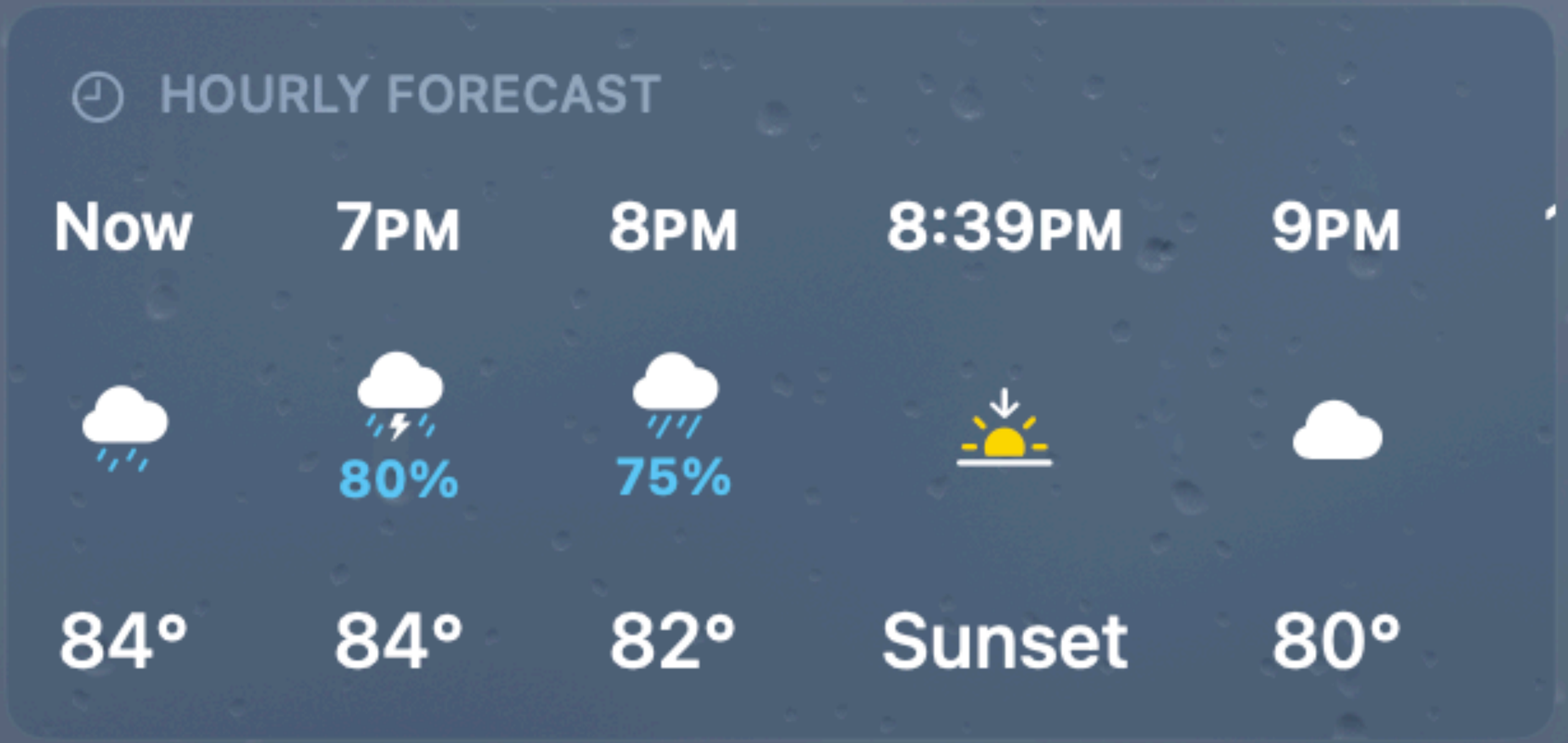
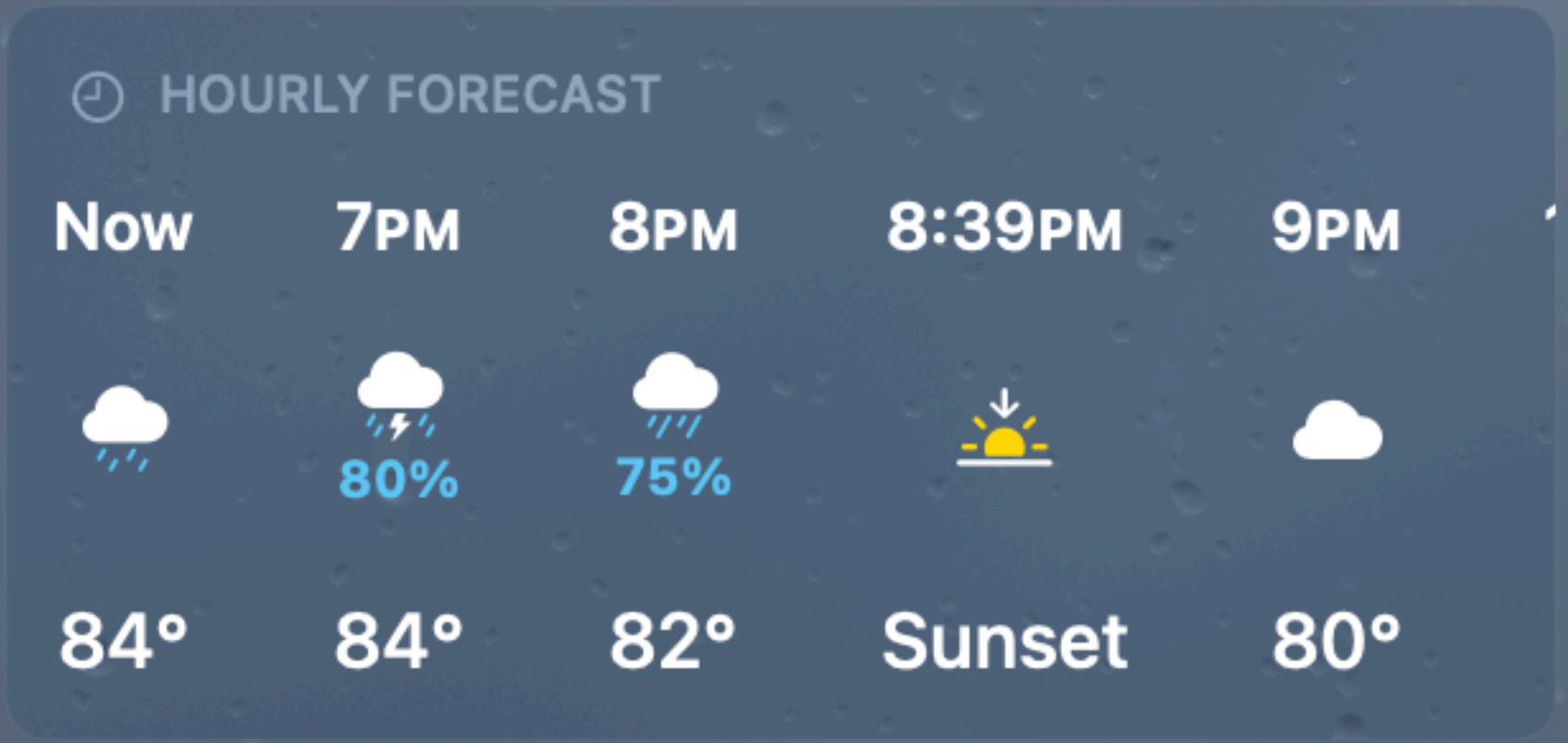
What we're seeing

