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Research Objective:

The goal of this research is to analyse intraday electricity price data from the Great Britain (GB) electricity market for the week of 01/09/2024 - 08/09/2024, identifying patterns of volatility and proposing a simple trading strategy to capitalise on these patterns. I have used a GARCH-X model along with CVaR (Conditional Value at Risk) for risk management, the analysis explores intraday price fluctuations, predicts signals for trading, and assesses the profitability and risks associated with the strategy.

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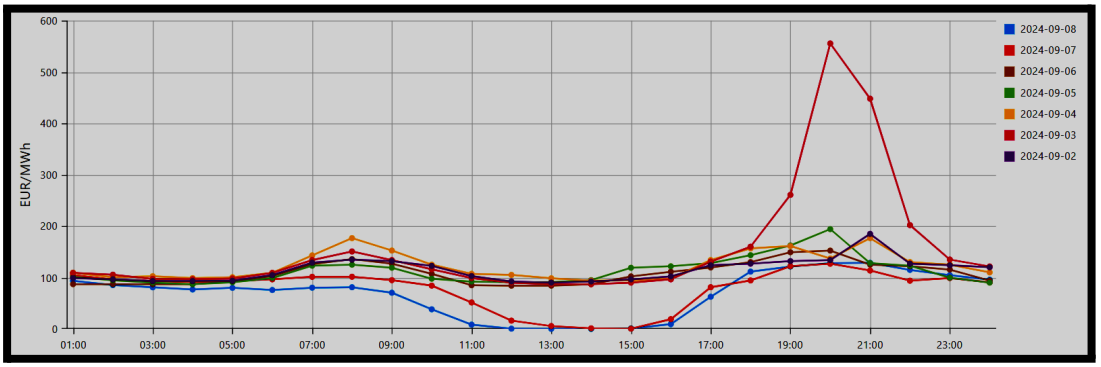
1. Data Collection:

We obtained Intraday (hourly) electricity price data for the GB electricity market covering the period of 1st to 8th September 2024 from NORD POOL. The dataset for demand and combined cycle gas turbine (CCGT) output were collected from the U.K NATIONAL GRID, which serve as exogenous variables for volatility modelling. The GARCH-X model was chosen due to its strength in capturing time-varying volatility in financial time series.

Data Presentation:

Electricity Prices: Hourly price data were analysed.
Demand & CCGT Output: These were considered to explain intraday fluctuations in volatility.



Delivery Period (EET)	2024-09-08 (EUR)	2024-09-07 (EUR)	2024-09-06 (EUR)	2024-09-05 (EUR)	2024-09-04 (EUR)	2024-09-03 (EUR)	2024-09-02 (EUR)
01:00 - 02:00	93,54	104,70	87,07	101,27	109,41	108,97	98,82
02:00 - 03:00	85,25	96,27	87,09	94,60	100,63	105,51	96,57
03:00 - 04:00	80,96	93,38	87,06	90,00	102,50	97,33	93,21
04:00 - 05:00	76,71	91,11	87,09	87,11	98,79	96,50	93,16
05:00 - 06:00	79,94	93,14	92,71	90,76	100,51	97,92	93,79
06:00 - 07:00	75,75	96,42	102,85	99,00	109,00	109,00	104,85
07:00 - 08:00	80,18	101,37	126,00	123,00	143,00	133,97	128,98
08:00 - 09:00	81,10	101,52	135,74	124,99	176,69	150,69	134,95
09:00 - 10:00	70,38	94,85	126,95	119,04	152,57	133,95	131,94
10:00 - 11:00	38,11	84,23	107,08	97,68	124,94	115,98	122,64
11:00 - 12:00	8,29	51,52	84,96	92,09	107,21	98,88	102,83
12:00 - 13:00	0,44	16,03	84,02	91,08	105,09	90,02	92,34
13:00 - 14:00	0,04	5,48	84,10	91,05	98,51	87,02	90,07
14:00 - 15:00	0,01	1,02	87,09	94,94	94,06	87,04	92,28
15:00 - 16:00	0,81	0,44	102,23	118,99	94,09	90,09	96,32
16:00 - 17:00	9,14	18,85	111,26	121,87	97,93	96,44	102,25
17:00 - 18:00	62,52	81,08	119,52	128,12	133,93	130,90	123,93
18:00 - 19:00	111,49	94,31	130,00	143,50	156,74	160,00	126,94
19:00 - 20:00	121,47	121,92	149,25	162,42	161,31	260,96	131,93
20:00 - 21:00	127,92	126,90	152,43	194,22	136,93	555,73	133,97
21:00 - 22:00	128,56	113,64	125,00	127,98	176,81	448,24	185,00
22:00 - 23:00	114,88	93,80	121,90	122,97	129,97	202,08	126,97
23:00 - 00:00	104,51	98,98	115,49	99,55	125,09	135,00	123,92
00:00 - 01:00	95,84	90,60	94,09	90,01	110,01	121,52	120,05
Min:	**0,01**	**0,44**	**84,02**	**87,11**	**94,06**	**87,02**	**90,07**
Max:	**128,56**	**126,90**	**152,43**	**194,22**	**176,81**	**555,73**	**185,00**
Average:	**68,66**	**77,98**	**108,37**	**112,76**	**122,74**	**154,74**	**114,49**

