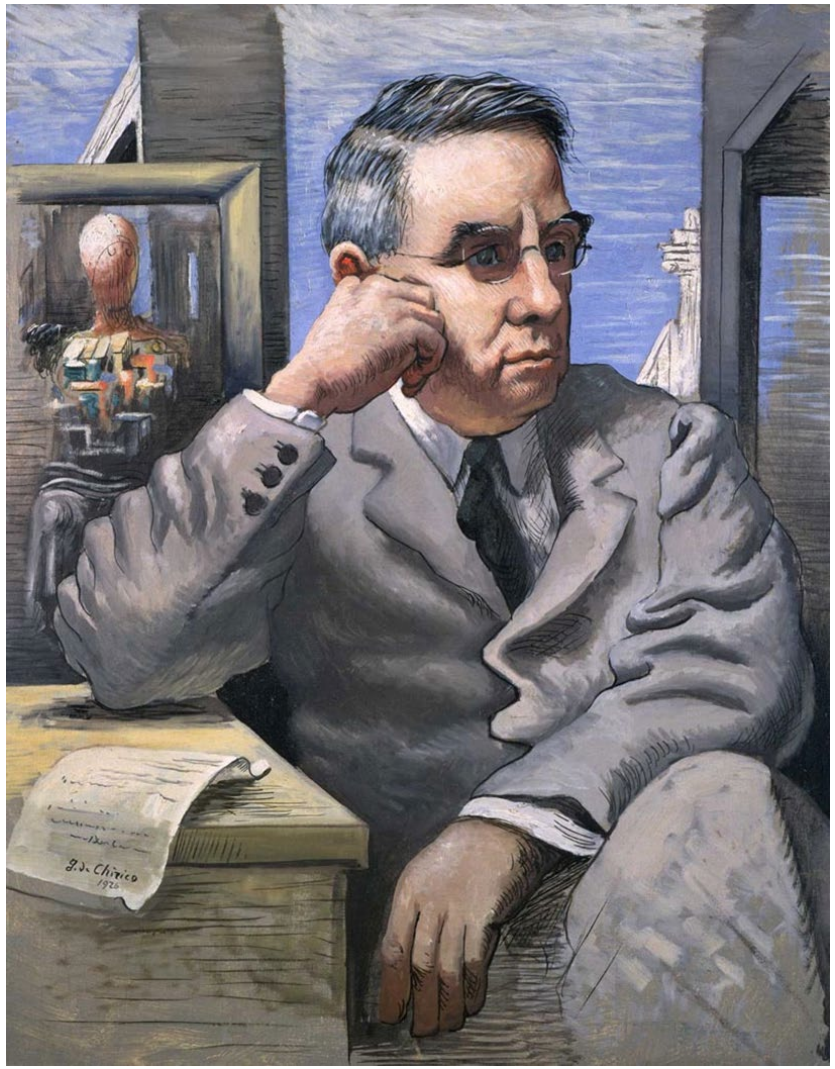
THE BARNES FOUNDATION


G. de Chirico
1926

# Goals for a predictive analytics model

- Pricing
- Revenue projection
- Visitation and attendance behavior
- Products and offers

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# The Barnes Foundation / WCAI

