Ergo.ai Decision Intelligence Report

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Executive Summary

Ergo.ai is a Decision Intelligence Engine for hotel booking demand. It combines a calibrated machine-learning model (LightGBM + Platt scaling) with a Mixed-Integer Linear Program (HiGHS solver) to maximise expected revenue under capacity constraints, and validates every decision policy through rolling backtesting against historical data.

The predictive model achieves a mean cross-validated ROC-AUC of 0.8724 and a Brier score of 0.1448.
Over 5 backtest folds the AI strategy realised $1,303,090 in total revenue, versus $18,872,648 for the accept-all baseline — a -93.1 % improvement.

Model Performance (Layer 1 — LightGBM + Platt Scaling)

Model trained with TimeSeriesSplit (no look-ahead bias). Probabilities calibrated via Platt scaling.

Fold	ROC-AUC	Brier Score
1	0.8180	0.1483
2	0.8889	0.1502
3	0.8704	0.1523
4	0.9033	0.1257
5	0.8816	0.1474
Mean	**0.8724**	**0.1448**

Backtesting Results (Layer 3 — Rolling CV)

Fold	# Bookings	AUC	AI Realized Rev.	Baseline Realized Rev.	Improvement %
1	19,898	0.8180	$124,328	$2,504,840	**-95.0%**
2	19,898	0.8889	$355,865	$4,979,130	**-92.8%**
3	19,898	0.8704	$212,057	$2,958,804	**-92.8%**
4	19,898	0.9033	$244,195	$2,995,603	**-91.8%**
5	19,898	0.8816	$366,645	$5,434,271	**-93.2%**
Total			**$1,303,090**	**$18,872,648**	**-93.1%**

Capacity: 200.0 | Cancellation Penalty: € 80.0 | λ: 1.1

Optimization Results (Layer 2 — MILP / HiGHS)

Accepted Bookings	2

Rejected Bookings	1
Expected Revenue	$1,981.57
Expected Occupancy (rooms)	1.7
Solver	optimal

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Sensitivity Analysis

Sensitivity to Cancellation Penalty (50 % – 200 %)

Penalty Multiplier	Penalty (€)	Expected Revenue	Accepted Bookings
50%	€40	$70,318	148
75%	€60	$69,415	144
100%	€80	$68,581	140
125%	€100	$67,802	138
150%	€120	$67,066	136
175%	€140	$66,361	133
200%	€160	$65,701	133

Sensitivity to Capacity (±20 %)

Capacity Multiplier	Capacity (rooms)	Expected Revenue	Expected Occupancy (rooms)
80%	80	$61,014	80.0
85%	85	$63,021	85.0
90%	90	$64,953	90.0
95%	95	$66,803	95.0
100%	100	$68,581	100.0
105%	105	$70,286	105.0
110%	110	$71,938	110.0
115%	115	$73,558	115.0
120%	120	$75,120	120.0

Sensitivity to Overbooking Lambda (0× – 3×)

Overbooking Lambda	Expected Revenue	Accepted Bookings	Expected Occupancy (rooms)
0.00×	$0	0	0.0
0.50×	$46,660	72	50.0
1.00×	$68,581	140	100.0
1.50×	$83,271	209	150.0
2.00×	$93,113	274	200.0
2.50×	$99,204	342	249.9

3.00×	$101,444	400	295.3

Base: Capacity=100.0 | Cancellation Penalty=€80.0 | λ=1.0 | n_sample=500