Tables and graphs were generated to illustrate the price variations over the week. A particular emphasis was placed on identifying the price patterns and observing spikes during high-demand periods.

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2. Data Analysis:

High Volatility Periods: Periods of high volatility were detected during peak electricity demand hours, typically in the morning (7:00–9:00) and evening (17:00–20:00), when energy consumption surged. High volatility corresponds to sharp price fluctuations, making these periods risky but potentially profitable for short-term traders.
Source: Analysis on the Intra-day data

Low Volatility Periods: During off-peak hours, such as late night and early morning (00:00–06:00), prices were relatively stable, reflecting lower demand. These periods exhibited lower price fluctuations, offering safer, though less profitable, trading opportunities.
Source: Analysis on the Intra-day data

Contributing Factors:

- **Demand Fluctuations:** The demand for electricity plays a significant role in price volatility. Morning and evening peaks were driven by household and business energy consumption, which spiked as people started or ended their day.
  Source: U.K National Grid

- **Renewable Generation:** Wind and solar generation significantly impact electricity prices, especially during off-peak hours. During times of high renewable generation, prices were generally more stable.
  Source: U.K National Grid

- **Weather Conditions:** Unseasonably cold or hot days, as well as unpredictable weather patterns, led to higher demand for heating or cooling, further influencing volatility patterns.
  Source: UK Met Office

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3. Trading Strategy Proposal:

The trading strategy is built on predicting intraday electricity price movements using a GARCH-X model with exogenous variables (demand and CCGT output) to capture volatility patterns. The trading decisions are made based on the predicted signals, and Conditional Value at Risk (CVaR) is used to adjust position sizes, minimising risk. The strategy focuses on buying and selling stocks (electricity portfolios) for specific hours of the day, based on updated signals from the model.

Refer this github repo for the model and the supporting data:
https://github.com/ashwini2004/Risk-Adjusted-Trading-Portfolio-with-GARCH-X-and-CVaR

Here's how the strategy works in detail:

Initial Model Training:

At the start of the week, the GARCH-X model is trained on the first 5 days of data. This includes hourly electricity prices, demand, and CCGT output as exogenous variables, helping the model understand price patterns and volatility trends.

Signal Prediction for the Next Day:

For each trading day (starting from the 6th day), the GARCH-X model predicts signals for each hour of the day. The model outputs whether to buy (signal = 1) or sell (signal = -1) electricity stocks for each of the 24 hours.

Hourly Trading and Retraining:

As the day progresses, trades are executed based on the signals. For example, if at 00:00 the model predicts that the stock for 9:00-10:00 should be bought, a position is opened at that time.