## Summary of findings

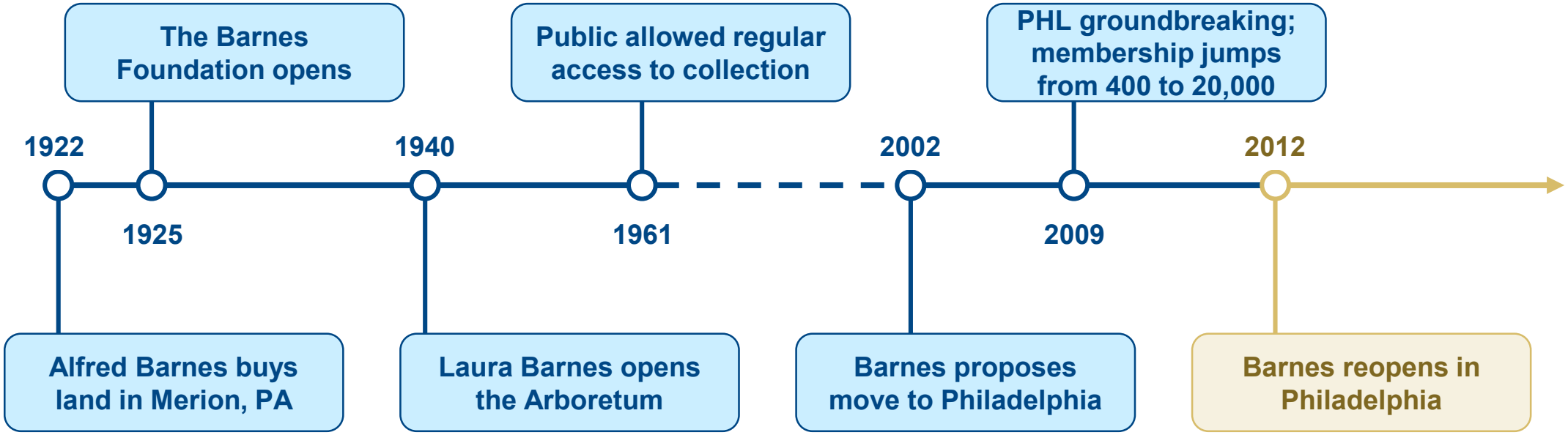
May 16, 2019

# Executive summary

- Barnes asked WCAI to help anticipate attendance
- WCAI modeled non-member and member attendance, testing three drivers:
  - Barnes effects (e.g., pricing and exhibits)
  - Competitive effects (e.g., peer pricing and attendance)
  - Macro effects (e.g., seasonality and unemployment)
- Models were selected on the basis of statistical robustness, stability, and business intuition
- Most important factors were pricing, special events / exhibitions, and seasonality
- Models anticipate moderate declines in attendance in a “do nothing” scenario; however price discounts and special exhibitions/events arrest decline

# The Barnes Foundation has a storied 96-year history – but has only been in Philadelphia since 2012

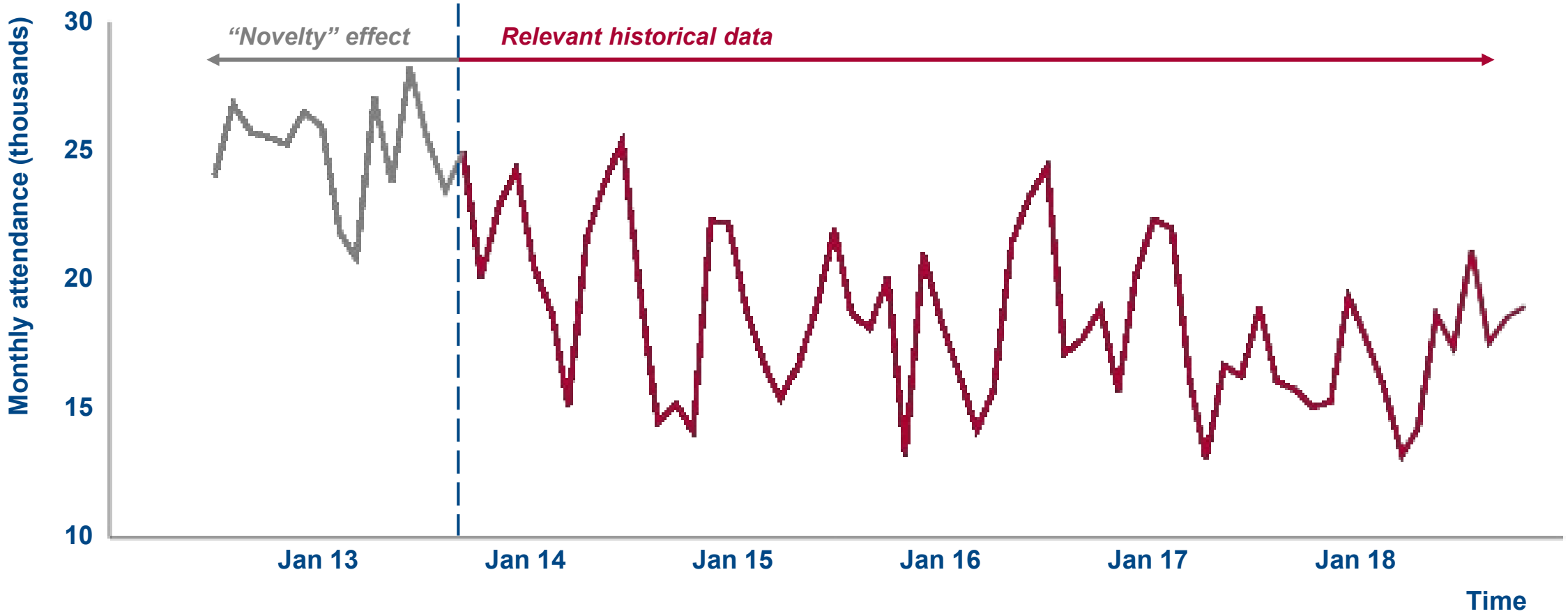
## A brief history of the Barnes Foundation




