

Integrated Adaptive Demand Forecast

Combining recurring seasonality, the current relative demand level, and local momentum into a forward weekly forecast

STUDY QUESTION

Can a simple adaptive seasonal architecture outperform fixed seasonal and rolling-average benchmarks on genuinely unseen data?

Executive Summary

The flagship model combines three ideas developed separately: a two-harmonic Fourier seasonal curve, seasonally normalized recent demand, and a six-week local trend. The architecture was selected using 2023–2024 rolling-origin development forecasts, frozen, and then evaluated once on the untouched 2025 holdout.

The final model achieved 2025 MAE of 1.97 and RMSE of 3.23, improving on the recent four-week baseline by 19.2% in MAE and 12.7% in RMSE. A later 2026 out-of-time check remained directionally favorable under an overlap-weighted calendar approximation, but the mismatch in weekly bucket definitions prevents a definitive 2026 validation claim.

Architecture

Component	Role
Fourier seasonality	Estimates the recurring annual demand shape.
Seasonally normalized demand	Measures whether the current year is running above or below expected seasonal level.
Six-week local trend	Estimates current level and direction using progressively larger weights on recent weeks.
Reapplication to seasonal scale	Converts the adaptive relative level back into expected weekly New Customers.

$$\text{Forecast}_t = \max(0, S(w_t) * \max(0.01, L_t) - 1)$$

$S(w_t)$ supplies seasonal shape; L_t supplies adaptive level and local trend.

Development Selection

2024 rolling-origin model	MAE	RMSE	Bias	Correlation
Adaptive seasonal K2 + 6-week trend	5.22	7.65	-0.51	0.598
Seasonal month mean	5.44	8.48	-1.33	0.478
Recent 4-week mean	5.51	7.82	+0.29	0.559
Recent 6-week mean	6.38	8.69	+0.33	0.420
Same week prior year	6.98	10.01	-1.78	0.345

Strict 2025 Holdout

2025 model	MAE	RMSE	Bias	Corr.	Predictive R ²
Adaptive seasonal	1.97	3.23	+0.13	0.891	0.778
Recent 4-week mean	2.43	3.70	0.00	0.846	0.709
Recent 6-week mean	2.89	4.32	0.00	0.786	0.603
Seasonal month mean	3.52	4.90	+2.32	0.788	0.490

HOLDOUT RESULT

Versus the recent four-week baseline, the adaptive seasonal model produced 19.2% lower MAE and 12.7% lower RMSE on the untouched 2025 holdout.

2026 Out-of-Time Alignment Check

The 2026 target data used Monday–Sunday weeks, while the frozen historical model used fixed Jan 1–7, Jan 8–14, and subsequent seven-day buckets. Direct week-number matching therefore shifts the target by three days. The workbook uses an overlap-weighted approximation as a sensitivity check, not as a substitute for exact daily re-bucketing.

2026 overlap-weighted approximation (W01–W36)	Adaptive	Recent 4-week
MAE	1.560	1.621
RMSE	2.304	2.324
Bias (Pred-Actual)	-0.032	-0.335
Predictive R ²	0.591	0.584

Validation Discipline

- Chronological ordering preserved throughout.
- No random K-fold cross-validation.
- 2025 excluded from feature and model selection.
- Forecast inputs restricted to information available at or before the forecast origin.
- Negative and failed tests retained in the audit trail.
- Model frozen before holdout evaluation.
- Calendar-bucket definition treated as part of the model contract.

Key Takeaways

Result	The adaptive architecture beat simple seasonal and recent-level benchmarks on the strict 2025 holdout.
Status	Provisionally validated, not permanently validated, because only one untouched annual holdout was available.
2026 lesson	Calendar alignment can materially change the backtest conclusion and must be treated as part of the model specification.
Next checkpoint	Re-bucket exact 2026 daily New Customers into the frozen calendar and rerun the model without retraining.

Portfolio-Ready Summary

SUGGESTED HEADLINE

Built and provisionally validated an adaptive weekly demand forecast

I combined recurring seasonality with a seasonally normalized current level and six-week local trend, selected the architecture using rolling-origin development forecasts, and froze it before opening the 2025 holdout. The model reduced holdout MAE by 19.2% and RMSE by 12.7% versus a recent four-week baseline, while a later 2026 check surfaced calendar alignment as an explicit model-governance requirement.