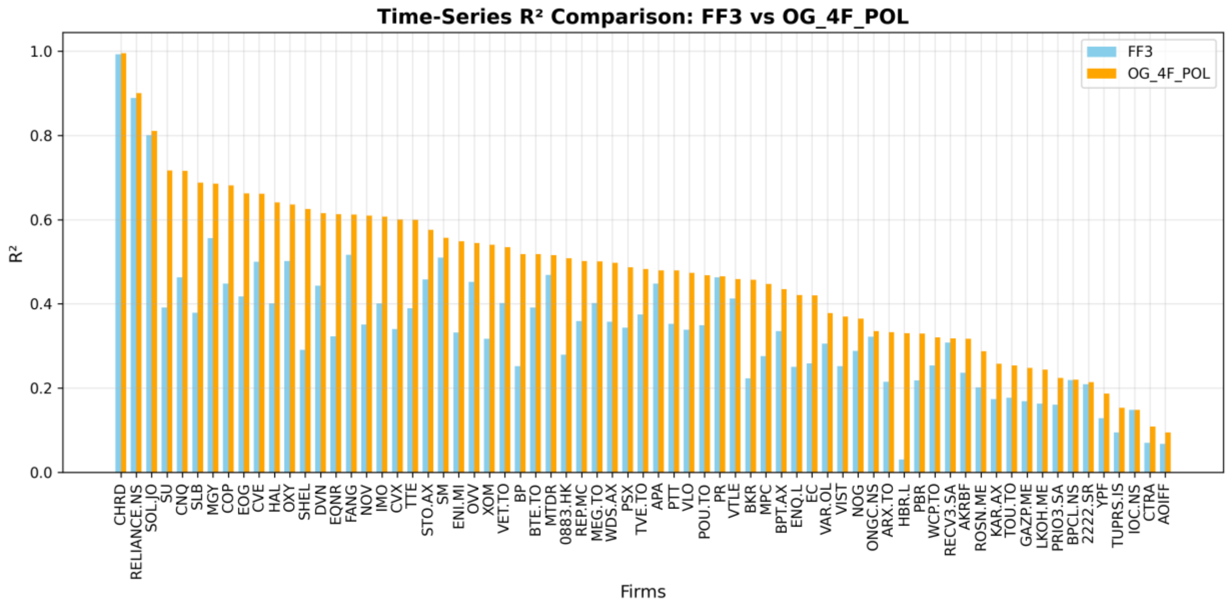
3.8 Dataset Testing

To reinforce the accuracy of our results, we tested our methodology using the Fragile States Index, which is a political stability ranking system like the WGI's indicator, with the key differences being that it uses more criteria and is published by the Fund for Peace rather than the World Bank. As the data it provides is formatted the same as the originally used indicator, we seamlessly reran the entire political risk factor generation and testing process on the new dataset.

4 Results

4.1 R-squared Comparison (Fig. 1)

The average R-squared of the 3-factor model was 0.3421, with the inclusion of the political risk factor bringing the average R^2 up to 0.4718, representing a significant change in variance explained by the model.

