# Technical Document: Dynamic Pricing Algorithms and Rules

**Project:** Dynamic Pricing Strategies for Fitness Classes based on Demand, Time, and Location

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**Objective:** To transition fitness class pricing from a fixed-fee model to a demand-responsive system using Price Elasticity and Time-Series Forecasting.

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## 1. The Core Pricing Algorithm

The pricing engine utilizes a **Heuristic Optimization Algorithm**. It does not predict price in a vacuum; instead, it calculates a **Price Adjustment Factor** by analyzing three distinct data dimensions:

1. **Demand Elasticity Factor:** Derived from Log-Log OLS Regression.
2. **Temporal Factor:** Derived from Prophet Time-Series Seasonality.
3. **Inventory Factor:** Derived from real-time occupancy rates.

## 2. Segment-Based Pricing Rules

Classes are categorized into four segments based on historical performance. Each segment triggers a specific pricing logic:

| Segment | Logic | Action Rule |
|---|---|---|
| **Premium Powerhouse** | High Occupancy / High Price | **Maintenance:** Maintain current price or apply +5% "Premium Guard" surge. |
| **Underpriced Value** | **High Occupancy / Low Price** | **Surge:** Apply **+15% Surge Multiplier**. Target for immediate yield growth. |
| **Price Sensitive** | Low Occupancy / High Price | **Re-evaluation:** Monitor for 2 weeks; if occupancy remains <30%, apply -5% correction. |
| **Low Interest** | Low Occupancy / Low Price | **Incentivize:** Apply **-10% "Fill-the-Room" Discount** to cover variable costs. |

## 3. Temporal Surge Rules (Prophet Integration)

The algorithm overrides standard pricing during "Power Hours" identified by the Prophet model:

- **Rule 3.1 (Peak Day Surge):** Apply an additional **2% multiplier** on Tuesdays and Wednesdays (statistically identified as the highest demand days).
- **Rule 3.2 (Rush Hour Surge):** Classes starting between **06:00–09:00** and **17:00–20:00** are subject to an immediate surge if occupancy is predicted to exceed 80%.

## 4. Revenue Protection Logic (The Elasticity Guardrail)

To ensure that price increases do not lead to a total loss of customers, the algorithm is capped by the **Elasticity Coefficient**:

- **Model Coefficient:** -0.3235 (Inelastic).
- **The Guardrail Rule:** No single price increase shall exceed **20%** in a single period. According to our model, a 20% increase results in a maximum projected volume drop of only **6.4%**, ensuring that Total Revenue (P×Q) always increases.

## 5. Final Calculation Formula

The dynamic price for any specific class is calculated as follows:

$$\text{Price}_{\text{Dynamic}} = \text{Price}_{\text{Base}} \times (1 + \text{Segment Multiplier} + \text{Temporal Multiplier})$$