(or, a probability forecasting primer)

Chad Janicek / 13 Aug 2025


HOURLY FORECAST
Now
7PM
8PM
8:39PM
9PM
80%
75%
84°
84°
82°
Sunset
80°


THIS IS NOT GONNA END WELL FOR YOU, NO.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Definition

Probability Forecast

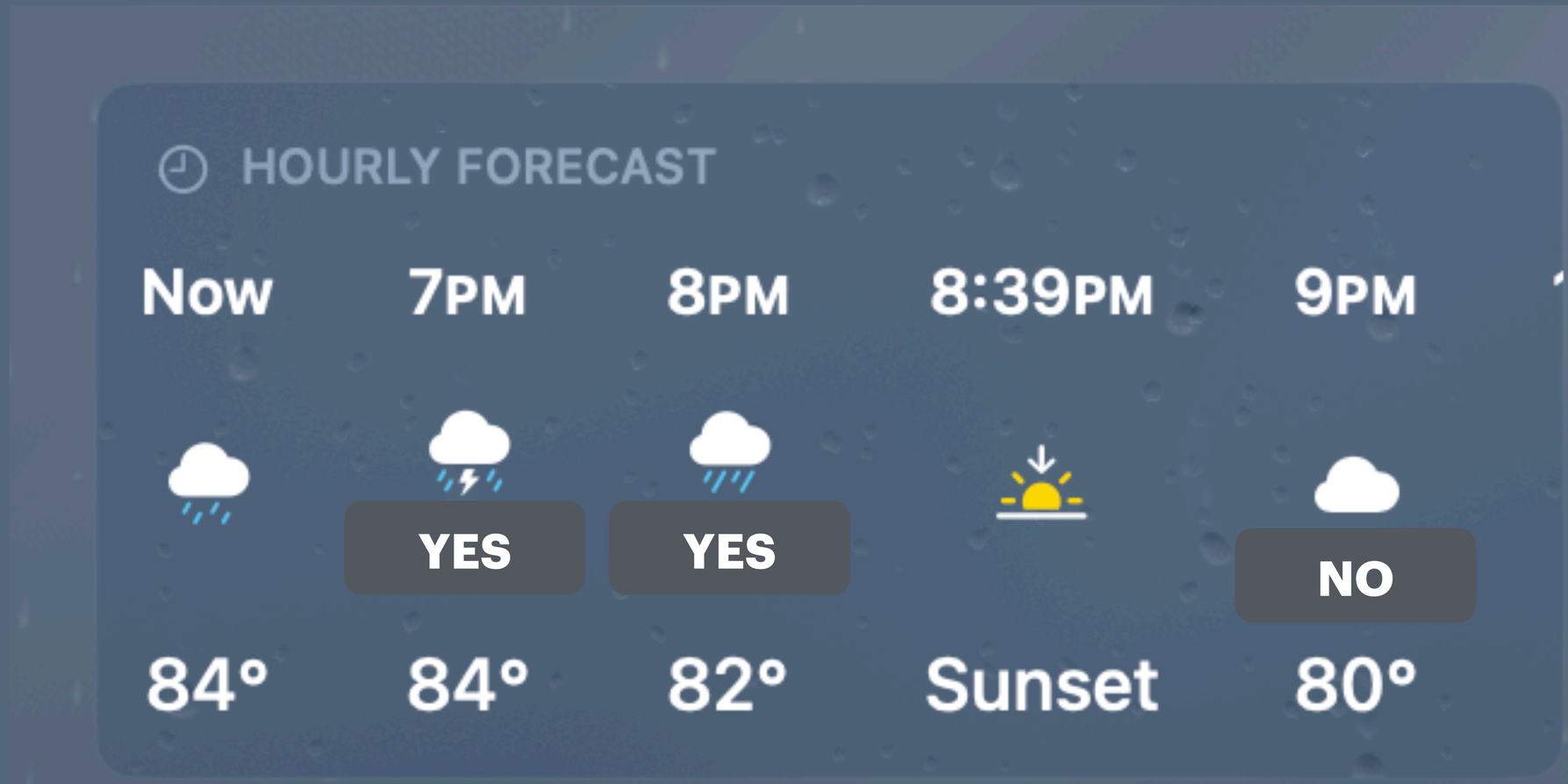
A prediction that quantifies the **likelihood or chance** of various future outcomes or events occurring.

(See also: probabilistic forecast)

Definition

Deterministic Forecast

A forecast that provides a **single, specific prediction** for a future outcome or event, without considering the likelihood of other possible outcomes.


HOURLY FORECAST
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9PM
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YES
NO
84°
84°
82°
Sunset
80°

Definition

“PRO” Style Forecast

A forecast that provides a multiple specific predictions, often a **Pessimistic**, a **Realistic**, and an **Optimistic** prediction, but without considering the likelihood of any of the predicted outcomes.

(See also: Goldilocks forecast)

Rambo
@RamboMizzou

Dropping my best case and worst case scenarios:

Alabama
Best: 12-0
Worst: 0-12

Arkansas
Best: 12-0
Worst: 0-12

Auburn

Best: 12-0
Worst: 0-12

Florida

Best: 12-0
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Georgia

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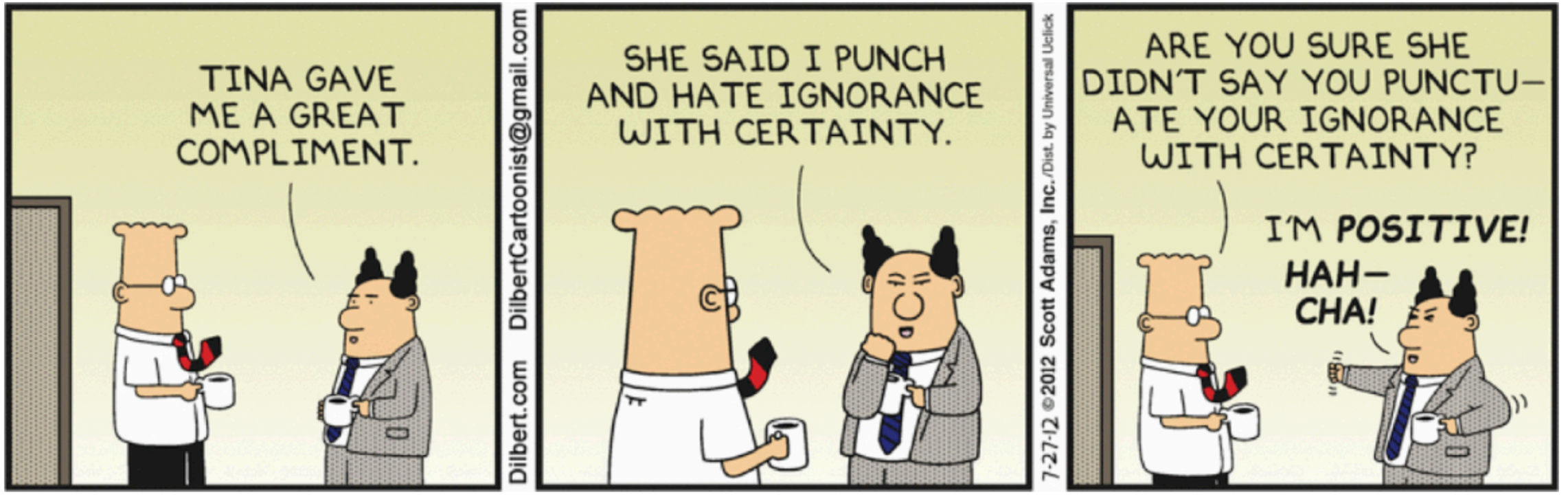
TINA GAVE ME A GREAT COMPLIMENT.
SHE SAID I PUNCH AND HATE IGNORANCE WITH CERTAINTY.
ARE YOU SURE SHE DIDN'T SAY YOU PUNCTU-ATE YOUR IGNORANCE WITH CERTAINTY?
I'M POSITIVE!
HAH-CHA!
Dilbert.com DilbertCartoonist@gmail.com
7-27-12 ©2012 Scott Adams, Inc./Dist. by Universal Uclick