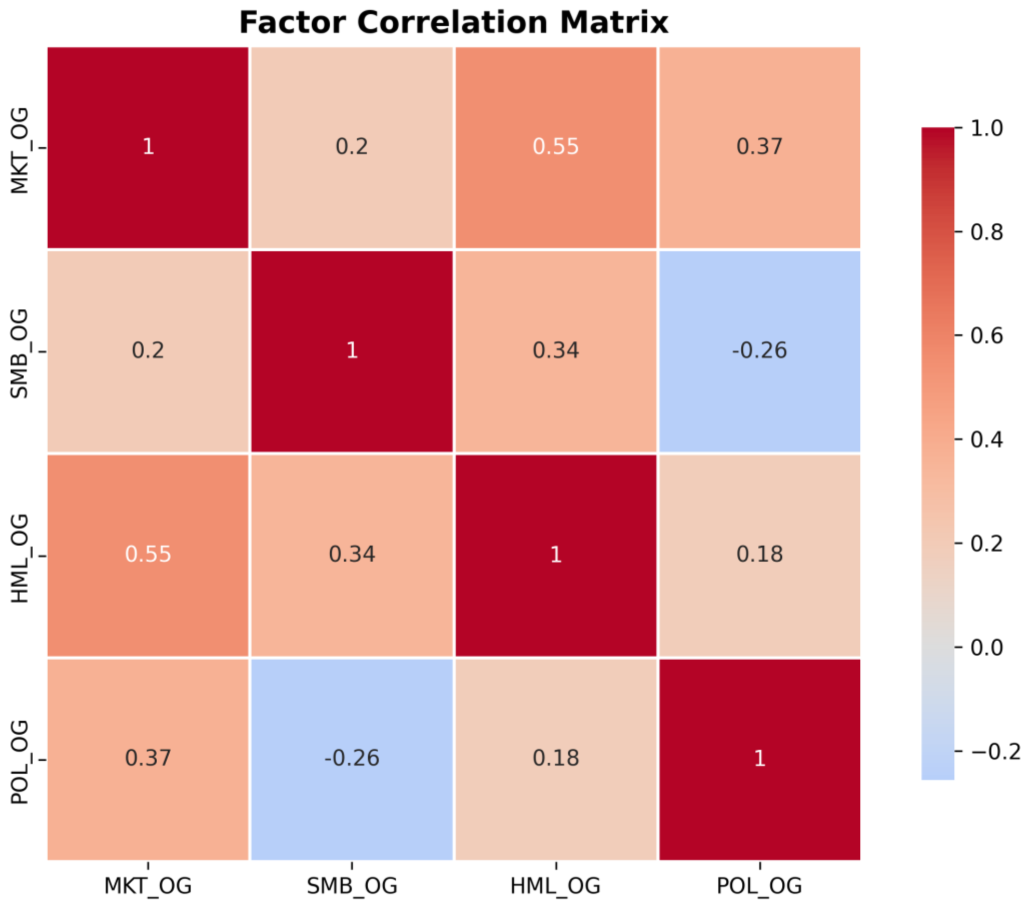


4.2 Factor Correlation Stability & Correlation Matrix (Fig. 2)

The correlation between the political risk factor and the other factors remained stable over the calculation period, only experiencing slight amounts of drift, as suggested by the following coefficients of variation:

- 0.328 when measuring correlation between SMB and POL
- 0.563 when measuring MKT and POL
- 0.681 when measuring HML and POL

The stability in the POL factor's relationships are evident when compared to the relationship between SMB and HML, which had a coefficient of variation of 2.485, or the relationship between SMB and MKT, with a coefficient of variation of 6.058.



4.3 Cross-sectional Regression

The cross-sectional regression returned λ = -0.0525 for the political risk factor. Considering the factor's β is -0.7708, this signifies that an increase in political risk results in an increased expected return within our model. Taking a 95% confidence interval showed that the true λ value is between -0.0953 and -0.0111, confirming the significance of the risk premium.

4.4 GRS Testing

- Both models failed to reject the null hypothesis of the GRS test, demonstrating that both the regular 3-factor model and the model with the addition of the political risk factor can be considered a good fit for oil & gas stock returns.
- The GRS statistic for the 3-factor model was 0.8711, with a p-value of 0.5964 which slightly improved when the political risk factor was added, dropping to a test statistic of 0.8492 with a p-value of 0.6207.

4.5 Factor Significance

- The one-sample t-test results showed that the political risk factor had a statistically significant impact on returns at the α = 0.05 level, with a t-value of -2.51.

- The t-tests also show that the rest of the factors in the model still provide statistically significant returns, as the t-values for the MKT, SMB, and HML factors were 2.60, 5.81, and -20.66 respectively.
- Applying the Holm-Bonferroni correction, all factors maintained statistical significance at the α = 0.05 threshold.

4.6 Fit Testing

- The factor model with the political risk factor included scored significantly better than the 3-factor model in all measures of parsimony, justifying the inclusion of the factor.
- The 3-factor model scored an AIC of -264.0479 and a BIC of -251.8758. Conversely, the 4-factor model had an AIC of -303.5952 and a BIC of -288.3800. These lower scores show the clear preference of the 4-factor model, as the difference in AIC/BIC scores are both significantly higher than the benchmark (ΔAIC > 10) for significance set by Burnham & Anderson (2002).
- The 3-factor model was similarly outperformed in adjusted R^2, with an average adjusted R^2 of 0.3272, which increased to 0.4553 when the political risk factor was considered.

4.7 Predictive Testing

- Over the out-of-sample testing period of 2013-2025, the 3-factor model had a hit ratio of 0.52384, which increased to 0.52507 when the political risk factor was added, which is an incredibly insignificant change.
- Both models had extremely similar RMSE and MAE statistics, with the 3-factor model having an RMSE of 0.2451, which increased to 0.2452 when the political factor was considered. Similarly, it had an MAE of 0.1093, which increased to 0.1098.

4.8 Dataset Analysis

- Due to the similarities between the indicators, combined with the small sample size of our stock universe, there was no significant change that came from using the Free States Index over the Absence of Violence/Terrorism ranking.

5 Discussion

5.1 Key Findings

1. **Explained Variance & Factor Significance**
    - The variance on oil company returns explained by the factor model when political risk was included increased by 13%, which is significantly above our threshold for significance (5% change). This demonstrates that political risk has significant explanatory power when examining stock returns in the oil and gas industry.

