Predicting Average Electricity Prices from Data Center Investments and the AI Boom in the US

36-671 Time Series Project

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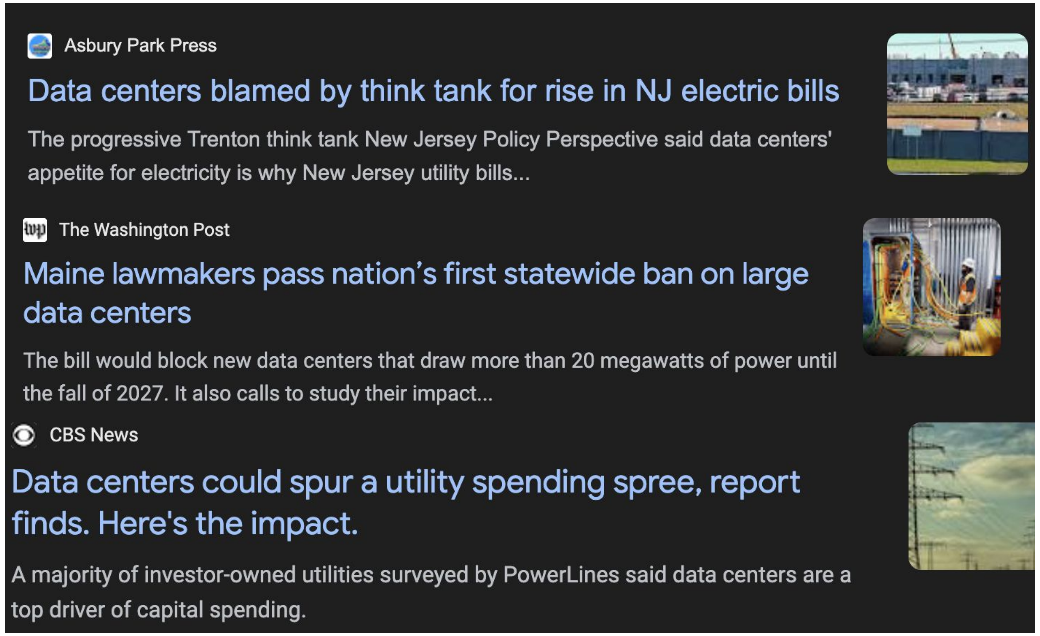
Agenda

1. Background and Motivation
2. Exploratory Data Analysis
3. Analysis and Findings
4. Limitations and Next Steps

Motivation

- Rapid growth of AI led by major tech firms is driving large-scale expansion of data centers
- Data centers are highly electricity-intensive and significantly increasing power demand
- **Key concern:** Rising demand may be putting upward pressure on U.S. electricity prices
- **Impact:** Rising electricity prices affect households, businesses, and economic stability



Research Questions

Hypothesis: Data center growth and AI-related activity influence U.S. electricity prices.

Research Questions:

1. Do investments in data centers and growing public sentiment towards AI predict or relate to electricity prices?
2. What model best predicts electricity prices?