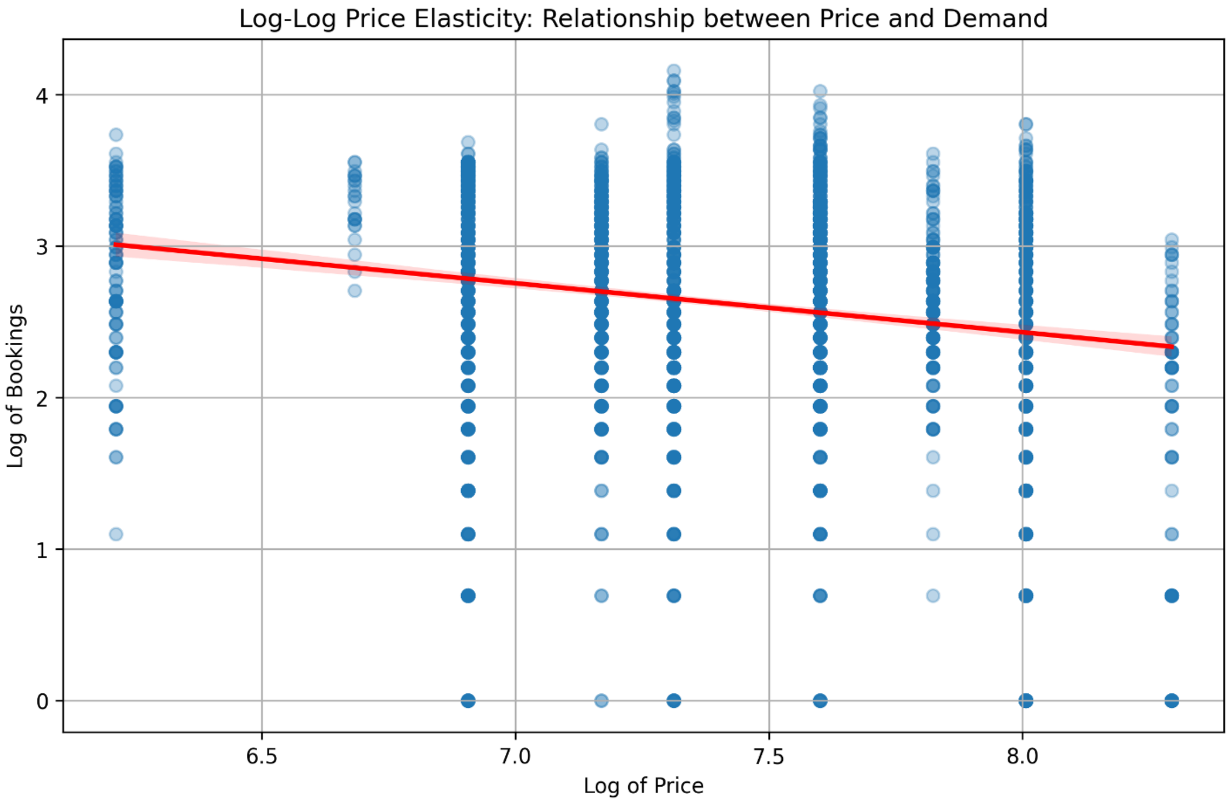
## 6. Verification and Performance Metrics

The success of these rules is verified through back-testing against the test dataset using:

- **Revenue Lift:** Target > 5% (Achieved: **6.91%**)
- **Yield per Slot:** Measures the average revenue earned per available mat.
- **Occupancy Variance:** Target a reduction in the gap between peak and off-peak **attendance.**

## Appendix: Statistical & Empirical Evidence

### Evidence 1: Price-Demand Sensitivity (Log-Log Regression)




### Figure A1:

Log-Log Regression analysis demonstrating a negative price elasticity of -0.3235. This provides the mathematical basis for surge pricing during high-occupancy windows.