Source: The Barnes Foundation; The New York Times (A Museum, Reborn, Remains True to its Old Self, Only Better)

# The relocation has made it difficult to anticipate attendance – only recently is there sufficient history to model demand

**Barnes attendance since relocation**




Source: The Barnes Foundation

# WCAI sought to deliver a demand forecasting model to effectively use the data Barnes has collected

## Our task

| | |
|---|---|
| **Project goals** | • Provide “do-nothing” attendance forecast |
| | • Anticipate impact of Barnes’ actions on attendance |
| | • Provide insights as Barnes builds analytics capabilities |
| **Design choices** | • Minimize analytical complexity |
| | • Minimize implementation complexity |

## Our deliverable

**Attendance forecast**

*Quarterly attendance and revenue projections*

**Key**

| |
|---|
| User (scenario) input |
| Calculated field |
| Model output |

**Scenario definition**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Most recent quarter** | 201806 | | | | | |
| | | **Q3** | **Q4** | **Q1** | **Q2** | |
| **Price change (%)** | | -9% | 0% | 0% | 0% | *% change versus prior quarter* |
| | | **Q3** | **Q4** | **Q1** | **Q2** | |
| ***Non-member events*** | | | | | | |
| **Special exhibitions** | | 1 | 0 | 1 | 0 | *1 if a new exhibition starts in this quarter; 0 if no* |
| | | **Q3** | **Q4** | **Q1** | **Q2** | |
| ***Members and free events*** | | | | | | |
| **Exhibition Preview** | | 0 | 0 | 1 | 0 | *1 if an exhibition preview is offered to Members starts in this quarter; 0 if no* |
| **First Sunday** | | 0 | 0 | 1 | 0 | *1 if the First Sunday programming is offered in this quarter; 0 if no* |
| **Student Night** | | 0 | 0 | 1 | 0 | *1 if the Student Night programming is offered in this quarter; 0 if no* |

**Projections (quarterly)**

| ***Non-members*** | **201806** | **Q3** | **Q4** | **Q1** | **Q2** | **Cumulative year** |
|---|---|---|---|---|---|---|
| Attendance | 39,695 | 37,603 | 37,808 | 31,460 | 39,695 | 146,566 |
| Average price | $ 20.97 | $ 19.19 | $ 19.19 | $ 19.19 | $ 19.19 | -8.5% |
| Revenue | $ 832,488 | $ 721,575 | $ 725,516 | $ 603,705 | $ 761,728 | $ 2,812,524 |

**Projections** | Calculations> | Member and Free model | Non-member model | Monthly aggregated | Quarterly aggregated | Special exhibit days in Q | Data> | Overview Data | 2018 Forecast | Special Exhibits

- **Embedded in current reporting templates**
- **Requires no additional work to use and update**

# We approached the problem in three steps

| | | |
|---|---|---|
| 1 | **Define model structure**<br>• How should we segment the population?<br>• Over what time step should we model? | • Segment for populations that have different expected demand drivers and historical experience<br>• Select granular time step while minimizing “noise” |
| 2 | **Hypothesize demand drivers**<br>• Which factors drive demand for each segment?<br>• Which factors are actionable by Barnes? | • Identify long-list of variables capturing Barnes actions, competitor actions, and macro factors |
| 3 | **Select model**<br>• Given hypothesized drivers, which model best captures attendance? | • Filter for statistical significance & business intuition<br>• Select top models by back-test performance<br>• Further filter on secondary statistical tests |

# Step 1: Define model structure (1/2)
## We developed separate models for members and non-members

**Basis for segmentation**

- Members / non-members should **respond differently** to Barnes actions (e.g., prices)
- Historically **observe different behavior**
- More granular segmentation risks compounding model error for limited benefit