- While the improvement in GRS statistics corroborates that the addition of the political risk factor results in the model better explaining the variance of the data, the 4-factor model still allows for a similar amount of unexplained variance to effect returns, although to a lesser degree than the 3-factor model.
- The political risk factor itself had a statistically significant impact on returns when tested against that null hypothesis that it would have no impact.
- The political risk factor was weakly correlated with every other factor in the model, demonstrating that factoring in political risk provides unique returns in the sector.
- The AIC, BIC, and adjusted R^2 significantly favoring the risk-factor included model shows that the factor's impact on improving the explanatory power of the model justifies the complexity it adds and is not a result from overfitting data.

2. **Impact on Returns**
   - The risk premium had a value of -0.0525, demonstrating that as the portfolio's exposure to political risk increases by one unit of β, the expected returns increase by 5.25%. The time-series median β for political risk was -0.7708, meaning that oil and gas stock returns are highly sensitive to political risk, with exposure to this risk resulting in a 4.12% increase in expected annual returns for a company with median exposure to political risk, in comparison to a company with no political risk exposure.
3. **Consistency Across Datasets**
   - Since using both indexes resulted in the same outcomes when sorting stocks, we can eliminate the possibility of dataset bias affecting results.
4. **Predictive Capability**
   - As both models provide a low hit ratio that is marginally (2%) better than random chance, we conclude that they both have extremely low predictive power.
   - As the political risk factor did not yield in a relevant change to the hit ratio, MAE or RMSE, we similarly conclude that it does not provide any extra predictive capability.

5.2 Limitations of Methodology

1. **Sampling & Sample Size**
   - The small sample size of 68 stocks forces us to perform monthly portfolio calculations to be able to run cross-sectional regression analysis, resulting in our factor model not being directly comparable to a true Fama-French factor model.
   - A few large oil & gas companies in more politically risky jurisdictions are privately owned, resulting in a smaller pool of high-risk companies which may skew data slightly

- Stock de-listings limit the accuracy of any factor model through survivorship bias, which is unavoidable, but is mitigated through the volume of stocks analyzed.
- The largest oil producers considered in our model (e.g. ExxonMobil, Shell) have global operations, so while we determined a company's country of operation to be the country where they had the most capital invested, these larger producers expose themselves to political risk that is not measurable with this model.

2. **Scope**
    - This model is quite limited in scope, as it is only applicable to producing companies within the oil and gas industry, as pure development/exploration provide volatile returns that are derived from increasing asset value, which are mostly uncorrelated with general market dynamics, and were thus unfit to be considered within the model.

5.3 Implications for the Fund

While the model covered in this study is not directly applicable to the fund's current operations, we gain several useful insights:

1. **Further Research Potential**
    - Oil & gas is not the only sector that is prone to the effects of political risk, and further research with a wider scope could create a measure of political risk that is directly applicable to the derivatives that the fund trades.
    - While both models provided extremely low predictive capability for price, we suggest future research to examine the impact of political risk factors on the prediction of volatility, as the volatility of an asset is generally associated with its risk.
2. **Portfolio and Risk Management**
    - While our findings suggest that political risk should be a critical consideration within oil sector portfolio management, our model leaves a portion of return variation unexplained. Consequently, we advise portfolio managers implementing this strategy to develop additional factors that would explain systematic risk within the sector not covered by our model.
    - If AlgoGators invests in stocks in the future, the methodology described within this study would be incredibly useful for risk management within specific sectors of a portfolio that experience similar exposure to political risk.
    - Although the Fama-French model our methodology is based on is intended to be used for the stock market, the general model can be adapted for use in the futures market, and the political risk factor could be modified to measure political risk associated with asset classes rather than specific companies.

6 Conclusion

This research project examines the impact that political risk has on the returns of oil producing companies operating in politically risky jurisdictions. Our hypothesis that political risk has explanatory power on oil stock returns was confirmed: when analyzing adjusted R-squared performance and GRS, the model that factored for political risk performed significantly better. Through our analysis of the model's AIC and BIC, we found that the model's improvement was legitimate, and not a result of overfitting. By analyzing correlation, we were able to determine that the political risk factor provides uncorrelated returns that would have been unaccounted for by a standard 3-factor model. Our hypothesis that political risk would come at a positive risk premium was confirmed through cross-sectional analysis, where we found that companies operating with increased sensitivity to political risk through operational jurisdiction provide higher annualized returns, resulting in a positive risk premium. Finally, by testing the capability of our models to predict future returns, we found that both 3-factor and political risk included models had no significant predictive capability, which is not uncommon for factor models.

Overall, these results provide opportunities for optimized portfolio and risk management within the commodities space, as well-known pricing models neglect inclusion of sector-specific factors for factors that are applicable to the broad market, resulting in worse sector-specific performance, which our work attempts to mitigate. Further research can directly apply our methodology to sectors that experience similar tolerance of political risk to create a more comprehensive model that focuses on pricing and trading political risk in a group of sectors. However, for broad applications, the methodology would have to be altered to accommodate different market dynamics.

7 References

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8 Appendices

Variables

R_f – Risk Free Rate
α – Returns unexplained by model
β – Portfolio sensitivity to given factor
λ – Factor risk premium
ε – Error term

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