**Evidence 2: Model Diagnostic Check (Residual Plot)**

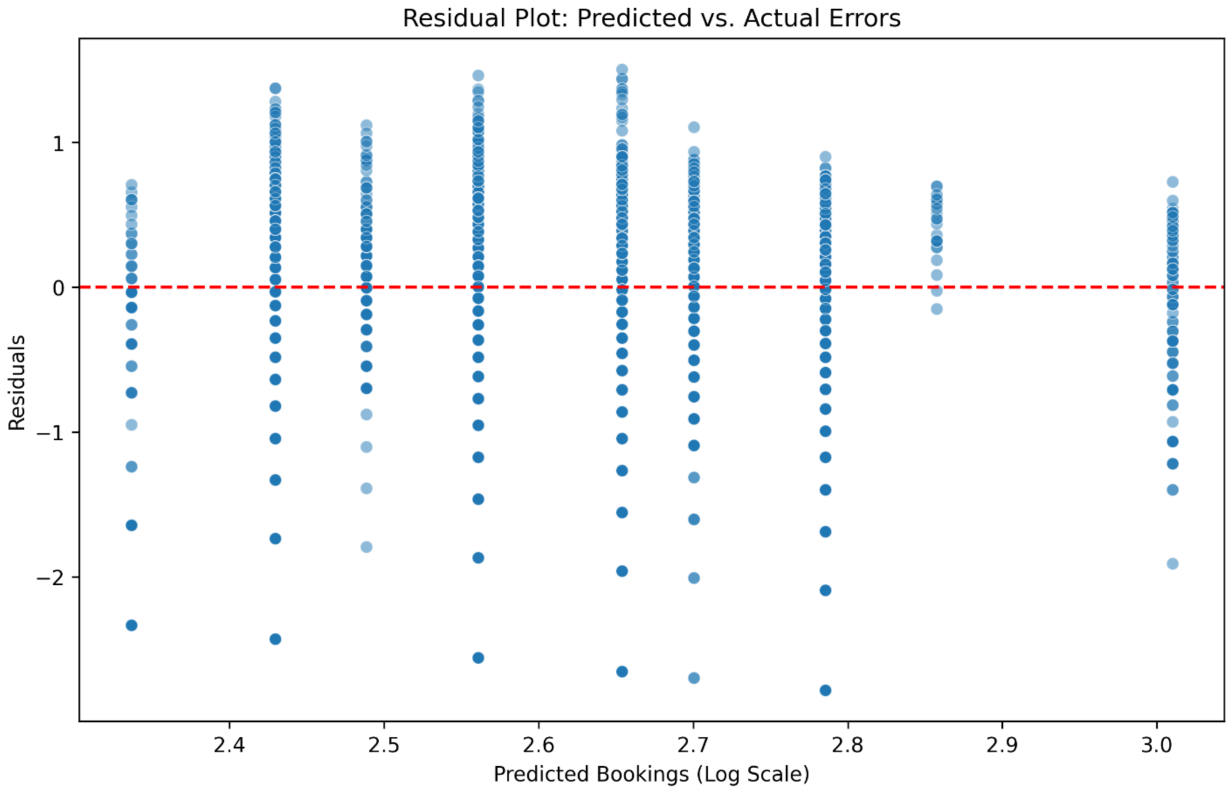



**Figure A2:**

Residual Plot showing an unbiased distribution of errors around the zero-line, confirming the statistical validity of our elasticity coefficient