"Probability forecasting is the worst form of forecasting, except for all those other forms that have been tried from time to time.

- Sir Winston Churchill, probably

Call Me “Maybe”

What we’re seeing…


and now it's time for something
completely different

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Let’s define some terms

Definition

Uncertainty

The existence of more than one possible outcome.

Definition

Probability

The extent to which an event is likely to occur

Ex: 30% or 50/50

How we measure uncertainty

Definition

Risk

A state of uncertainty where one or more outcomes involves an undesirable result

Ex: sales tax could decline, yikes!

Definition

Exposure

The real-world value of a possible negative outcome, often combined with the probability of the event

Ex: A 10% chance that sales tax declines by $1mm

How we measure risk

When should we reach for probability forecasting?

- When we have a high degree of uncertainty
- When we have complex or noisy historical data
- When quantifying our risk is required for informed decision making

Let’s look at some examples

1. Sales tax forecasting

Challenges

- Noisy historical data
- Lots of possible variables
- Influenced by outside economic factors
- Bad things can happen when you’re wrong

How to build a simulation

- Identify your variables
- Define *prediction intervals* for each one
- For each simulation, randomly select a value for each variable (often from a normal distribution)
- Summarize the results of all simulations

1. Identify your variables

- Growth by industry
- Population growth
- Inflation
- New businesses expected to open

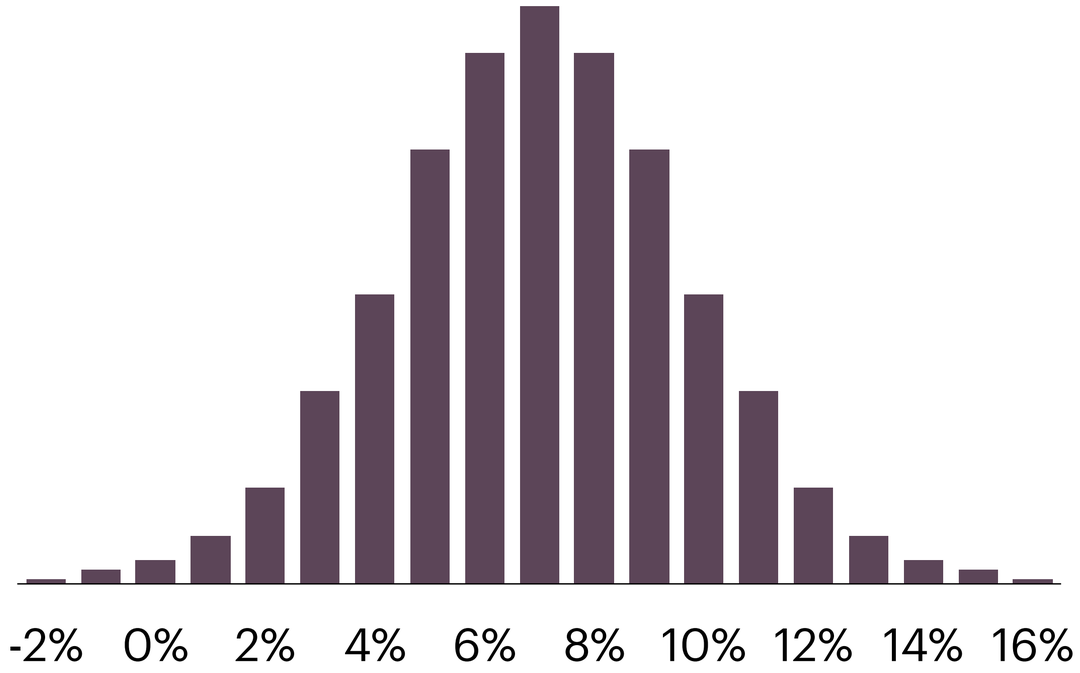
2. Define *prediction intervals*

e.g., 90% confidence intervals

- Retail will grow between 2% and 12%
- Population will grow between -1% and 1%
- Inflation will average between 2% and 4%
- New In-n-Out will open between Dec 2025 and Apr 2026