**Non-member vs member attendance**
Thousands of quarterly visitors


Source: The Barnes Foundation

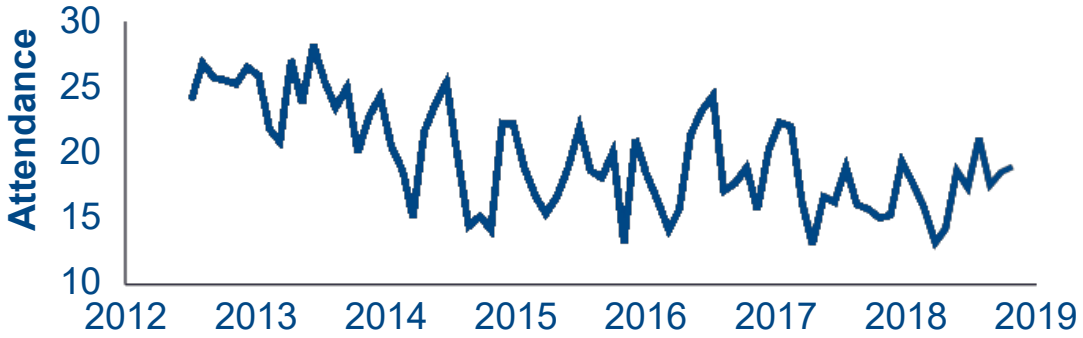
# Step 1: Define model structure (2/2)
## We elected to model attendance on a quarterly time-step

**Basis for decision**

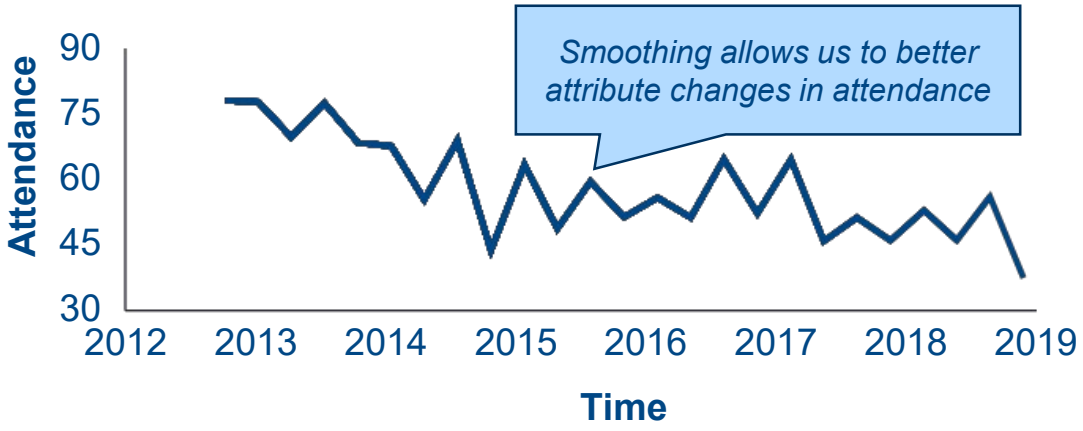
- Quarterly data smooths random variation in attendance, allowing us to **better observe economic effects**
- Quarterly forecasts are fit for budgeting and planning purposes

