A. Mini-Benchmark Forecast Comparison

To support the motivational analysis in Section 3, we include the full set of 15 curated time-series case studies used to compare a text-only LLM with our multimodal MORFI model. Each example corresponds to a recognizable technical chart pattern. For the LLM, we used the GPT-4o variant of ChatGPT [36] with only textual input. For the multimodal case, we used GPT-4V (Vision) [37] for the MORFI VLM, providing both the numerical sequence and the corresponding chart image. For each case, we report the model predictions and note whether they aligned with the expected pattern outcome.

The following trend labels are used to qualitatively categorize model predictions across all 15 forecasting cases:

- *Breakout Up:* Clear upward movement above recent highs.
- *Breakout Down / Breakdown:* Clear downward movement below recent support.
- *Reversal Up / Reversal Down:* Change in direction from recent trend.
- *Continuation Up / Down:* Movement continuing in the same direction as previous trend.
- *Gradual Rise / Drop:* Small directional movement.
- *Sharp Rise / Drop:* Sudden large movement in one direction.
- *Fluctuation:* Oscillations without clear direction.
- *Stable:* Minimal change, hovering around the same values.
- *Sideways:* Movement within a tight range or horizontal band.

Each model's behavior was labeled by examining the next 2 forecasted steps and grouping the trend accordingly. A model was considered the "winner" for a pattern if its forecast trend matched the expected chart-based behavior more closely than the other model.

As shown in Table 5, MORFI matched the expected trend in 13 out of 15 cases, while the text-only LLM aligned in only 6. In several pattern types—such as descending triangles, cup and handle formations, and consolidation ranges—the LLM failed to detect reversals or breakouts visible in the chart, often defaulting to stable or fluctuating forecasts. In contrast, MORFI more consistently recognized structural cues implied by visual support and resistance levels, demonstrating the benefit of incorporating graphical representations into time-series forecasting [10, 28, 33].

Below, we provide the input sequences and model predictions for all 15 case studies from our mini-benchmark. Each sequence corresponds to a well-documented technical chart pattern, as described in both classic references and recent empirical work on pattern-based forecasting.

As a visual reference for the benchmark sequences, Figure 4 shows all 15 pattern examples with annotated support, resistance, or trend structure, matching the patterns described in Table 1.

1. Descending Triangle
- Input: [100, 102, 101, 100, 101, 102, 101, 100, 101, 100]
- LLM Prediction: [102, 101]
- MORFI Prediction: [101, 100]

2. Double Top
- Input: [105, 108, 110, 108, 105, 110, 108, 104]
- LLM Prediction: [101, 98]
- MORFI Prediction: [102, 100]

3. Ascending Triangle
- Input: [120, 122, 124, 123, 125, 124, 126]
- LLM Prediction: [127, 128]
- MORFI Prediction: [127.5, 129]

4. Head & Shoulders
- Input: [130, 134, 138, 134, 132, 136, 130]
- LLM Prediction: [134, 133]
- MORFI Prediction: [126, 124]

5. Inverse Head & Shoulders
- Input: [80, 76, 72, 76, 78, 74, 80]
- LLM Prediction: [77, 77]
- MORFI Prediction: [82–84, 84–86]

6. Bearish Flag
- Input: [150, 140, 130, 135, 137, 136, 133, 128]
- LLM Prediction: [121, 112]
- MORFI Prediction: [124, 120]

7. Bullish Flag
- Input: [90, 100, 110, 108, 107, 109, 111]
- LLM Prediction: [113, 115]
- MORFI Prediction: [114, 118]

8. Double Bottom
- Input: [200, 195, 190, 195, 198, 190, 195, 200]
- LLM Prediction: [195, 190]
- MORFI Prediction: [203, 206]

9. Symmetrical Triangle
- Input: [70, 74, 72, 75, 73, 76, 74, 77]
- LLM Prediction: [75, 78]
- MORFI Prediction: [75, 79]

10. Rising Wedge
- Input: [60, 62, 63, 64, 65, 64, 63, 62]
- LLM Prediction: [60, 58]
- MORFI Prediction: [61, 60]

11. Falling Wedge
- Input: [140, 138, 137, 136, 135, 136, 137, 138]
- LLM Prediction: [139, 140]
- MORFI Prediction: [139, 140]