## Evidence 3: Temporal Demand Decomposition (Prophet Forecast)

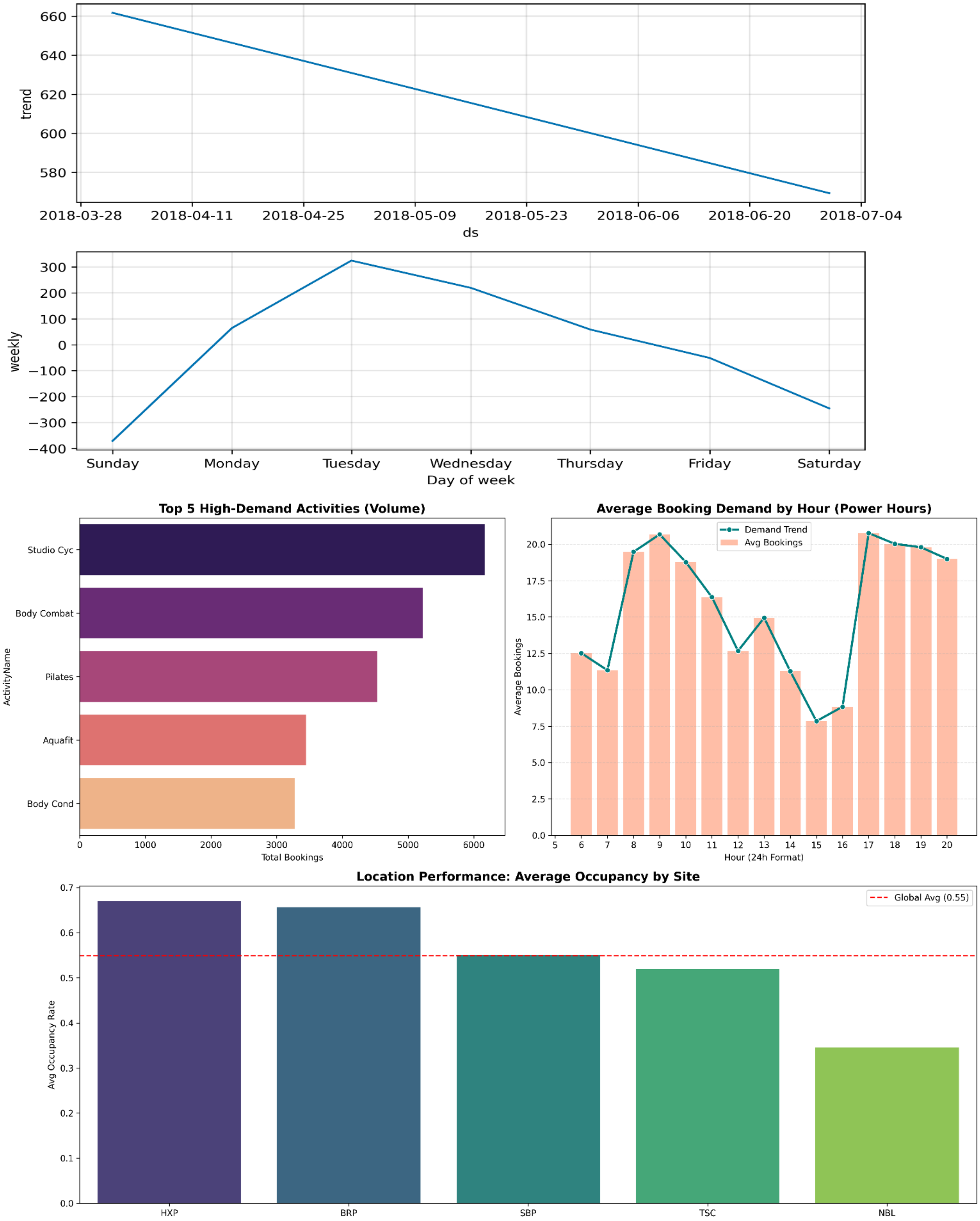