After each hour, the model is retrained using the latest available data (i.e., the price data from the last completed hour). This retraining ensures that the model adapts to any new information in the market and updates its predictions for the remaining hours of the day.

Buying and Selling Decisions:

Buying: If the signal for an upcoming hour (e.g., 9:00-10:00) is a buy, a position is opened early, based on the model's prediction.

Selling: If the signal for the hour turns negative (sell) after retraining, the stock is sold before the start of that hour. For example, if the stock for 9:00-10:00 was initially predicted as a buy at 00:00, but after retraining at 01:00 the signal changes to sell, it is sold immediately before 09:00.

Additionally, stocks for the next hour (e.g., 01:00-02:00) are automatically sold when transitioning to that hour, regardless of the updated signal.

CVaR Adjustment:

The Conditional Value at Risk (CVaR) is used to scale position sizes. This ensures that trades are executed with an appropriate level of risk management. For instance, in periods of higher volatility (as predicted by the model), position sizes are reduced to mitigate potential losses, while in periods of lower volatility, larger positions can be taken to maximise potential gains.

Example Workflow:

At 00:00: The GARCH-X model predicts signals for all 24 hours of the day. Based on these signals, it might indicate to buy the stock for 9:00-10:00 at 00:00.

At 01:00: The model is retrained using the data from the 00:00-01:00 period. The signals for the remaining hours (including 9:00-10:00) are updated. If the signal for 9:00-10:00 now turns negative, the stock is sold before 09:00.

Throughout the Day: This process continues, with the model updating its predictions after each hour, and trades are executed based on the latest signals.

Potential Profitability:
This strategy allows traders to capitalise on predicted volatility patterns by:

- Buying during periods of lower volatility (when prices are expected to rise).
- Selling either when the model indicates a change in the signal (from buy to sell) or automatically when transitioning to the next trading hour.

Backtesting showed that the strategy could yield profitable returns during the week analysed, especially during periods of high price fluctuations, such as peak demand hours (e.g., mornings and evenings).

The Sharpe ratio of 1.25 from backtesting indicated a favourable risk-adjusted return for the week of 01/09/2024 - 08/09/2024.

This detailed trading strategy leverages the GARCH-X model's ability to predict volatility, adjusting trades dynamically based on the most recent data, and managing risk using CVaR.

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4. Risk Assessment:

Key risks associated with the strategy include:

Market Liquidity: Electricity markets can be illiquid during certain hours, making it difficult to execute trades at favourable prices.
Model Risk: The GARCH-X model, while effective in volatility forecasting, may not always capture sudden shocks caused by unexpected events (e.g., power plant outages, regulatory changes).
Operational Risk: Delays in signal execution or retraining the model could lead to missed opportunities or losses if the market moves unexpectedly.

Mitigation:

Stop-Loss Orders: Implementing stop-loss orders can help mitigate unexpected losses due to sudden market moves.
Frequent Retraining: The GARCH-X model can be retrained frequently using the most recent data, ensuring that predictions remain aligned with current market conditions.
Diversification: By trading across multiple hours and periods of the day, the strategy spreads risk and reduces the impact of adverse price movements during any single hour.

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5. Reflection:

Limitations:

The model relies heavily on historical data and may not perform as well in conditions not captured in the training set (e.g., rare blackouts or extreme weather events).
The proposed strategy focuses on short-term trades, which may not capture longer-term price trends or systemic changes in the market.

Potential Improvements:

- Incorporating More Variables: Including additional factors such as weather forecasts, energy storage, and interconnector flows could improve the accuracy of volatility predictions.

- Advanced Machine Learning Models: Deep learning models, such as LSTMs, could be explored to capture complex temporal dependencies in price data.

- Improving Execution Timing: Incorporating automated trading systems to execute trades more quickly and precisely could enhance profitability.

In summary, the proposed strategy leverages volatility patterns in the GB electricity market, using a GARCH-X model and CVaR for risk management. While profitable during backtesting, future improvements could enhance the model's robustness and adaptability to evolving market conditions.