**Quarterly vs monthly attendance**

Monthly data




Quarterly data




Source: The Barnes Foundation

# Step 2: Hypothesize demand drivers

## We expect demand to respond to Barnes actions, competitor actions, and macro factors

**Attendance** = (A) **Barnes actions** + (B) **Peer actions** + (C) **Macro factors**

**Non-members**

- Prices / discounts
- Special exhibitions

**Members**

- Member-only events
- New members added
- Membership drives

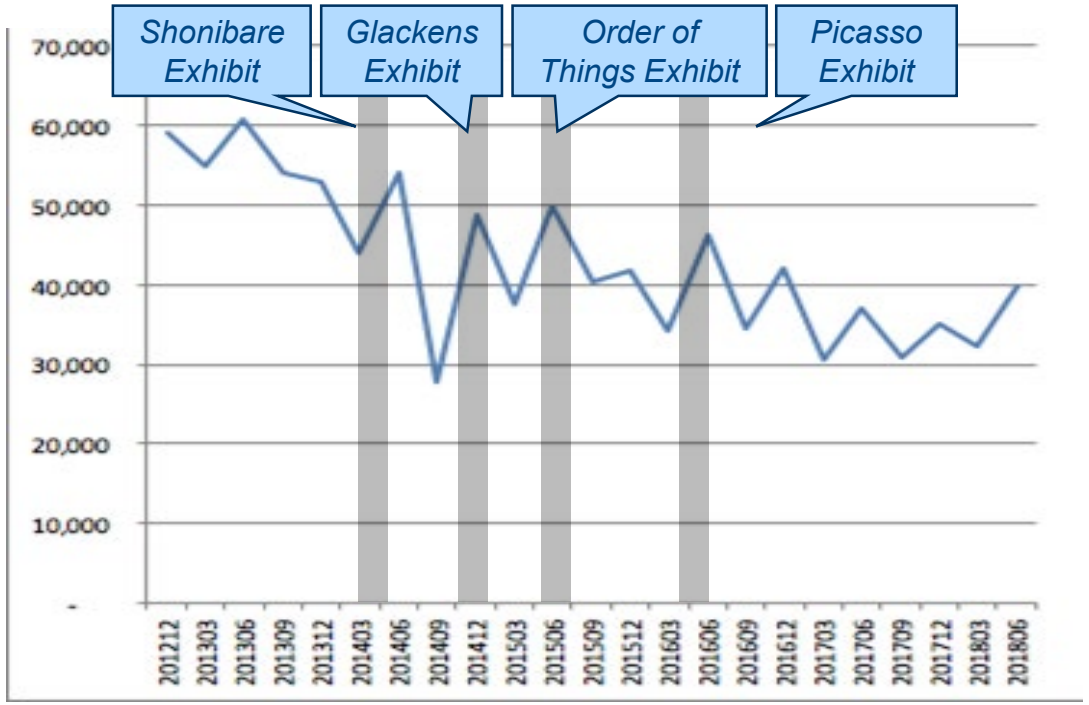
- Peer attendance over time measures
- Historical trends

- Seasonality
- PHL economic health (e.g., unemployment)
- PHL cultural attraction health (i.e., attendance across institutions)

# Step 2A: Hypothesize demand drivers (1/2)

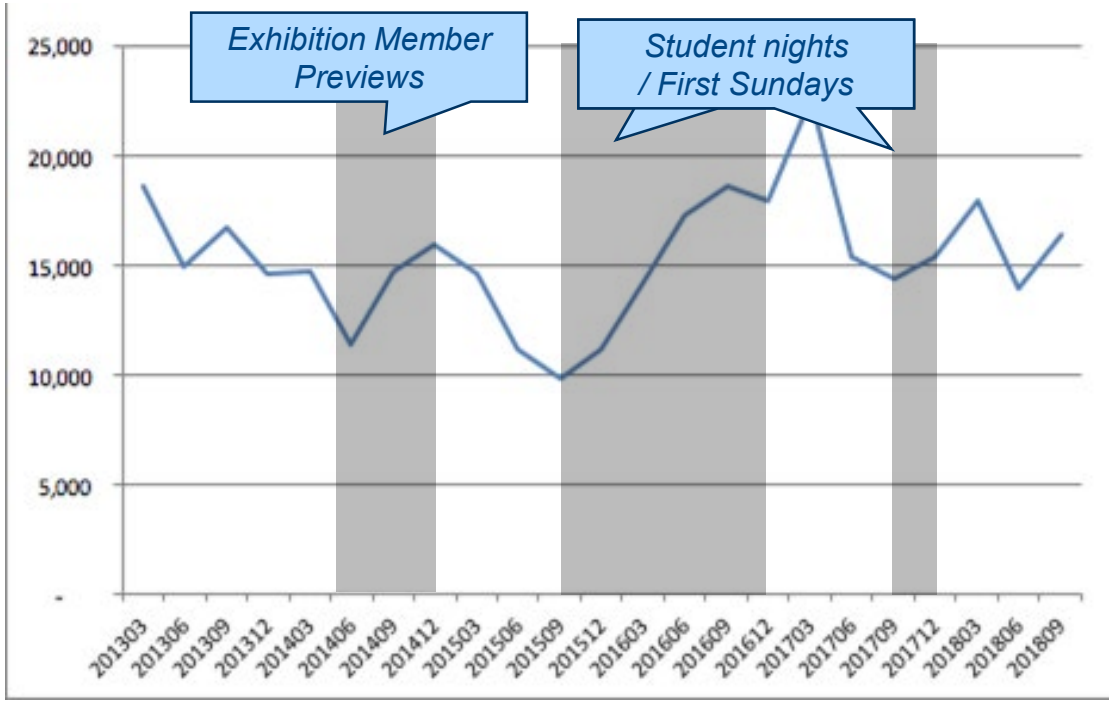
## We see a meaningful effect of special exhibits/events on attendance

