CAL POLY
Graduate Programs
ORFALEA COLLEGE OF BUSINESS

GSE 580: SEMINAR IN ECONOMICS

PRESENTATION

"The Effect of EU-ETS Carbon-Price Shocks on Green-Energy Equity Performance and Volatility"

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Research Question & Motivation

Motivation:

- Governments increasingly adopt carbon pricing to address climate change.
- Investors increasingly integrate climate policies into asset valuations.
- Crucial to understand how these policy shocks translate into market reactions, particularly for environmentally aligned (green) vs. traditional (brown) investments.

Research Question:

- How do significant carbon pricing events impact returns of green (e.g., ICLN) vs. brown (e.g., XLE) ETFs?

Hypotheses:

- *Null*: Carbon pricing events have no significant impact on ETF returns.
- *Alternative*: Green and brown ETFs respond differently to carbon pricing shocks.

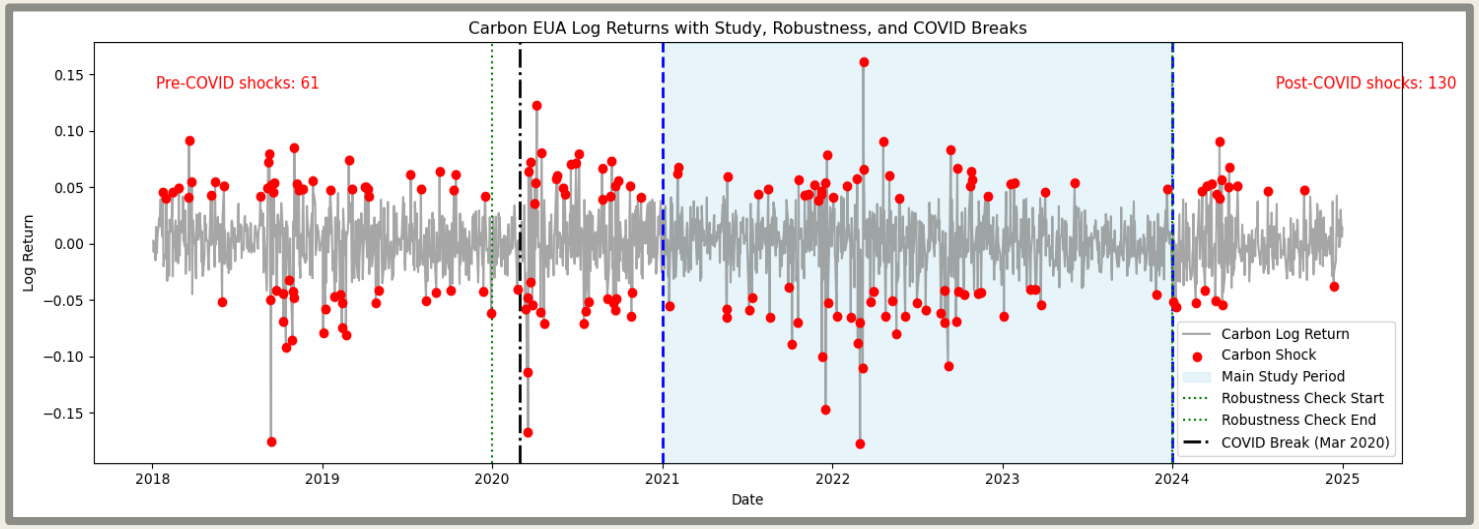
Data Sources & Methodologies

- **Data Sources:**
  - ETF price data (daily): Yahoo Finance (2018–2024)
  - Green ETF: iShares Global Clean Energy ETF (ICLN)
  - Brown ETF: Energy Select Sector SPDR Fund (XLE)
  - Benchmark ETF: SPDR S&P 500 ETF (SPY)
  - Carbon policy events data, curated from official announcements (IMF, EU ETS, World Bank)
- Gathered over 1,700 daily observations per variable, blending carbon prices, ETF returns, and the pulse of global markets (VIX, oil, stocks, T-Bill rates).
- This makes the results fully reproducible and robust to bias.
- **Methodologies:**
  - Event Study: Analyze returns and volatility around carbon shocks.
  - OLS Regression: Measure average impact of carbon shocks controlling for macro factors.
  - Causal Forest Analysis: Estimate heterogeneous (context-dependent) treatment effects.
  - Forecasting: Compare volatility forecasts (LSTM vs. GARCH).