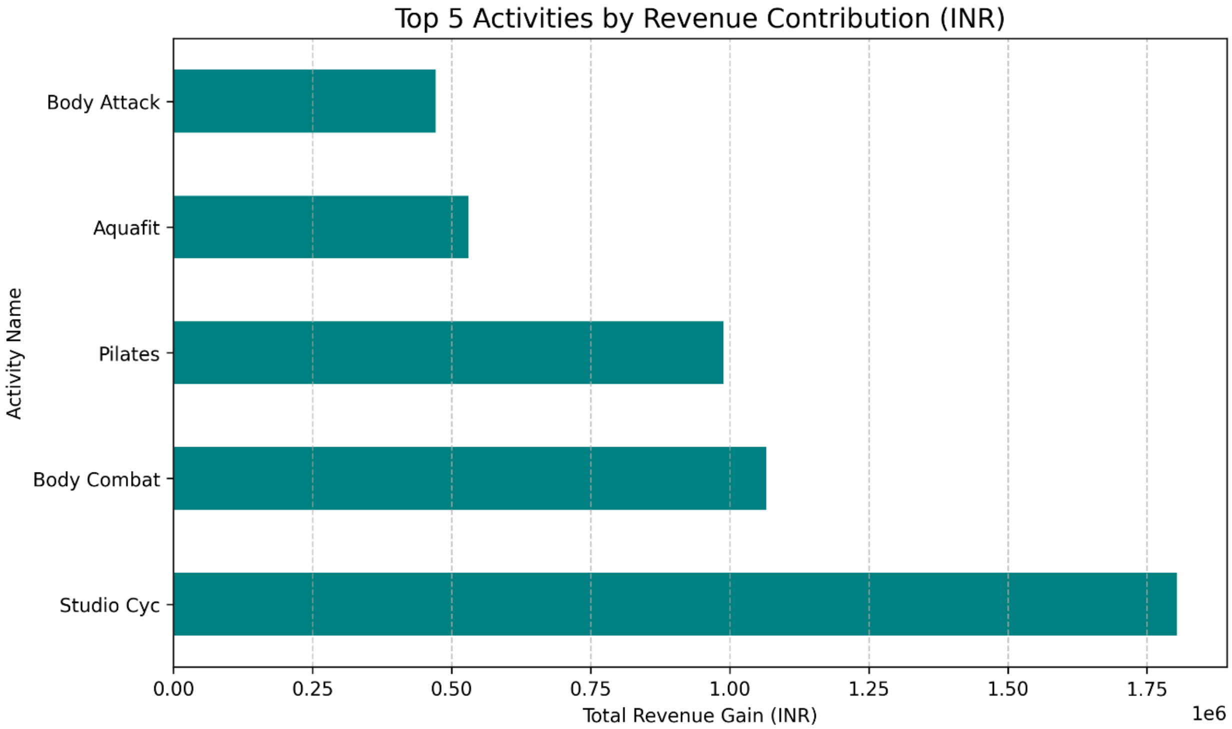
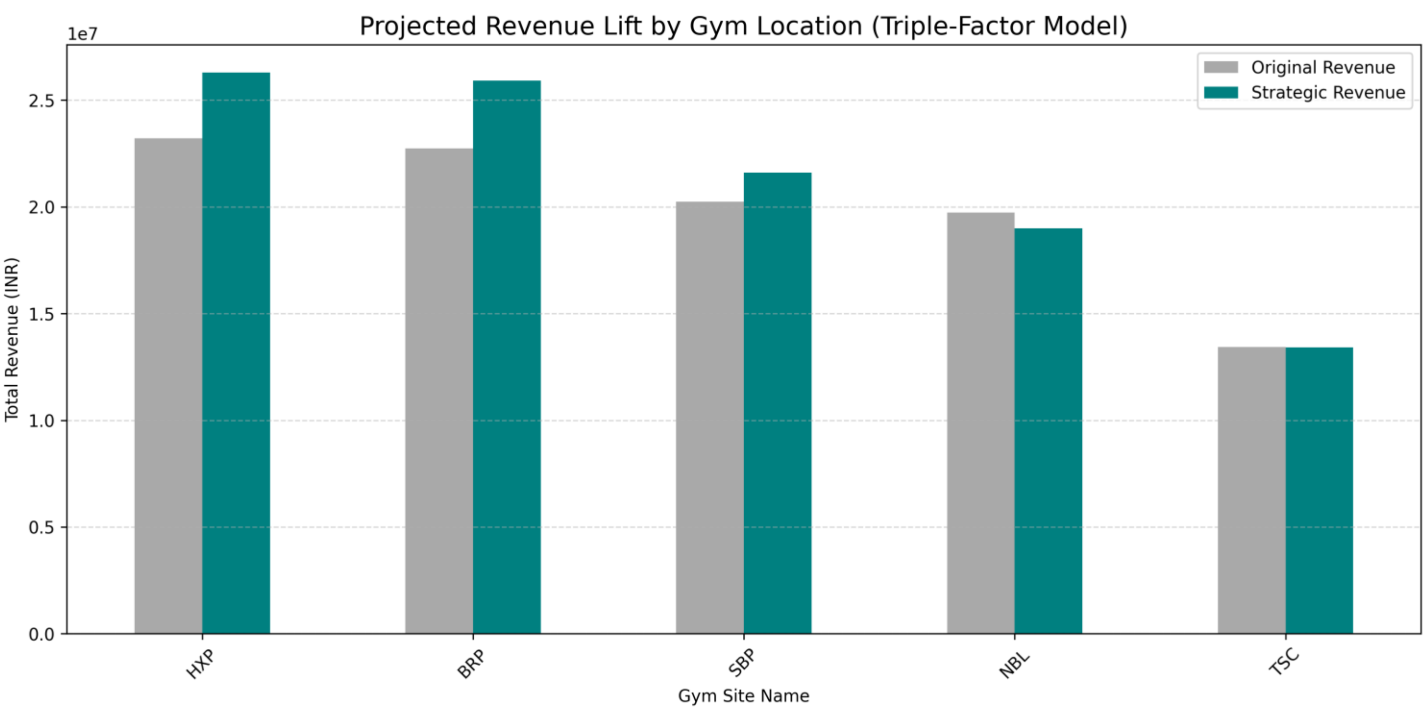