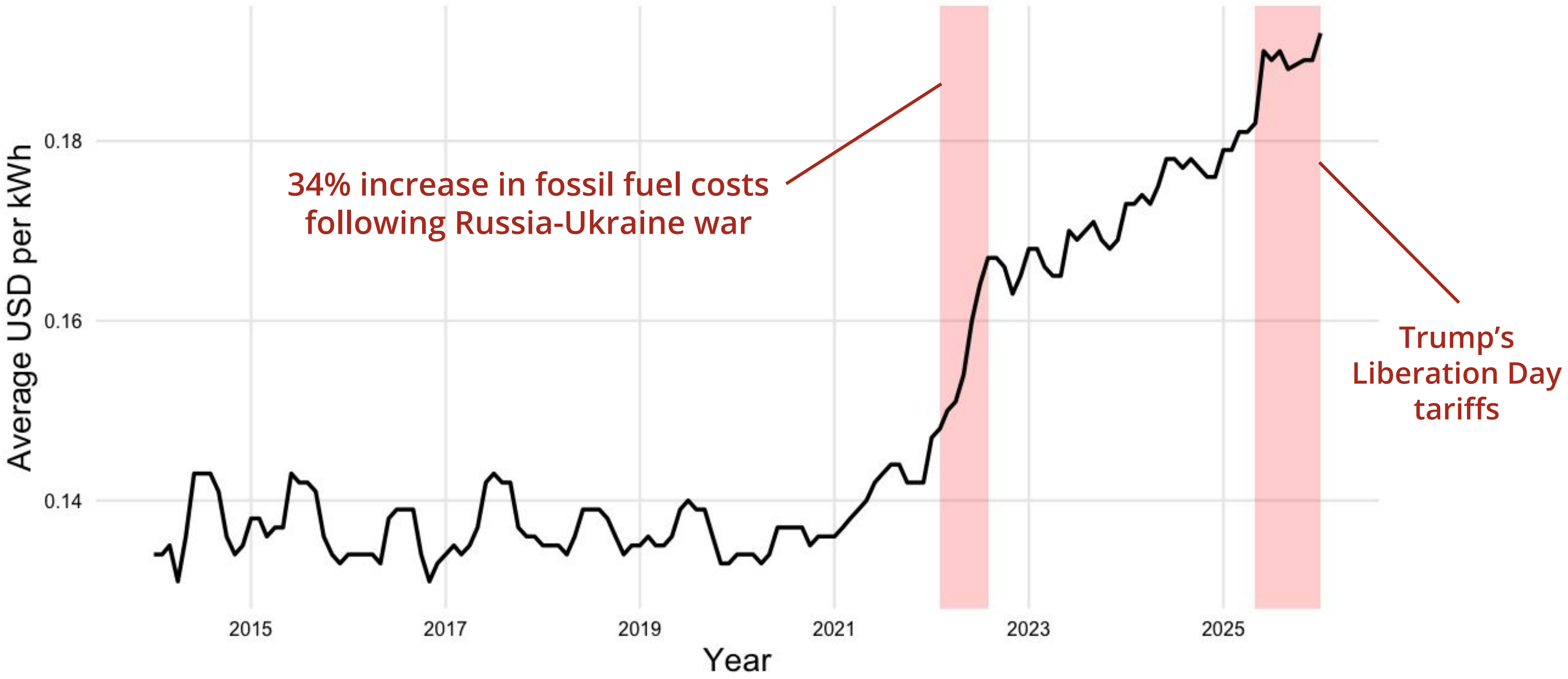
Data Sources

1. **Electricity Prices** (U.S. Bureau of Labor Statistics)
   - Monthly Average Electricity Cost per Kilowatt-Hour in U.S.
   - November 1978 to February 2026
2. **Investments and Data Centers** (U.S. Census Bureau)
   - Seasonally Adjusted Annual Rate (SAAR) of Data center investment in the US
   - January 2014 to January 2026
3. **Google Search Trends for the term "AI"**
   - Monthly interest on "AI" ranked from 0 to 100
   - January 2004 to March 2026