Carbon Shock Identification

- Autoregressive AR(5) model to detect statistically significant carbon price shocks.

$$\mathrm{EUA}_t = \alpha + \sum_{i=1}^{5} \beta_i \mathrm{EUA}_{t-i} + \varepsilon_t, \quad |\varepsilon_t| > 1.5 \times \mathrm{SD}(\varepsilon)$$

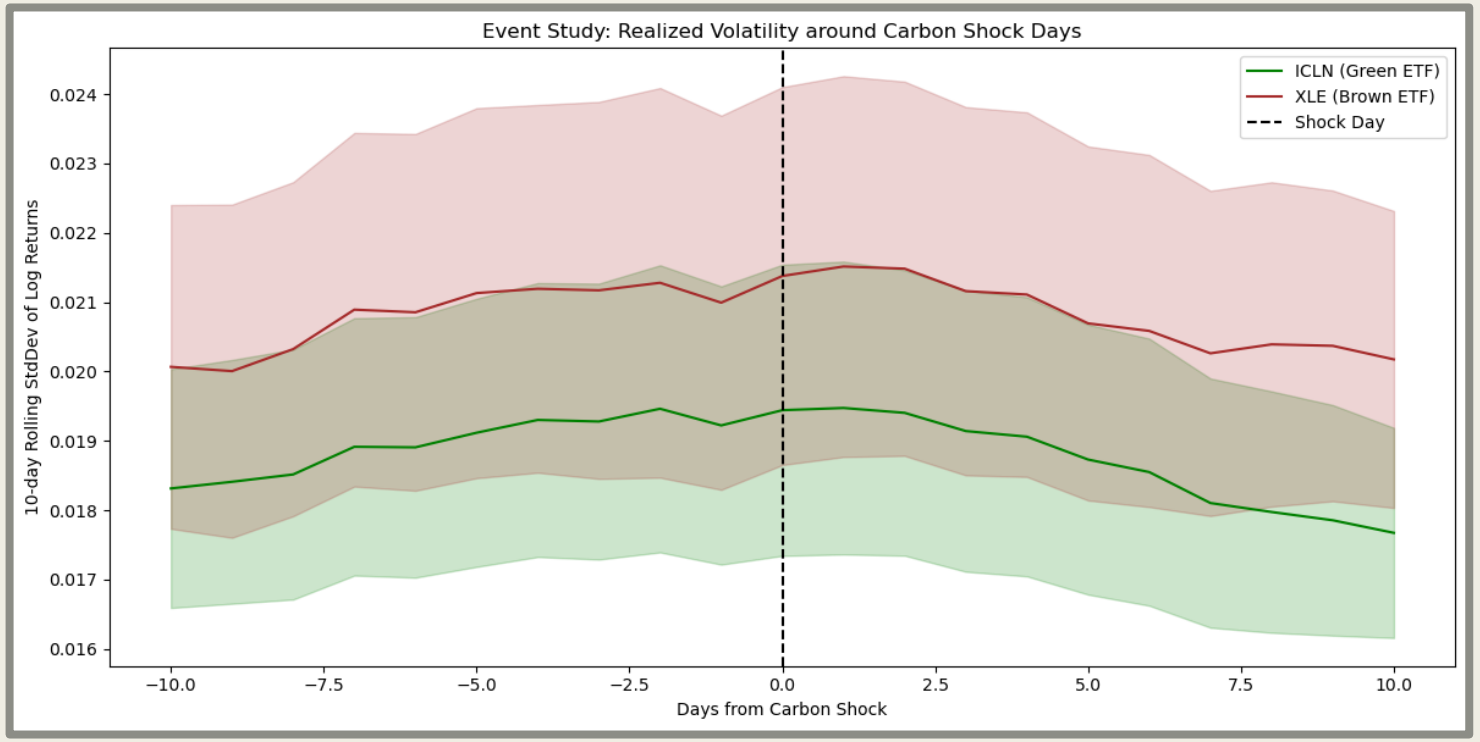


- Once the model estimates daily prices, the residual tells us how "surprising" today's price is.
- We define a "shock day" as any day when the residual (surprise) is larger than 1.5 times the standard deviation of all residuals.
- Shock days represent significant deviations from the typical price behavior.

Volatility Response (Model and Event Based)

- We examined volatility response around carbon shock events.
- Taking the 10-day rolling standard deviation of ETF log returns centered on shock day (t=0).