12. Cup and Handle
- Input: [100, 98, 95, 96, 98, 100, 99, 98, 101]
- LLM Prediction: [103, 105]
- MORFI Prediction: [99.3, 99.4]

13. Rounding Bottom
- Input: [50, 48, 47, 48, 49, 51, 53, 55]
- LLM Prediction: [57, 59]
- MORFI Prediction: [57, 59]

14. Consolidation Range
- Input: [120, 122, 121, 123, 122, 121, 120]
- LLM Prediction: [119, 118]
- MORFI Prediction: [121, 122]

15. Spike & Channel Down
- Input: [250, 230, 210, 220, 215, 205, 195, 190]
- LLM Prediction: [185, 180]
- MORFI Prediction: [185, 180]

B. Visual Representation

Figures 5 and 6 visualize the comparative MSE performance of VLMs and LLMs across stocks, as well as the effect of Chain-of-Thought prompting.

Pattern	Expected	LLM Prediction	MORFI Prediction	Winner
Desc. Triangle	Breakdown	Fluctuation	Breakdown	MORFI
Double Top	Reversal Down	Reversal Down	Reversal Down	Tie
Asc. Triangle	Breakout Up	Fluctuation	Breakout Up	MORFI
Head & Shoulders	Breakdown	Stable	Breakdown	MORFI
Inverse H&S	Breakout Up	Stable	Breakout Up	MORFI
Bearish Flag	Continuation Down	Sharp Drop	Gradual Drop	LLM
Bullish Flag	Continuation Up	Gradual Rise	Breakout Up	MORFI
Double Bottom	Reversal Up	Gradual Drop	Breakout Up	MORFI
Sym. Triangle	Breakout Up	Gradual Rise	Breakout Up	MORFI
Rising Wedge	Breakdown	Sharp Drop	Gradual Drop	LLM
Falling Wedge	Breakout Up	Gradual Rise	Gradual Rise	Tie
Cup and Handle	Breakout Up	Sharp Rise	Gradual Rise	MORFI
Rounding Bottom	Gradual Rise	Gradual Rise	Gradual Rise	Tie
Consolidation Range	Sideways	Breakdown	Sideways	MORFI
Spike & Channel Down	Continuation Down	Gradual Drop	Gradual Drop	Tie

Table 5. Model behavior on 15 chart-based forecasting cases. Each time series was designed to match a common technical pattern. "Expected" reflects what a human expert would forecast based on the chart. "LLM" and "MORFI" show each model's predicted trend type.