3. Randomize value selection

e.g., using a normal distribution

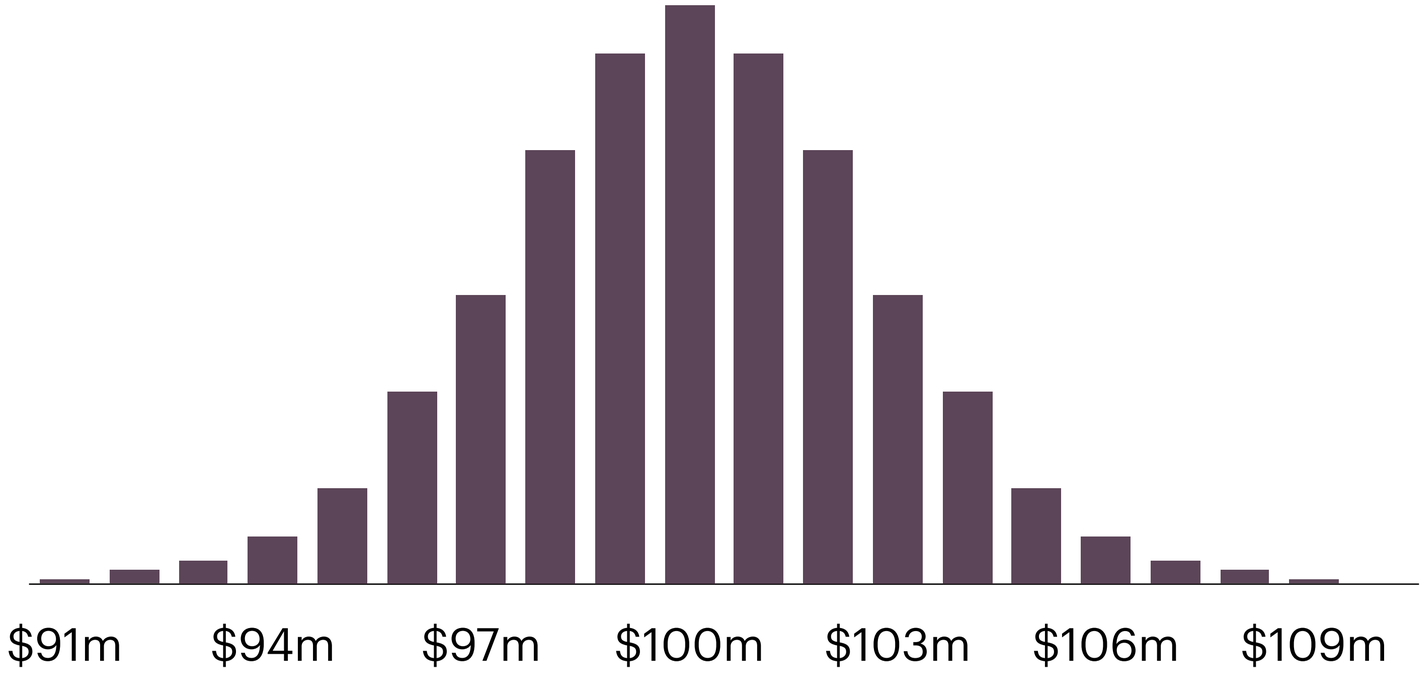


7.5% Simulation 1

2% Simulation 2

4% Simulation 3

4. Summarize the results



4. Summarize the results

Variance from Budget	Probability
>5% below	3%
0-5% below	25%
0-5% above	57%
>5% above	15%

How to use this info

Example scenario

- Budget recommendation: $85m (at 60% likelihood)
- Council wants to increase sales tax $2m for new projects
- Reduces likelihood to 40%

How to use this info

- Risk-weighted gap
- Value-at-risk
- Expected shortfall
- Etc.

Excel formulas

Pick a random number from a normal distribution

NORM.INV()

Pick a random number from a uniform distribution

RANDBETWEEN()

2. Economic Development Analysis

Retail recruitment

Project overview

- Major grocery development
- Lots of public improvements needed
- Uncertain timelines
- Short term general fund subsidies required
- How long until the city was generating positive revenue?

Retail recruitment

Known unknowns

- Store opening
- Property values at buildout
- Sales tax revenue generated
- Annual debt service for public improvements

Retail recruitment

Known unknowns

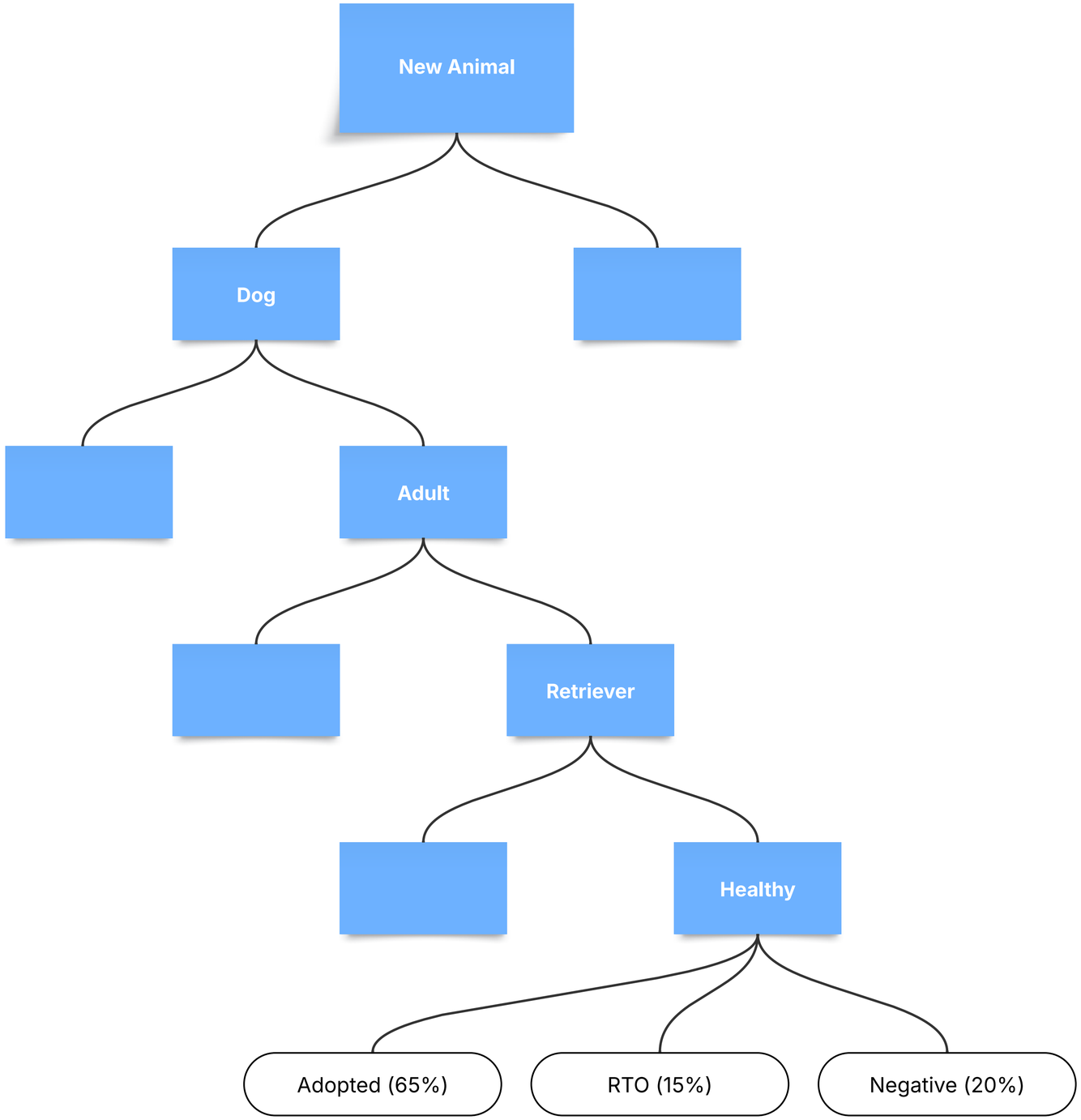
Variable	Lower Bound	Upper Bound
Opening Date	?	?
Property Value	?	?
Sales Taxes	?	?
Annual Debt Service	?	?