$$\sigma_\tau = \sqrt{\frac{1}{10} \sum_{k=\tau-9}^{\tau} (r_k - \bar{r}_\tau)^2}$$



- Both ETFs experience volatility spikes post-shock. But XLE (Brown) volatility remains consistent, but ICLN (Green) exhibits clearer post-event response dynamics.

OLS Regression Analysis

- To understand and quantify how much carbon shocks affect ETF returns, after adjusting for broader market conditions, we use OLS lets us isolate and measure this impact.

$$r_{it} = \alpha + \beta_1 \cdot \text{Shock}_t + \beta_2 \cdot \text{VIX}_t + \beta_3 \cdot \text{Brent}_t + \beta_4 \cdot \text{S\&P500}_t + \beta_5 \cdot \text{Rate}_t + \varepsilon_t$$

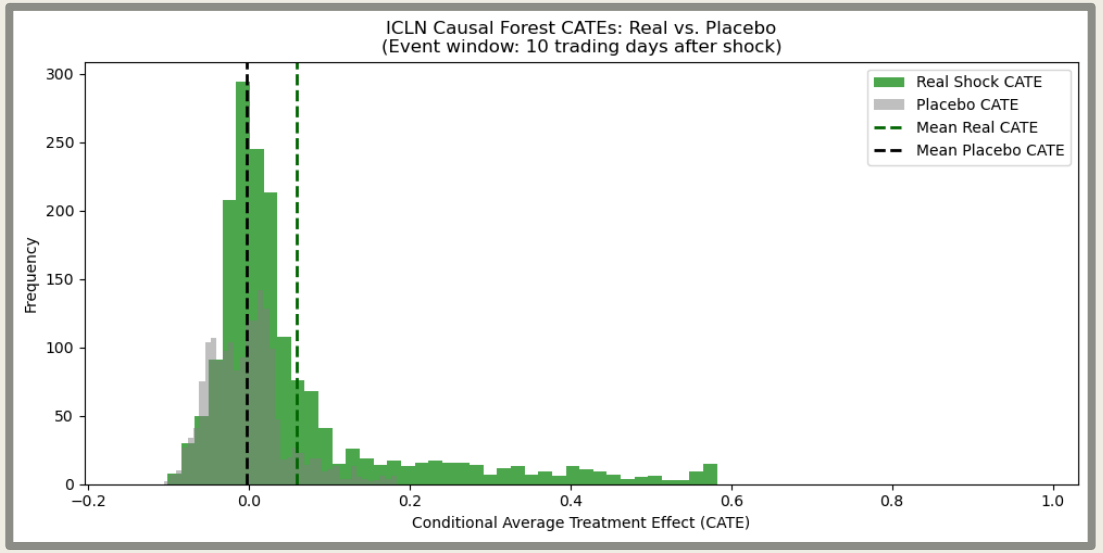
ETF	Coefficient (Carbon Shock)	Statistical Significance	Interpretation
ICLN (Green)	+0.20%	P<0.05	Positive & Statistically Robust
XLE (Brown)	~0.00%	P>0.1	No meaningful impact detected