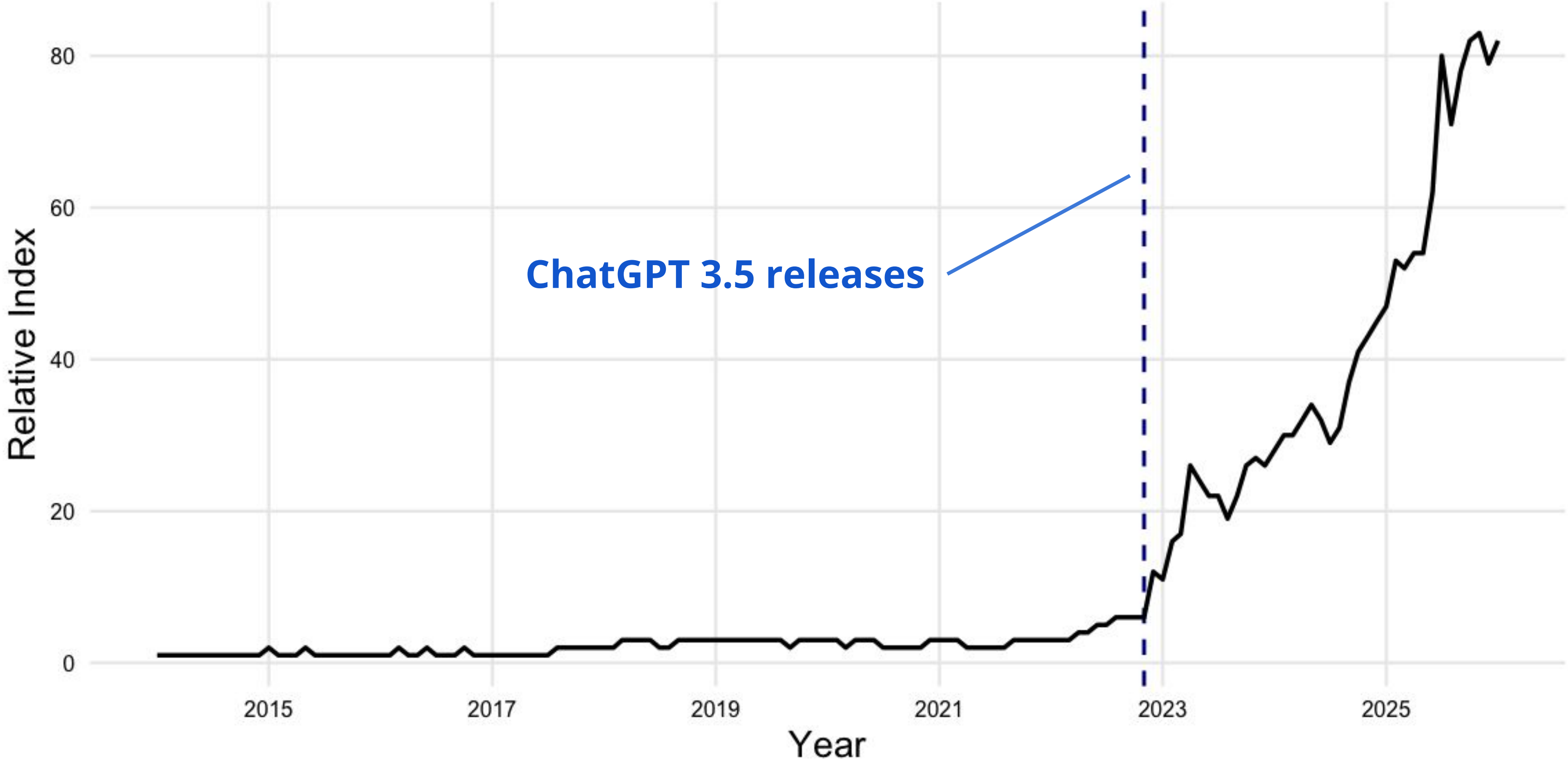
Methodology

1. **Data Preparation**
   - Aligned all series to monthly frequency
   - Restricted the maximal shared time period (2014-2026)
   - Log-transformed to stabilize variance
2. **Exploratory Analysis**
   - Identified trend and seasonality
   - Checked for stationarity with differencing
   - Examined cross-correlations
3. **Model Development**
   - Baseline: SARIMA model (electricity only)
   - Time series regression
     i. Contemporaneous variables
     ii. Lagged variables