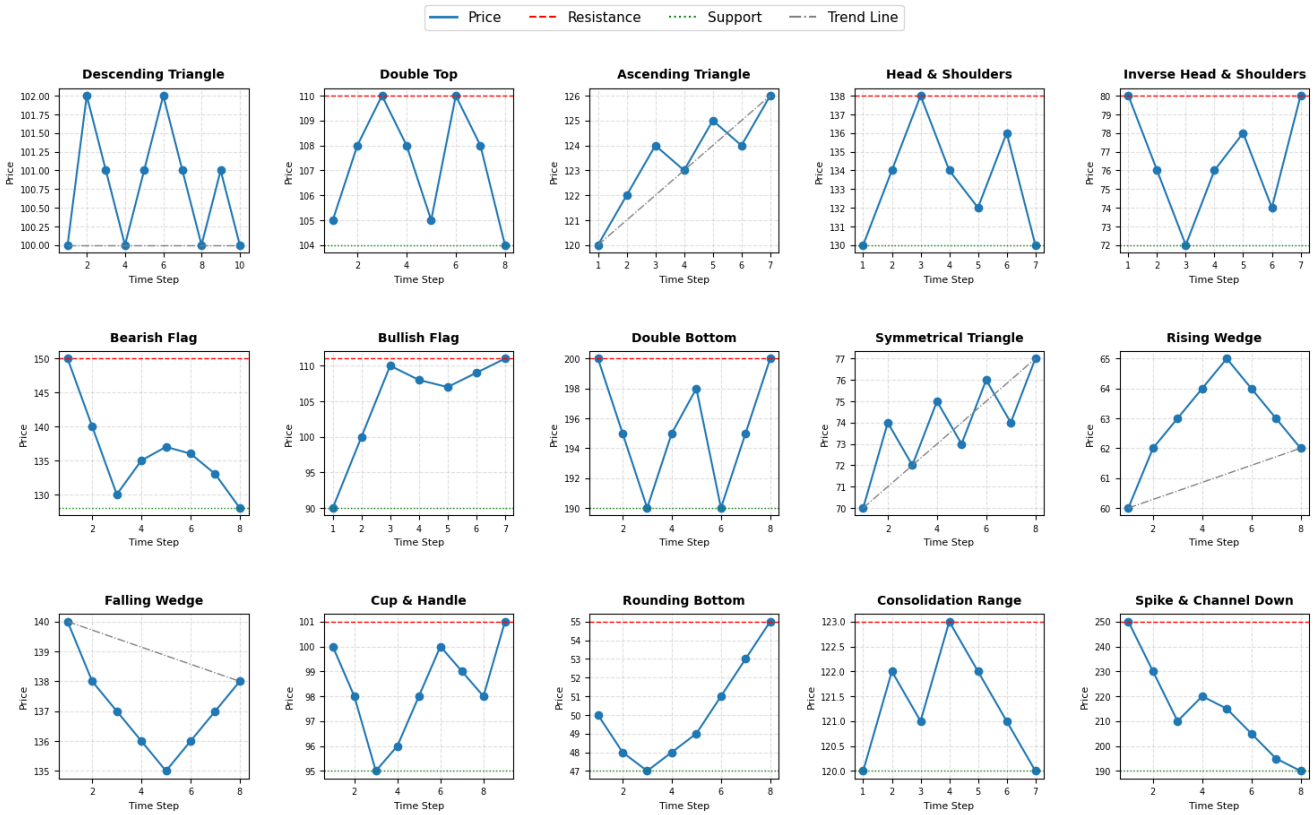

Figure 4. **Mini-benchmark chart-pattern inputs.** Each subplot depicts a curated example of a classic technical chart pattern used in our forecasting benchmark. The solid blue line shows the raw price sequence. Horizontal dashed and dotted lines indicate the resistance (maximum) and support (minimum) levels, respectively. For triangle and wedge patterns, a diagonal dash-dot line highlights the converging trend structure. A shared legend appears above the grid to clarify visual conventions. These inputs correspond to the patterns analyzed in Section 3 and summarized in Table 5.