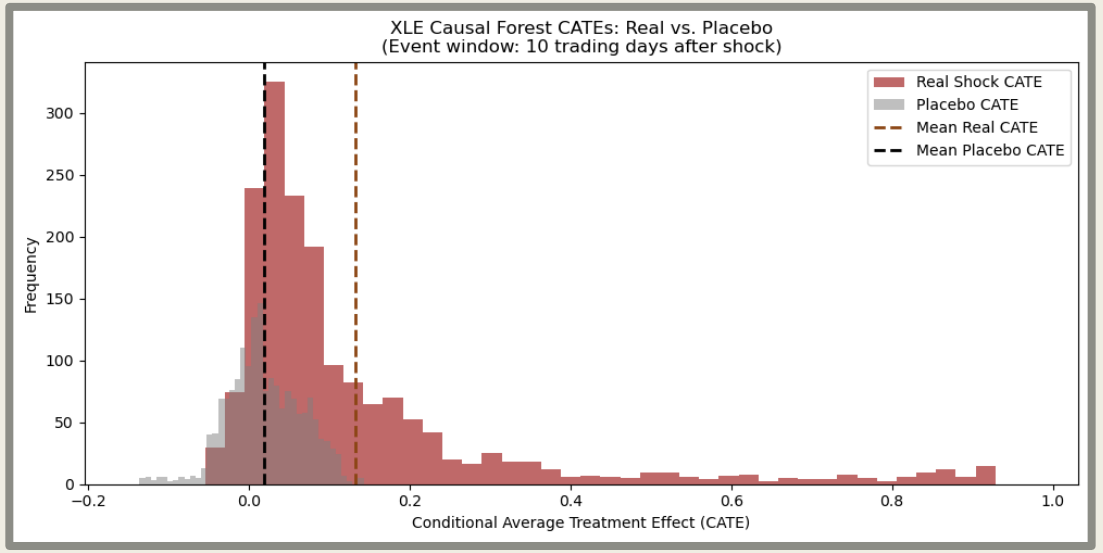
- ICLN (Green ETF): The Coefficient +0.20 means, on average, the returns of the green ETF increase by about 0.20% on days when there is a carbon shock. And the since $p < 0.05$, the effect is statistically significant.
- XLE (Brown ETF): The Coefficient ~0.00, indicates no measurable effect. And since $p > 0.1$, implying the carbon shocks have no reliable impact on brown ETF returns.
- These results clearly indicate that carbon shocks systematically and significantly boost returns for green ETFs, while leaving brown ETFs unaffected.

Robustness & Placebo Testing

- **Robustness Analysis:**
  - Placebo Test - Randomized shocks remove the measured effect entirely—proving causal effect validity.
  - Bootstrap Confidence Interval:
    - ICLN effect robust within 95% confidence intervals.
    - No significant effect for XLE confirmed via bootstrapping.

- Robust causal effect for ICLN; negligible for XLE across all contexts.





Causal Forest – Heterogeneous Treatment Effects

- Traditional methods (like OLS) give us average effects but might miss important differences across different conditions.
- The Causal Forest estimates what's called a Conditional Average Treatment Effect (CATE).