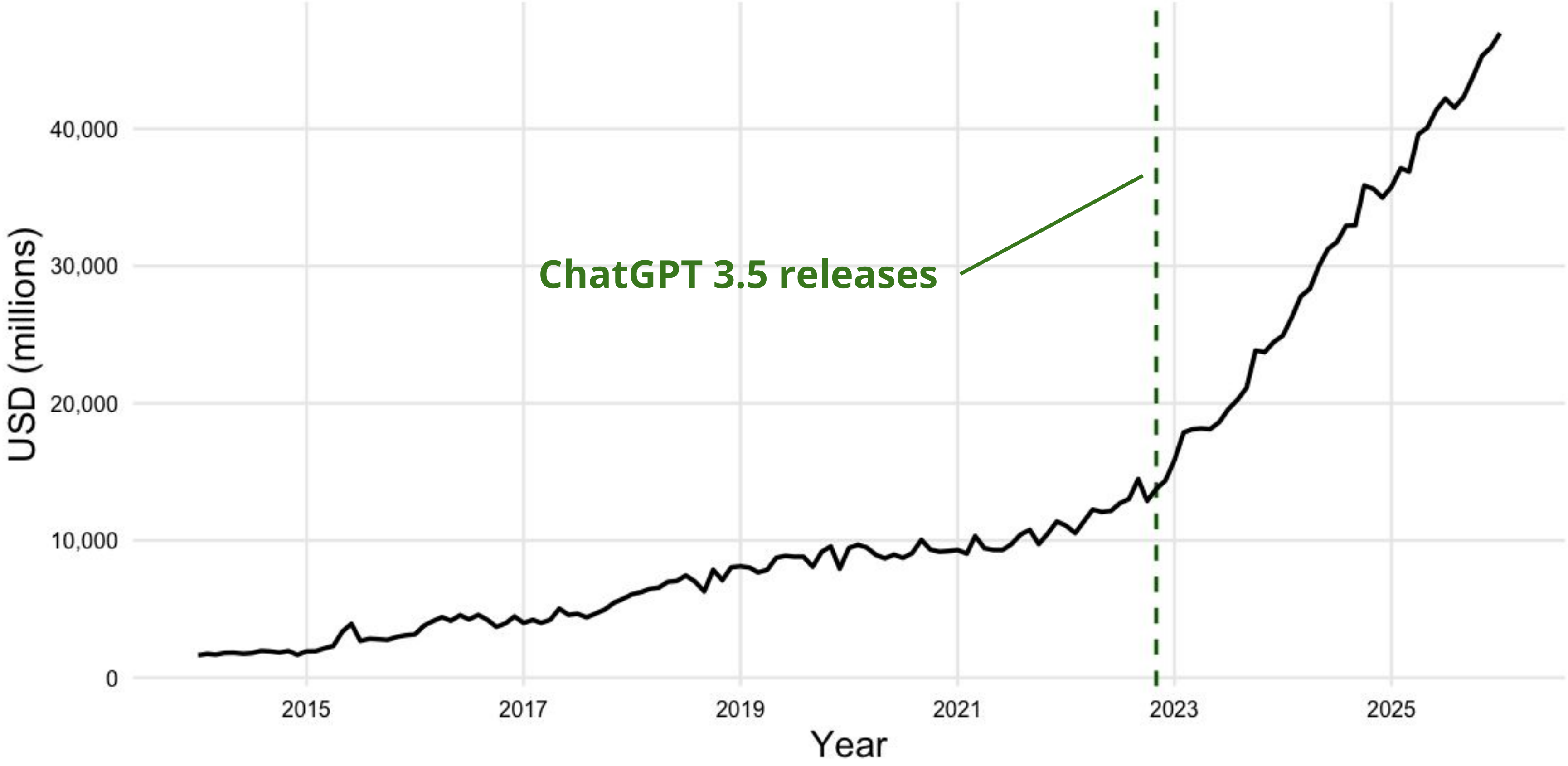
Average US Electricity Prices



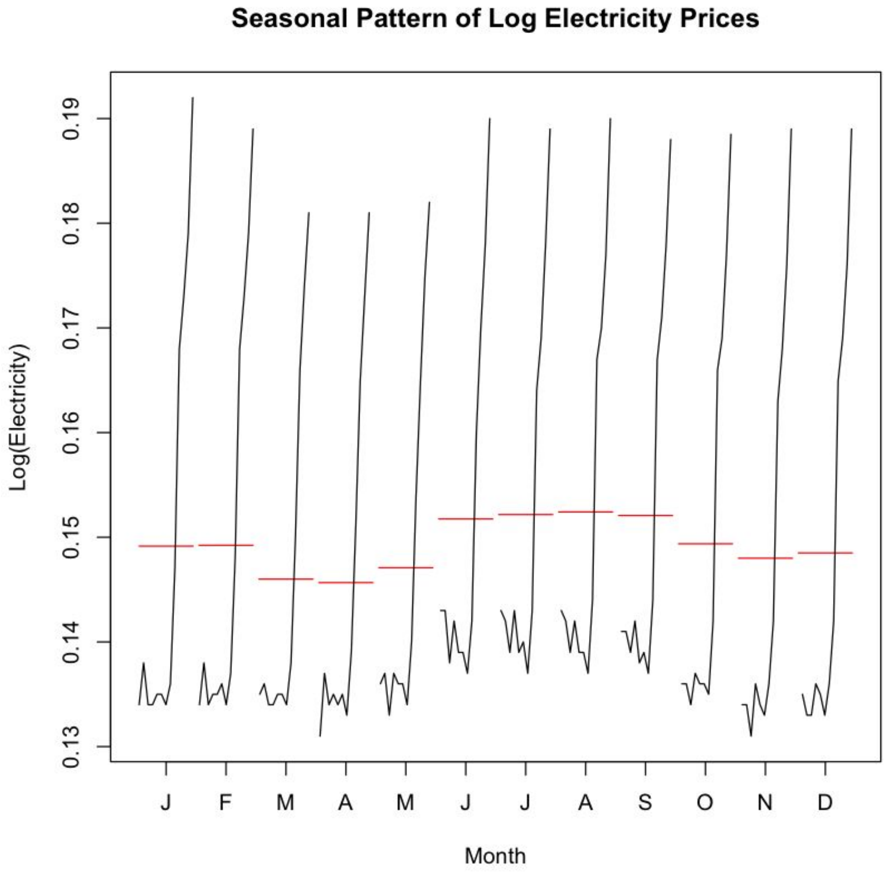
Google Search Trends for "AI"