**Non-member attendance**




Peaks in the non-member attendance often correspond with special exhibitions

**Member attendance**



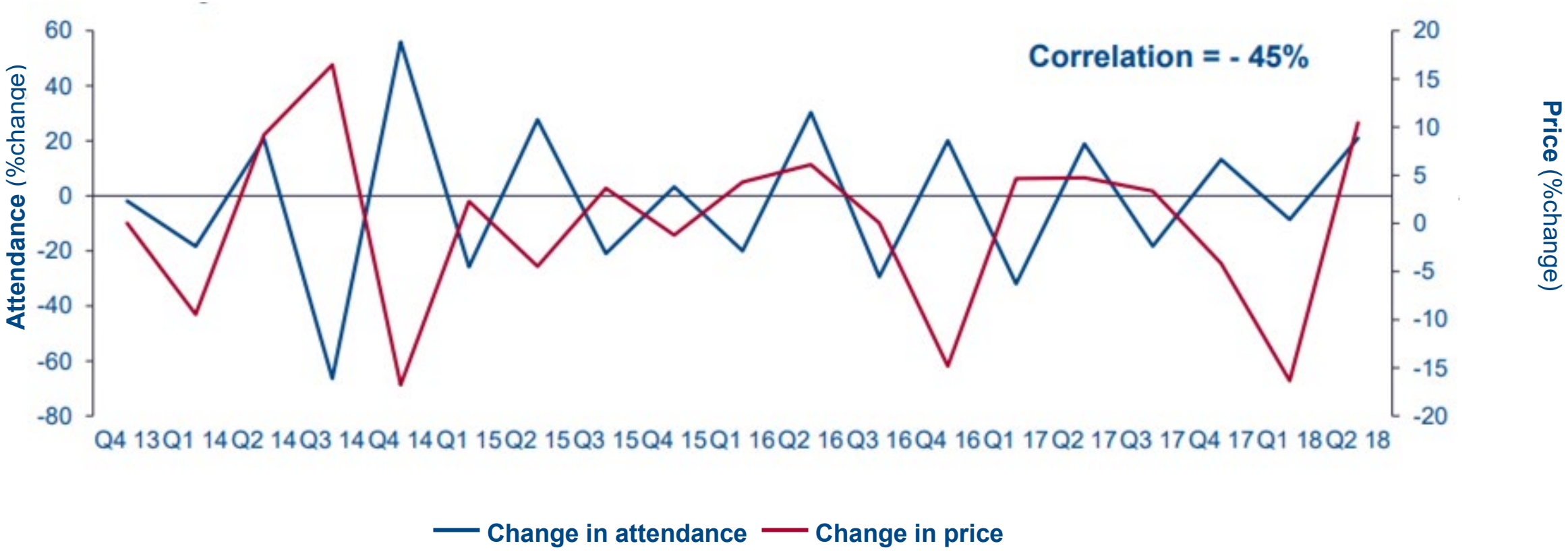

Peaks in the member attendance often correspond with special member-only events

# Step 2A: Hypothesize demand drivers (2/2)

## We observe an inverse