Retail recruitment

Results (expected subsidies)

	Lower Bound	**Upper Bound**
Year 1	$100k	$200k
Year 2	$25k	$80k
Year 3	$0	$25k

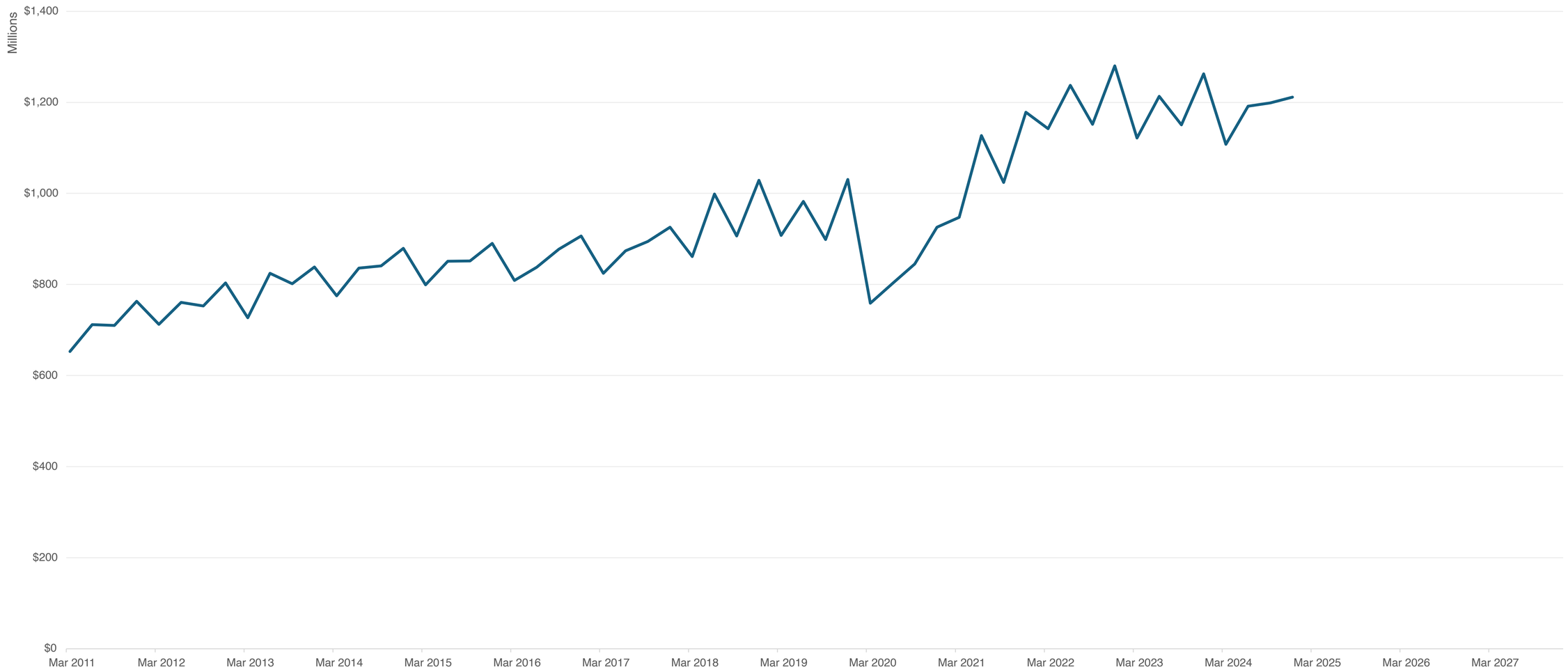
3. Animal Shelter Outcomes

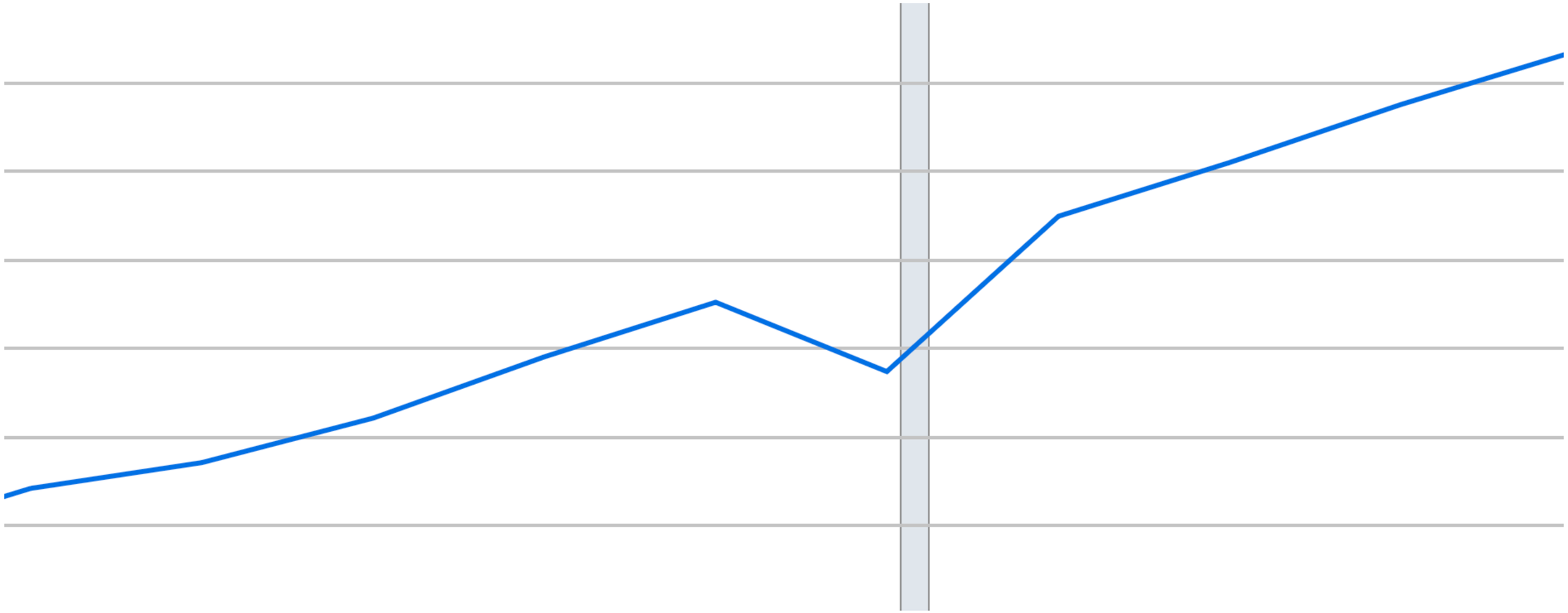

New Animal
Dog
Adult
Retriever
Healthy
Adopted (65%)
RTO (15%)
Negative (20%)

What we're seeing...