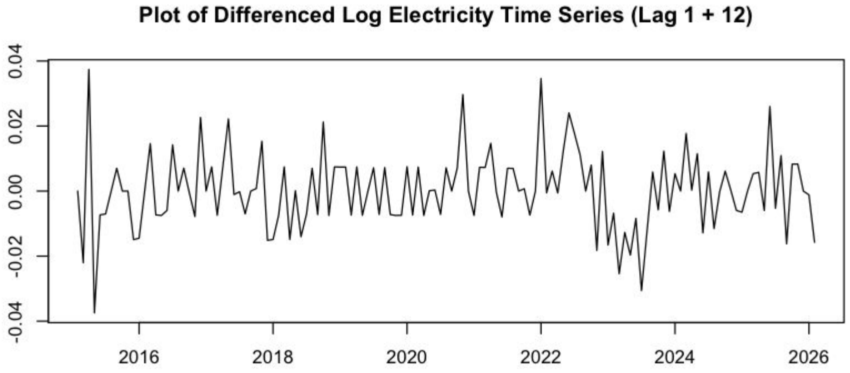


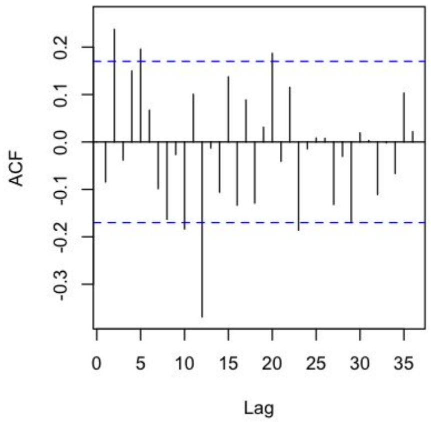
Data Center Investment Rate (SAAR)

