# Bayesian Regression-Based Marketing Mix Model (MMM)

Project Duration: September 2024 – December 2024

## Objective

To develop a predictive Bayesian MMM that quantifies the impact of marketing channels—Facebook, Google, TikTok, and Email—on sales performance. The model aims to:  
- Improve marketing ROI  
- Guide budget reallocation decisions  
- Adjust for ad saturation and lagged effects

## Methodology

### 1. Data Sources:

- Shopify Weekly Sales: shopify\_dtcfashionbrand\_weekly.xlsx  
- Channel Spend/Performance:  
 • Facebook Ads: facebook-all-time-weekly-performance.xlsx  
 • Google Ads: adwords-all-time-weekly.xlsx  
 • TikTok Ads: tiktok\_Alltime\_weekly.xlsx  
- Email Campaigns & Raw Inputs: Raw\_Data\_ClassProj.xlsx

### 2. Preprocessing Steps:

- Resampled daily data to weekly granularity  
- Synced date ranges across channels  
- Handled missing values using forward fill and interpolation  
- Converted spend to log-transformed values for interpretability

### 3. Feature Engineering:

- Generated adstocked variables using Hill-Adstock transformation  
- Captures saturation and lagged effect  
- Parameters tuned using grid search

## Modeling

### 1. Bayesian Regression Framework:

- Used PyMC for model inference  
- Sales modeled as function of adstocked channel spends  
- Included seasonality terms, control variables, and priors

### 2. Model Evaluation:

- R² ≈ 0.90: Excellent fit to actuals  
- MAPE ≈ 10%: Good forecasting accuracy  
- Posterior predictive checks confirmed calibrated uncertainty

## Insights

Channel | Contribution to Sales | ROI Impact | Action  
--------|------------------------|------------|--------  
Facebook | High | Positive | Increase Spend  
Google | Moderate | Neutral | Maintain Spend  
TikTok | Low | Negative | Decrease Spend  
Email | High | Very Positive | Retain & Test More

## Optimization Output

- Ran budget simulation scenarios using posterior samples  
- Proposed optimal budget split across channels to maximize ROI  
- Improved estimated incremental revenue while maintaining cost

## Deliverables

- Jupyter Notebook (Lightweight\_MMM\_Deep\_Dive\_112724.ipynb)  
- Transformed & aligned data sets

## Tools & Libraries

- Python (Pandas, NumPy, PyMC3, Arviz, Scikit-learn)  
- Excel  
- Matplotlib & Seaborn for visualization

## Challenges & Learnings

- Ensured data harmonization across platforms  
- Understood Bayesian vs frequentist interpretability  
- Applied adstock transformation theory  
- Practiced probabilistic programming for marketing analytics

## References

- Facebook Robyn: Analyst’s Guide to MMM: https://facebookexperimental.github.io/Robyn/docs/analysts-guide-to-MMM/