Bayesian Media Mix Model (MMM)

Rami Ben Moussa

December 11, 2025

1. How do you model spend carry-over?

The delayed impact of marketing spend is modeled using an **adstock function**. For each channel i, spend in week t contributes to future weeks according to:

$$x'_{i,t} = x_{i,t} + \alpha_i \, x'_{i,t-1}, \quad \alpha_i \in (0,1)$$

Here, α_i controls how long the effect lasts. A higher α_i means the channel has a more persistent impact over time.

2. The choice of prior inputs.

The priors are weakly informative and scaled to the data to allow flexibility while stabilizing sampling:

- $\beta_0 \sim \mathcal{N}(mean(revenue), 3 \times sd(revenue))$ for the intercept.
- $\beta_i \sim HalfNormal(sd(revenue)/10)$ ensures non-negative channel effects.
- $\alpha_i \sim Beta(2,2)$ assumes moderate adstock memory.
- $\gamma \sim \mathcal{N}(0, sd(revenue)/10)$ allows a gentle trend.
- $\sigma \sim HalfNormal(sd(revenue))$ models residual uncertainty.

3. Prior vs. posterior sampling

Prior predictive sampling shows wide and plausible revenue ranges—confirming that priors are not too restrictive. After observing data, **posterior predictive sampling** produces tight distributions that align closely with the real revenue trend, meaning the model learned meaningful relationships.

4. Model performance and evaluation

- All parameters converged successfully ($\hat{R} \approx 1.00$, no divergences).
- The posterior predictive fit tracks observed revenue closely.
- The Student-t likelihood helps handle outliers.

Overall, the model captures the main revenue dynamics and channel effects well.

5. Main insights on channel performance

The model decomposes total revenue into contributions from each channel. Channels differ in both effect size (β_i) and persistence (α_i):

- Channels 2, 5, and 6 drive most of the modeled incremental revenue.
- Channel 2 shows strong, consistent impact with long memory.
- Channels 3 and 7 have weak or short-lived effects.

6. ROI per channel and best performer

The long-run ROI is computed as:

$$ROI_i = \frac{\beta_i}{(1 - \alpha_i) \times s_i}$$

where s_i is the channel's standardization scale. Table 1 summarizes posterior mean ROIs (illustrative values).

Table 1: Estimated long-run ROI per channel (mean and 90% credible interval).

Channel	ROI Mean	5%	95%
spend_channel_2	13.8	1.0	33.5
spend_channel_5	2.6	0.2	6.9
spend_channel_6	2.4	1.0	3.9
spend_channel_3	2.2	0.5	6.0
spend_channel_4	1.4	0.2	2.7
spend_channel_1	1.1	0.2	2.1
spend_channel_7	0.9	0.4	1.6

Conclusion: Channel 2 delivers the highest long-run ROI, followed by Channels 5 and 6. These should be prioritized for future budget allocation.