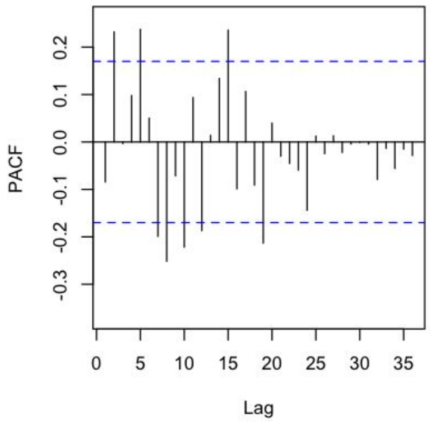


Electricity Prices ACF and PACF

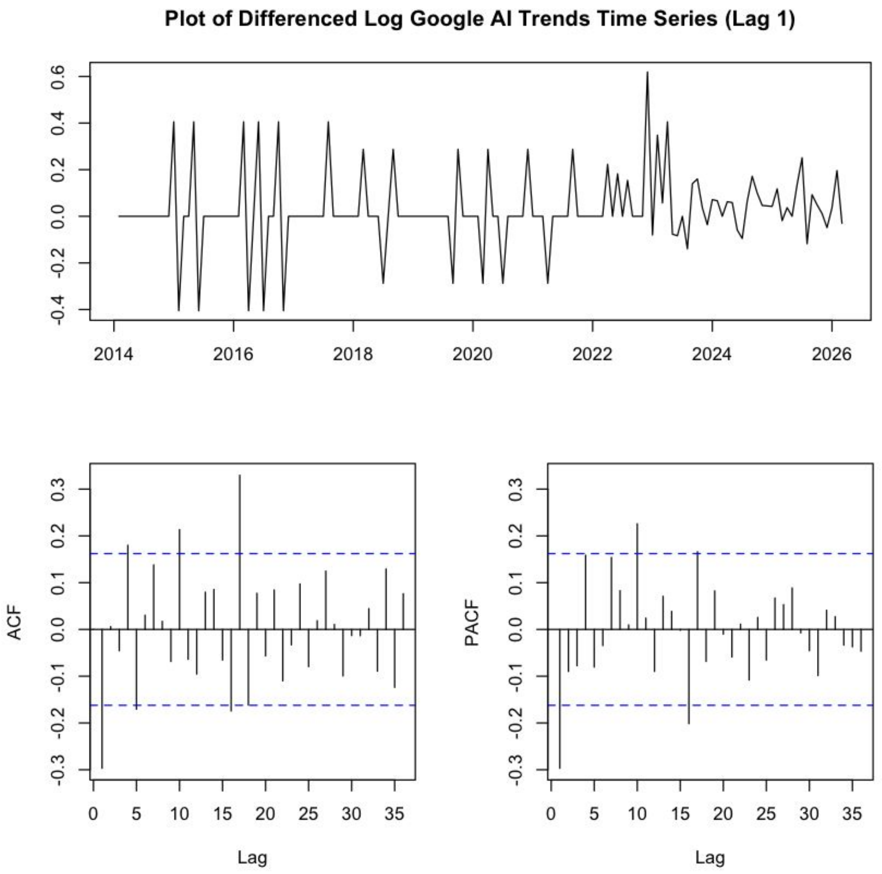


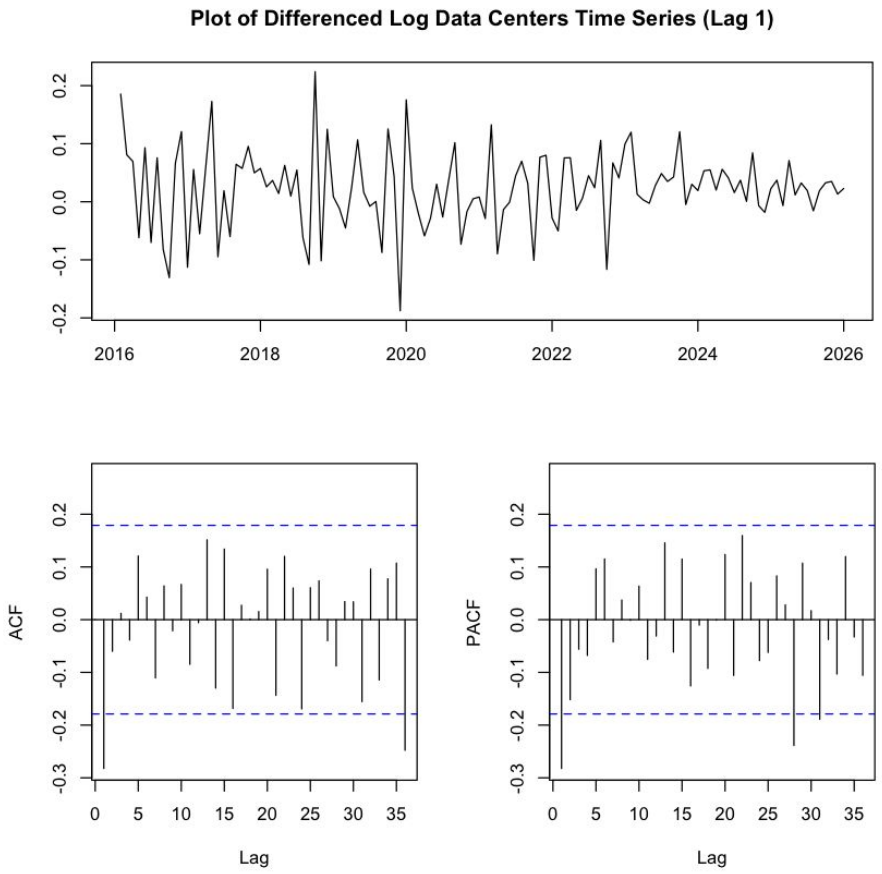






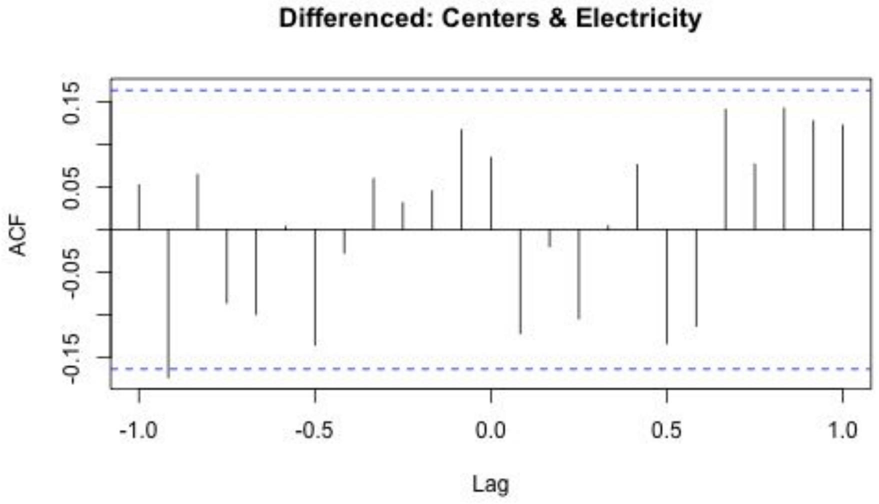
Data Centers and AI Trends ACF and PACF

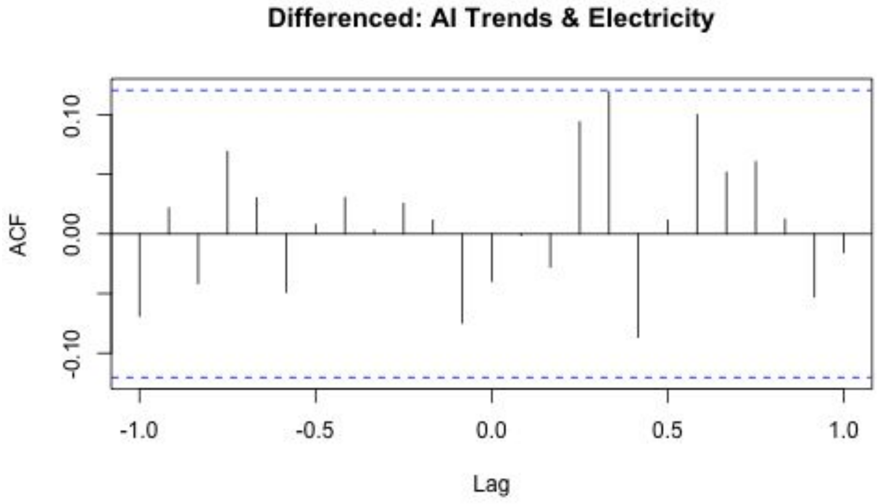




Cross Correlation Analysis

- Most cross-correlations fall within 95% confidence bounds
- Few individual lags showing spikes are isolated and not consistent across neighboring lags
- No clear evidence that AI trends or data center growth systematically lead or lag electricity price changes at the monthly level