**Figure A3**: Seasonal decomposition of demand. The 'Daily' trend panel justifies the 'Power Hour' surge windows (06:00-09:00 and 17:00-20:00) used in the final pricing logic. Effect of Location and Activity decides final pricing

## Evidence 4: Revenue Contribution by Activity and Location

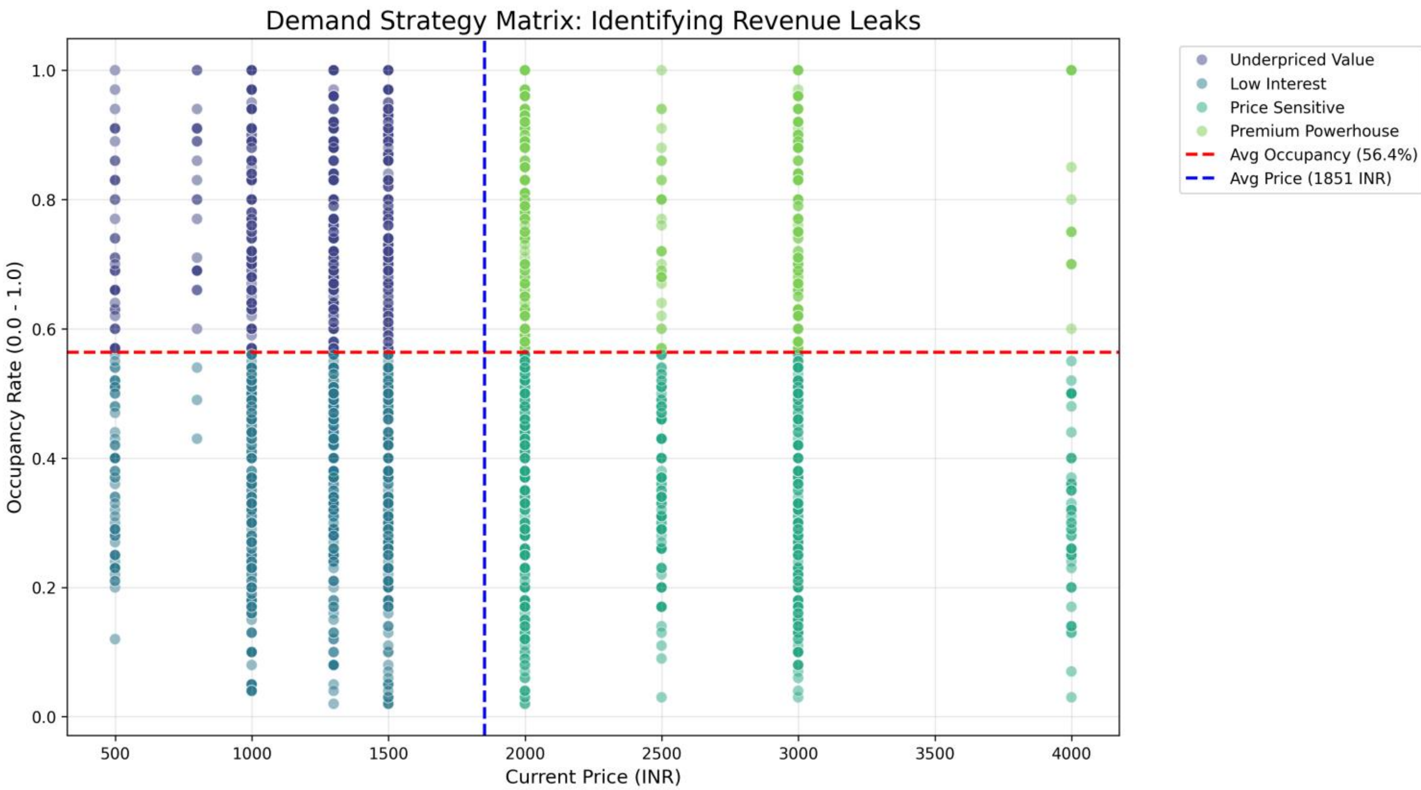



## Figure A4:

Projected Revenue Gain by Activity type. This highlights that Studio Cyc, Body Bombat, and Hxp,BRP are the primary engines of the projected 6.91% total revenue lift.