relationship between price and attendance

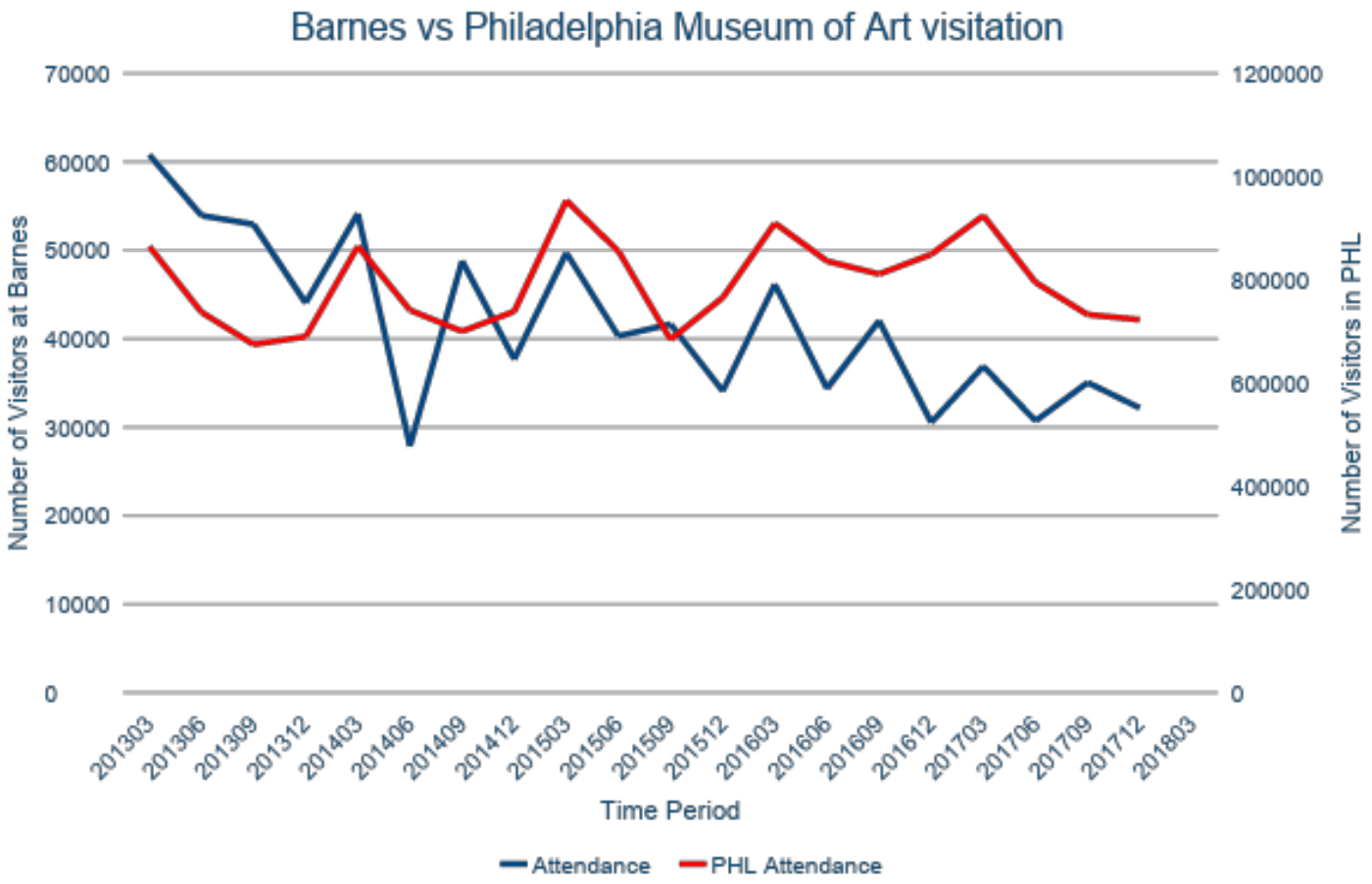
**Non-member attendance and average price after discounts**

QoQ % change



# Step 2B: Hypothesize demand drivers

## Aside from sharing seasonal peaks and troughs, we don't see a relationship between Barnes and the Philadelphia Museum of Art