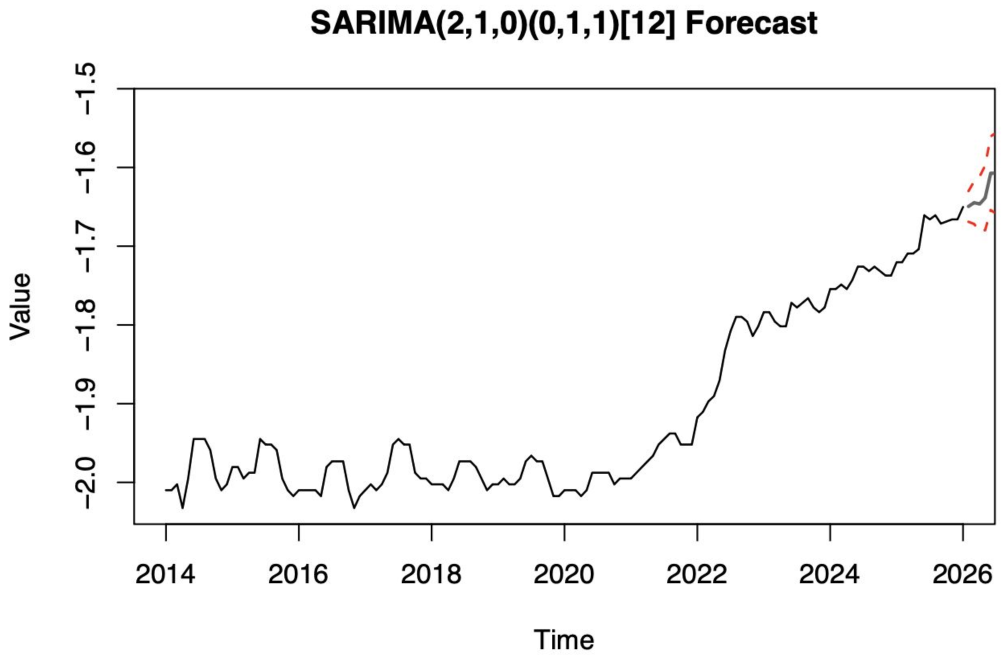




Baseline SARIMA Alone Forecasts Electricity Prices Remarkably Well

Baseline model: **SARIMA(2,1,0)(0,1,1)[12]** uses only the history of electricity prices to forecast future values.

- Differences once for trend (d=1) and once seasonally (D=1) to achieve stationarity
- Captures seasonal shock correction via a strong seasonal MA term (sma1 = -0.627)
- Low residual variance and strong fit metrics (low RMSE = 0.009, MAPE = 0.37%) indicate the model fits the data well with little remaining autocorrelation, meaning most structure has been captured



Adding AI Trends and Data Centers Does Not Improve the Model

Model 2: Contemporaneous Time Series Regression

- Regression with ARIMA(1,0,0)(2,0,0)[12] errors using:
  - Time trend
  - log(AI trends)
  - log(data centers)

Model 3: Lagged Time Series Regression

- Regression with ARIMA(1,0,2)(2,0,0)[12] errors using:
  - Time trend
  - lag-1 log(AI trends)
  - lag-3 log(data centers)

Model	MAPE	AIC	Key Findings
Baseline SARIMA	~0.37%	-831.1	Strong fit, no covariates needed, simplest model
Model 2	~0.39%	-885.1	Only time trend is significant
Model 3	~0.39%	-881.3	No covariate is significant

Conclusion

1. **Do investments in data centers and growing public sentiment towards AI predict or relate to electricity prices?**
   - No. Neither AI Search nor Data Centers were statistically significant.
   - Electricity prices seem primarily driven by their own historical momentum and seasonal cycles.
2. **What model best predicts electricity prices?**
   - Baseline SARIMA had the lowest MAPE (0.37%)
   - Model 2 had the best AIC, but included non-significant predictors
   - We prefer baseline SARIMA by principle of parsimony

Limitations and Next Steps

- **Filter to shorter time range from 2021 onwards**
  - All original time series plots indicate a shift in trend ~2021 vs. 2021 and onwards
  - Change in trend can introduce non-stationarity and bias trend estimates in time series regression
- **Use actual search counts instead of search popularity (0-100)**
  - Current AI trends data is very coarse, and search popularity may not most accurately reflect public sentiment towards AI
  - "A downward trend on the graph means a search term's relative popularity is decreasing, not necessarily that the total number of searches is decreasing." - Google News Initiative
- **Include another source or dataset we believe is cross-correlated with electricity prices (e.g., inflation rates)**

Thank You!