Quarterly collections

Southern California only





Quarterly collections

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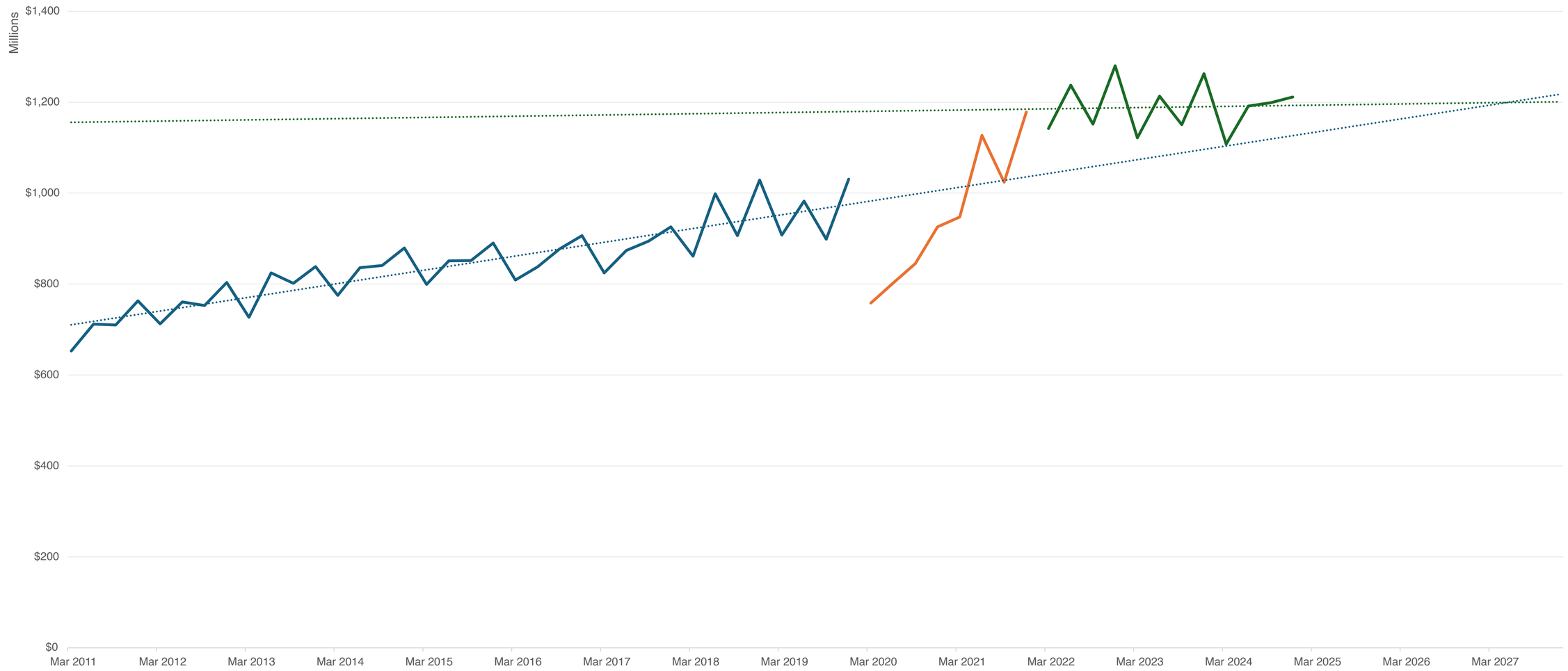
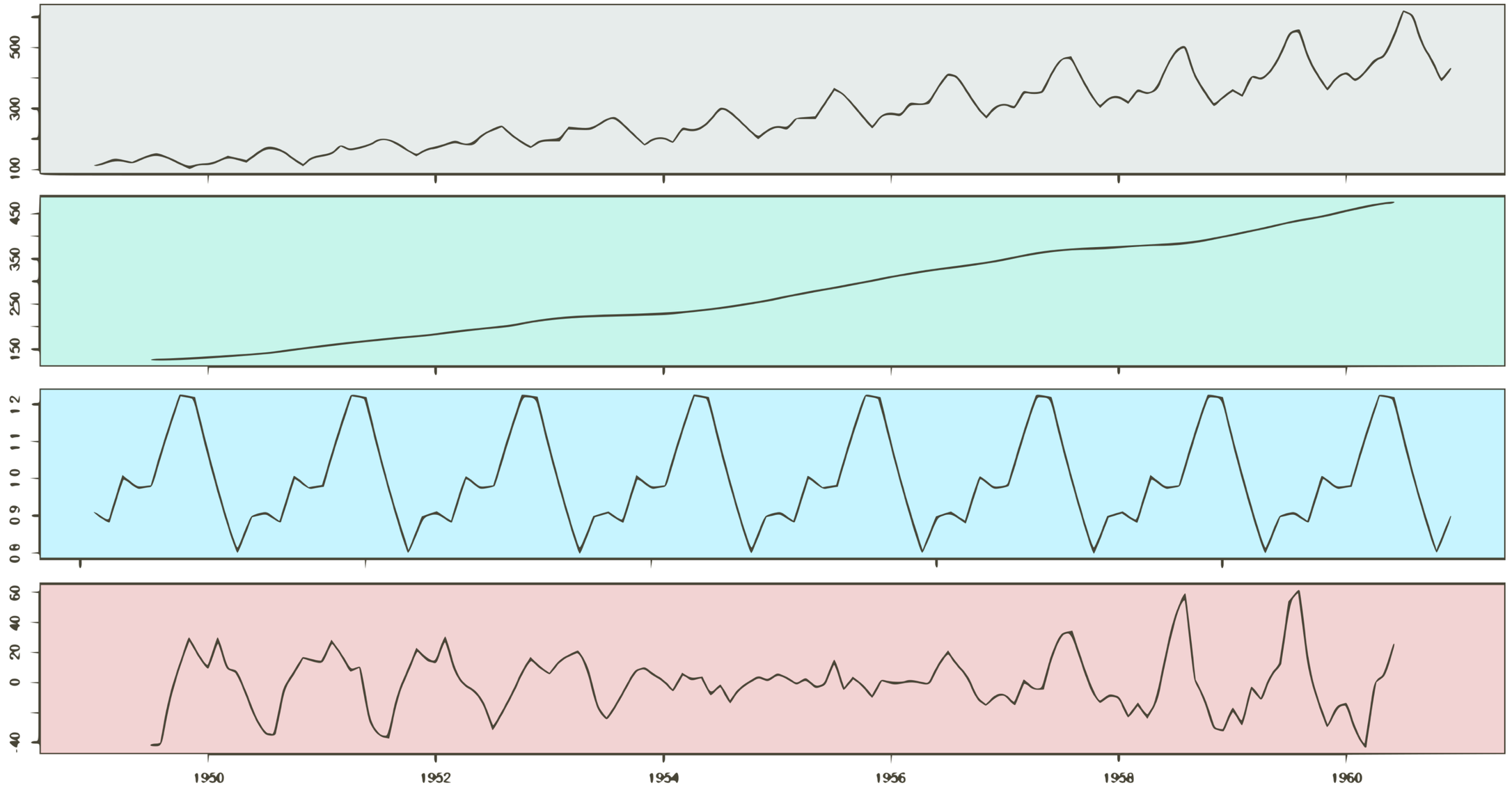


We built two different models

- Bayesian Structured Time Series
- Multi-Layer Perceptron

Bayesian Structured Time Series

- Decomposes traditional elements of time series data
  - Trend, Seasonality, Residual (noise)
- Adds Bayesian Priors to the model


100
300
500
150
250
350
450
0.8
0.9
1.0
1.1
1.2
-40
0
20
40
60
1950
1952
1954
1956
1958
1960

Bayesian Structured Time Series

- Decomposes traditional elements of time series data
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Want to learn more about Bayes?