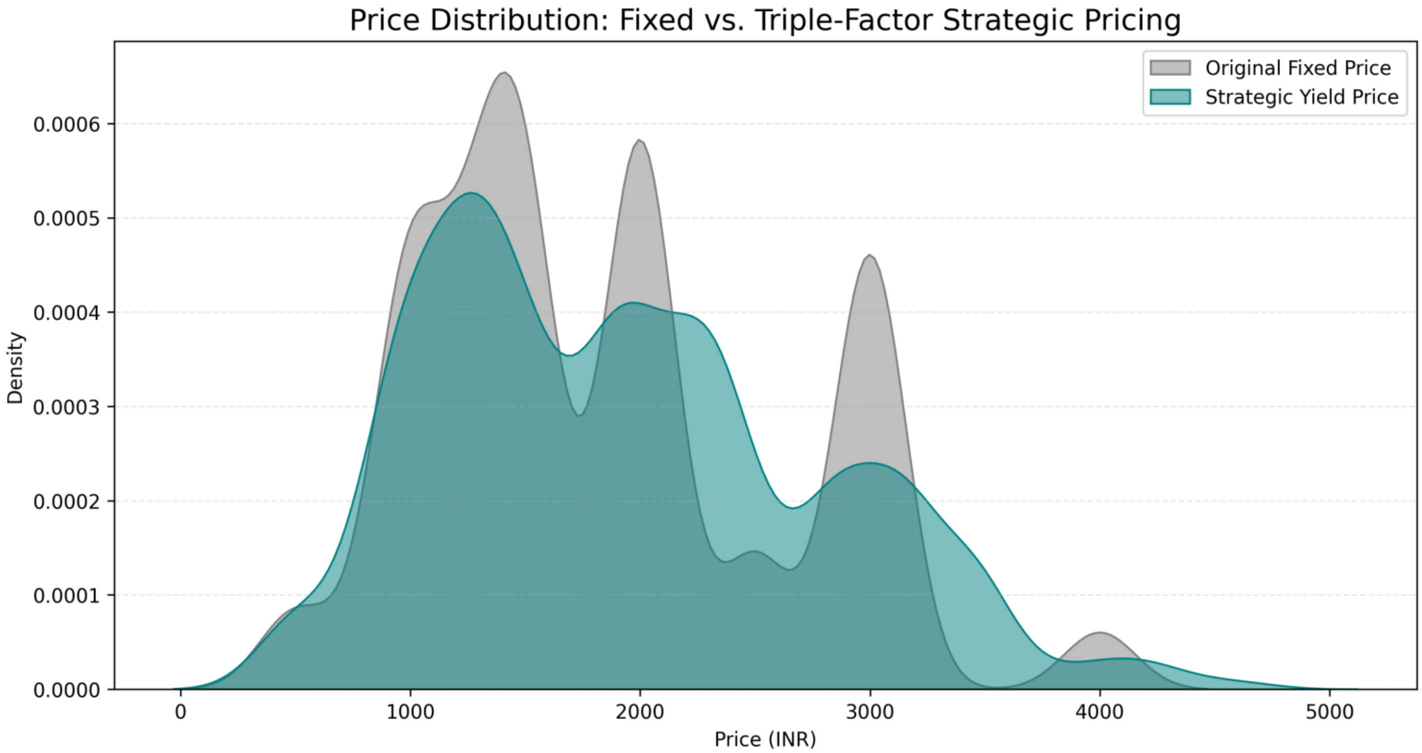
# Evidence 5: Demand Strategy Matrix




# Figure A5:

This is used to identify Revenue Leaks

## Evidence 6: Price Distribution: Fixed vs Triple Factor Strategic Pricing




## Figure A6:

## Evidence 7: Statistical Summary Table

```
                            OLS Regression Results
==============================================================================
Dep. Variable:           log_bookings   R-squared:                       0.035
Model:                            OLS   Adj. R-squared:                  0.034
Method:                 Least Squares   F-statistic:                     118.4
Date:                Mon, 23 Feb 2026   Prob (F-statistic):           4.03e-27
Time:                        18:51:41   Log-Likelihood:                -3784.7
No. Observations:                3289   AIC:                             7573.
Df Residuals:                    3287   BIC:                             7586.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.0198      0.221     22.691      0.000       4.586       5.454
log_price     -0.3235      0.030    -10.883      0.000      -0.382      -0.265
==============================================================================
Omnibus:                      742.512   Durbin-Watson:                   0.492
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1509.406
Skew:                          -1.331   Prob(JB):                         0.00
Kurtosis:                       4.982   Cond. No.                         126.
==============================================================================
```

## Table A1:

OLS Regression Summary. The P-value of 0.000 confirms that the impact of price on demand is highly significant and not due to random chance.