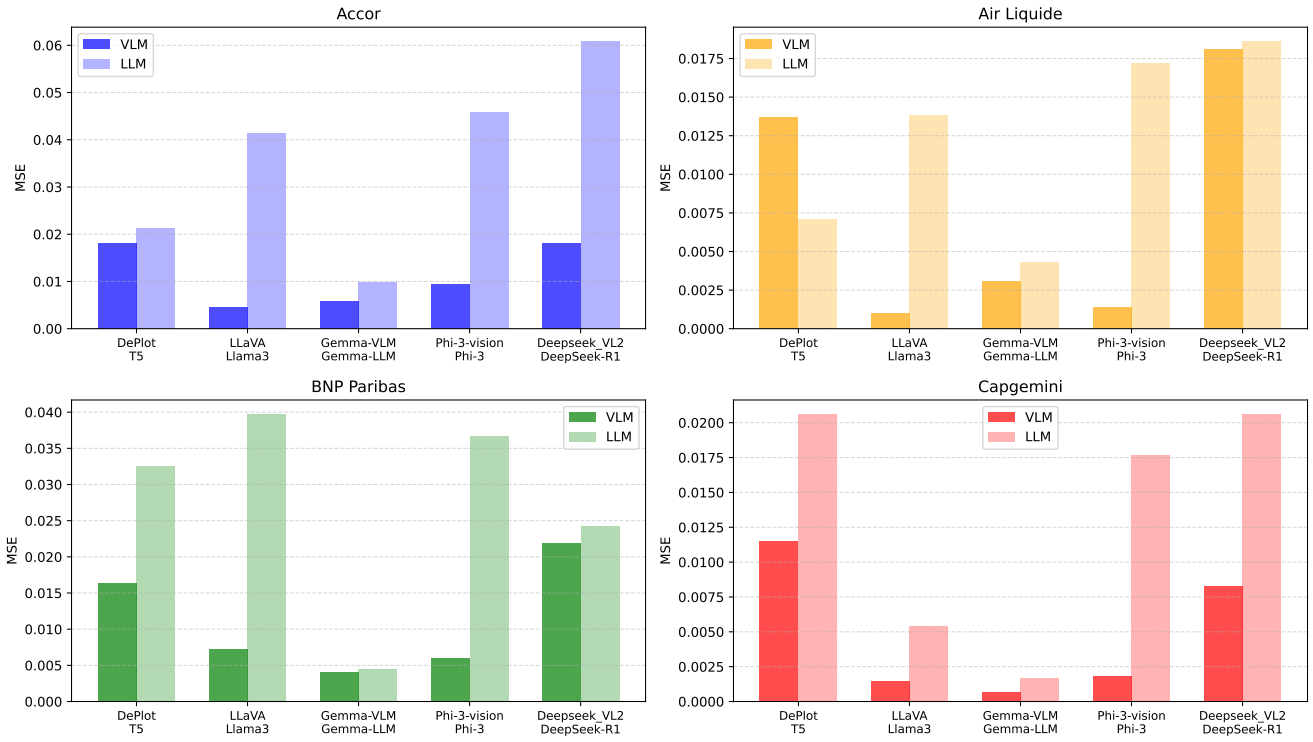

Figure 5. Comparison of VLM and LLM MSE values across four stocks.

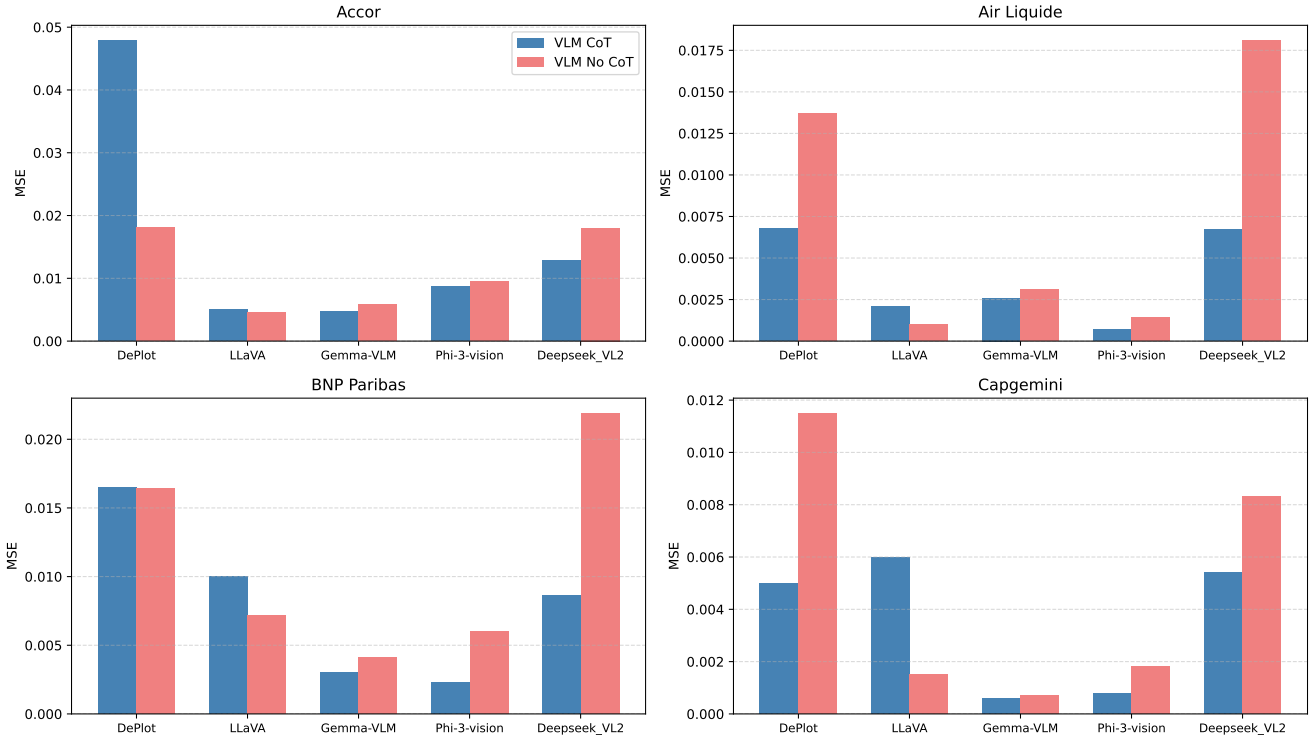

Figure 6. Comparison of VLMs with and without CoT prompting across four stocks.