- Try “Bayesian Statistics the Fun Way” by Will Kurt

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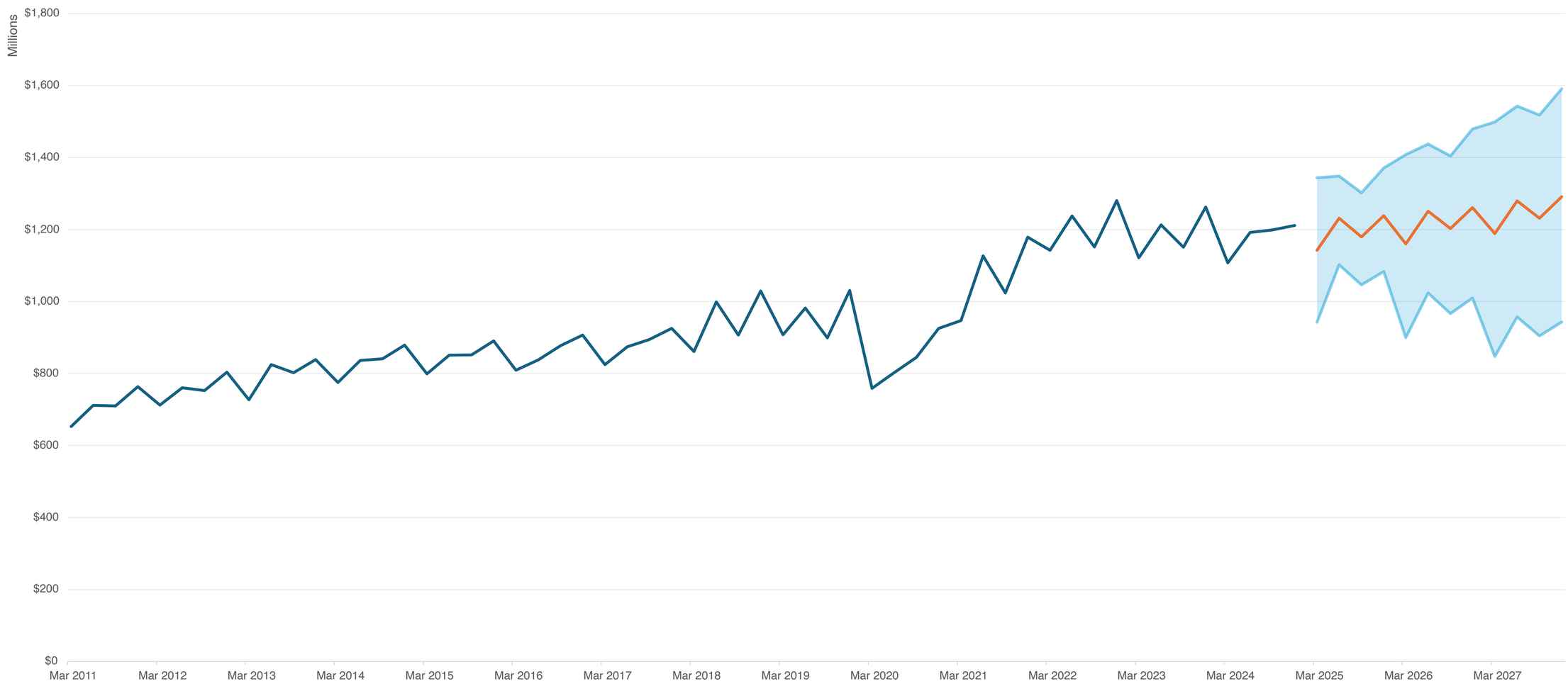
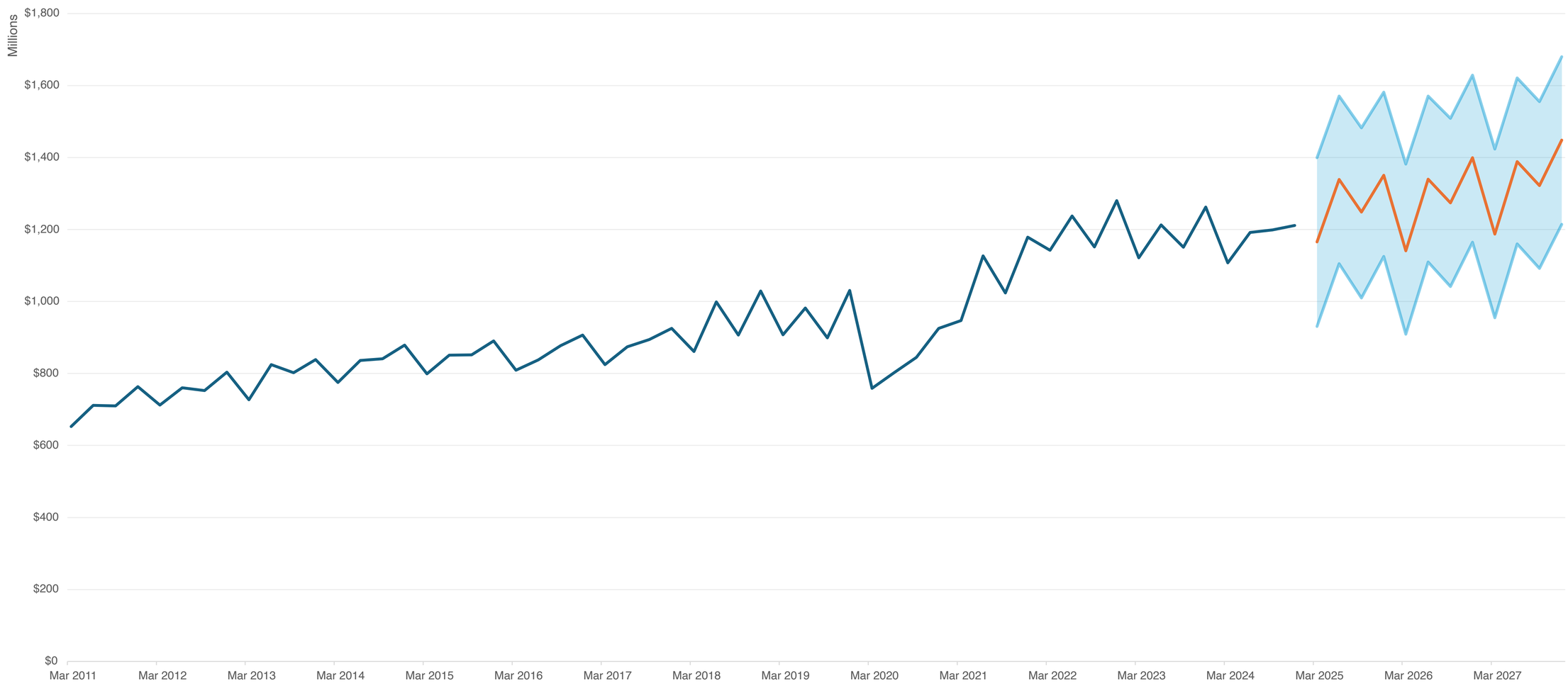
Bayesian Structured Time Series