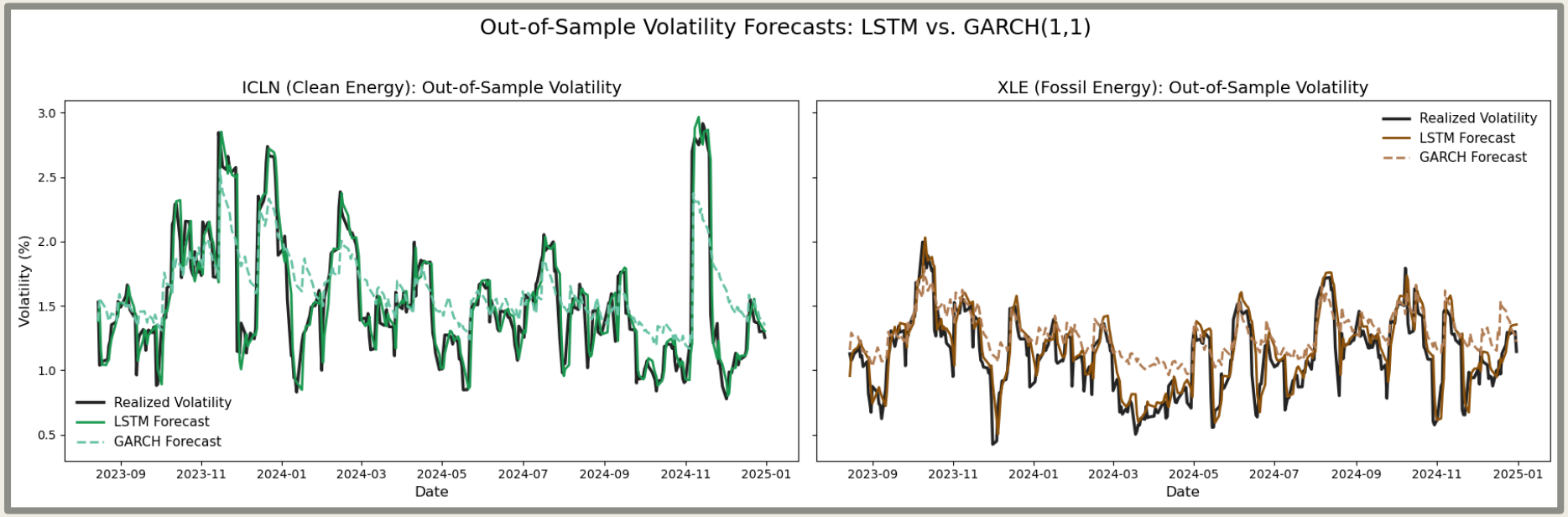
$$\hat{\tau}(X) = \mathbb{E}[Y(1) - Y(0) \mid X]$$

- **ICLN (Green ETF):**
  - Positive effect observed broadly across different market conditions.
  - Effects especially strong in high-volatility periods.
- **XLE (Brown ETF):**
  - No significant effects across any market conditions.
  - Causal Forest confirms no hidden or situational benefits from carbon shocks for brown ETFs.

Volatility Forecasting – LSTM vs. GARCH

- GARCH: A widely-used method to forecast volatility, relying primarily on past price volatility.

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$



- LSTM: A modern neural-network-based model designed to capture complex time dependencies and patterns that traditional methods may miss.
- LSTM forecasts volatility by learning from historical sequences of volatility data, automatically capturing subtle relationships.
- LSTM model improved volatility forecasting accuracy compared to the traditional GARCH model by approximately 13.2% (in RMSE terms) and about 14.0% (in MAE terms).

The Story, Implications, & Recommendations

- **Overall Story:**
  - Investors are sensitive to carbon pricing policy signals and actively reallocate capital accordingly.
  - Positive signals strengthen valuations of climate-aligned assets while raising concerns for traditional fossil-fuel investments.
- **Policy and Market Implications:**
  - Investors: Recognize policy events as critical trading signals for ESG-focused investment strategies.
  - Policymakers: Credible carbon policies have immediate and meaningful effects on capital markets.
  - Asset Managers: Can exploit policy announcement windows for strategic portfolio management.
- **Recommendations:**
  - Investors: Leverage climate policy announcements for tactical ESG portfolio adjustments.
  - Policymakers: Communicate policy intentions clearly and credibly to facilitate efficient market transitions.

Limitations, Next Steps & Conclusions

- **Limitations:**
  - Limited carbon event frequency restricts broader inference.
  - Potential confounding from macroeconomic or unrelated financial events.
  - ETF price movements may partially reflect broader ESG market sentiments not explicitly controlled in analysis.
- **Next Steps:**
  - Expand the dataset with additional historical carbon pricing events.
  - Incorporate macroeconomic controls and perform longer-term market impact analyses.
  - Refine visualizations and comprehensive research.
- **Conclusions:**
  - Financial markets are increasingly integrating climate policy risk into asset prices, suggesting growing climate-policy credibility and investor sophistication.

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THANK YOU!