Multi-Layer Perceptron

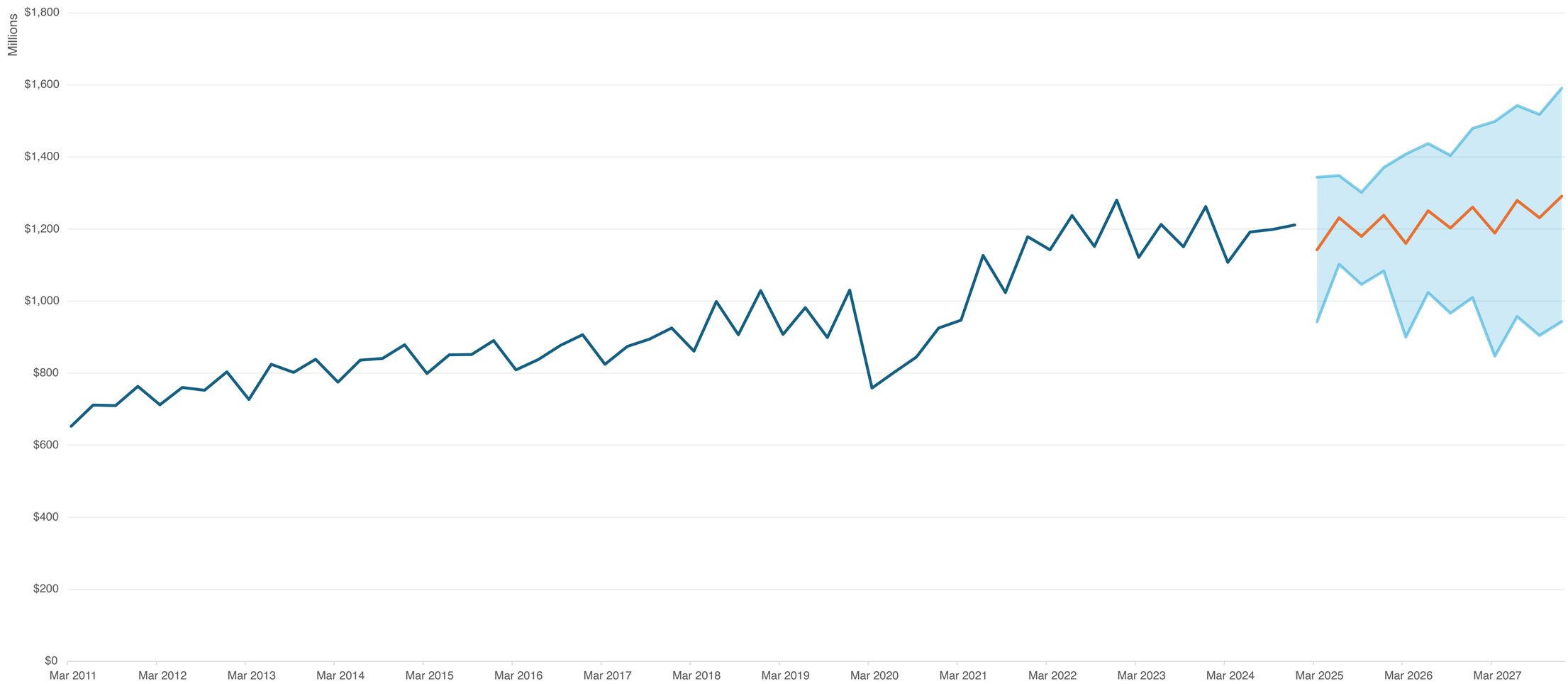
- A type of neural network
- Learns from our features (as well as dummy columns to help explain the seasonality and trend)
- After training, we can use the model to predict what happened in the past. Then we can use the errors in those predictions to help improve our predictions for the future.

Multi-Layer Perceptron



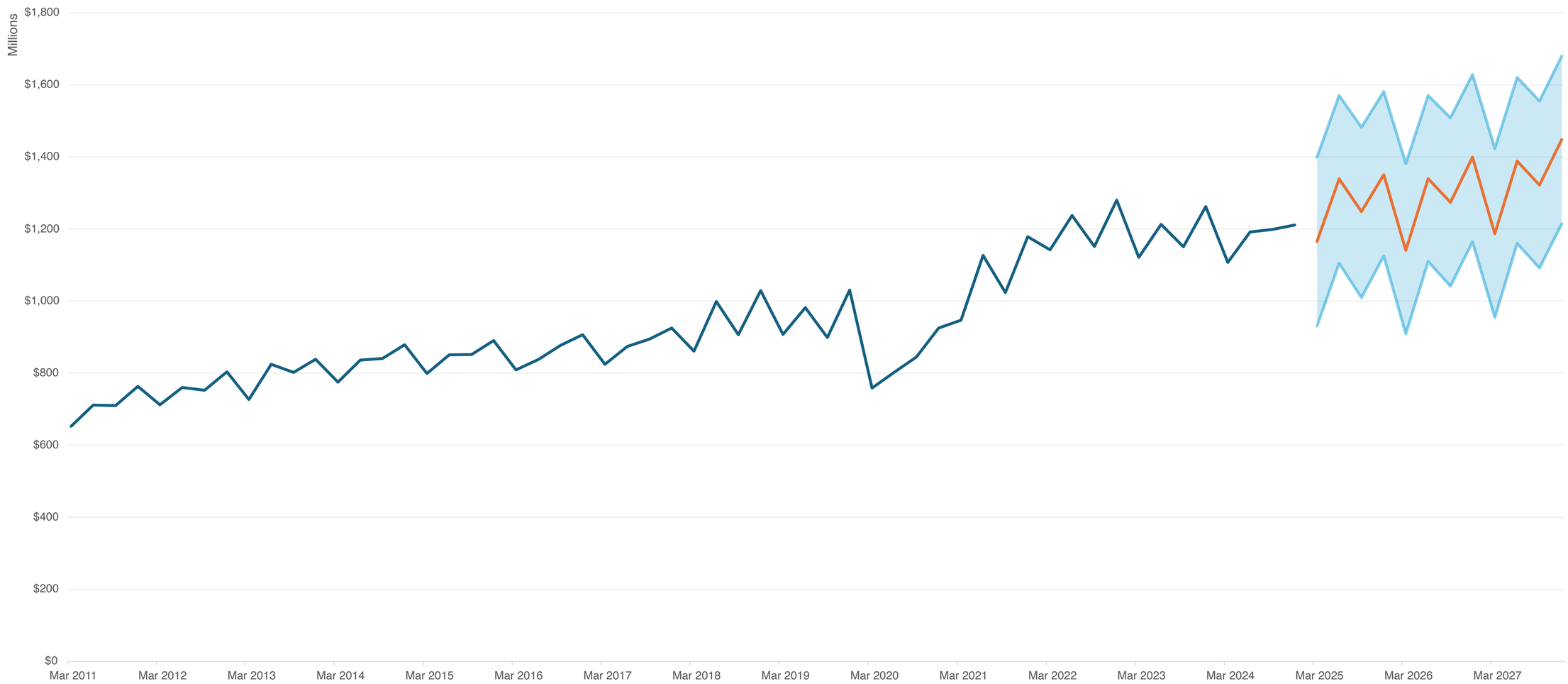
Comparing the two models

Bayesian



Comparing the two models

MLP



So, what are we seeing?

- Modest growth over the next 18-24 months
- Slower growth than you were probably used to pre-Covid
- Some downside risk, particularly 12+ months out

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