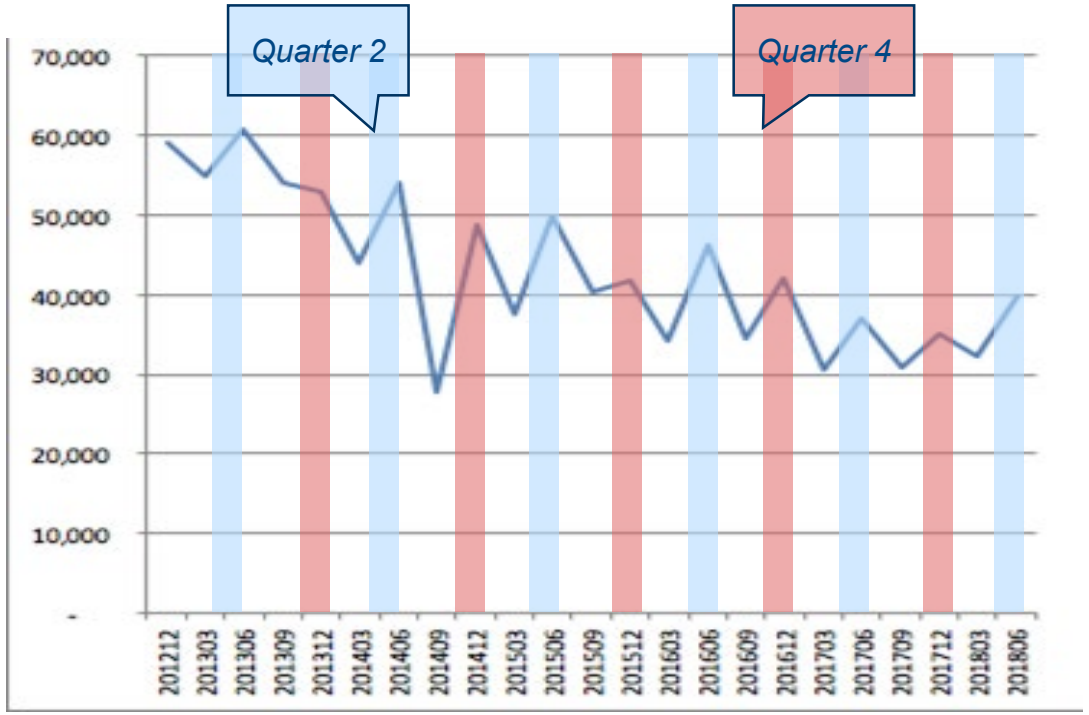

**Comments**

- The trend in Barnes attendance appears to be independent of the Philadelphia Museum of Art, which has remained stable over time
- To the extent Barnes attendance is correlated to that of the Philadelphia Museum of Art, it primarily reflects seasonal peaks and troughs

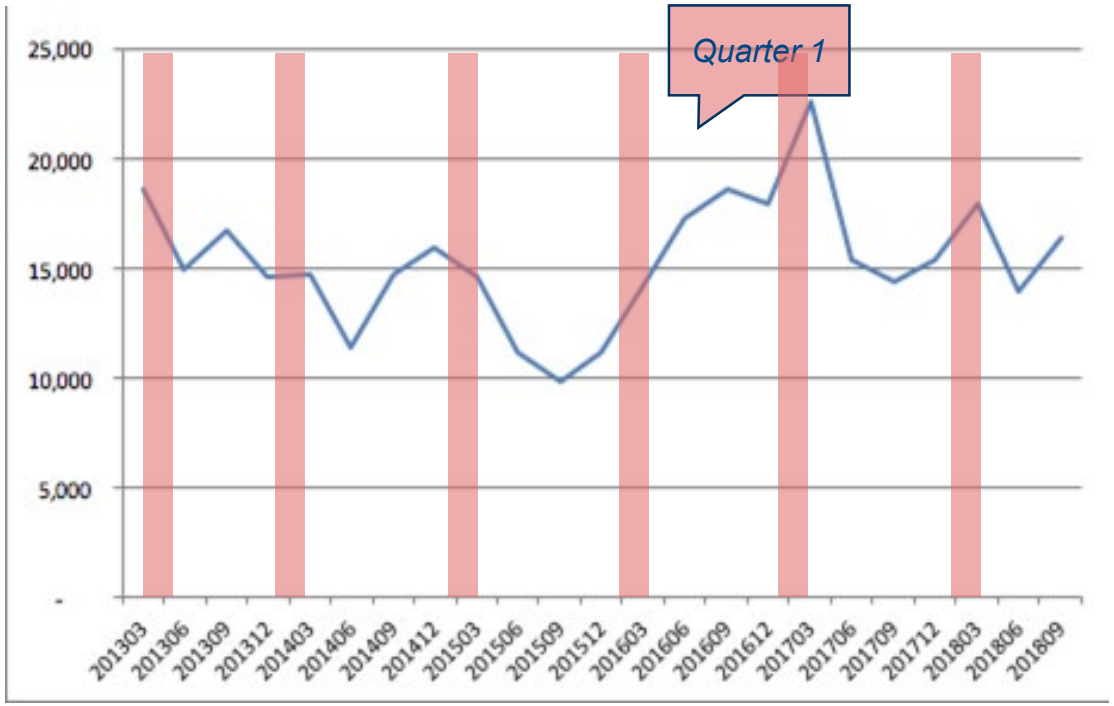
# Step 2C: Hypothesize demand drivers

## We see a strong seasonal effect for non-members, and a modest effect for members

**Non-member attendance**




**Member attendance**



# Step 3: Select model

## We filtered potential models to identify a short list of candidates

| Filtering process | Description |
|---|---|
| Statistical significance and economic intuition | • Reject all models that have variables with p-value > 5% or unintuitive signs |
| Back-testing performance | • Rank-order models on back-tested RMSE and $R^2$ |
| Actionability | • Ensure models have Barnes-specific drivers, like pricing and special events |
| Stability | • Ensure models are stable to removing data, have acceptable confidence bands |

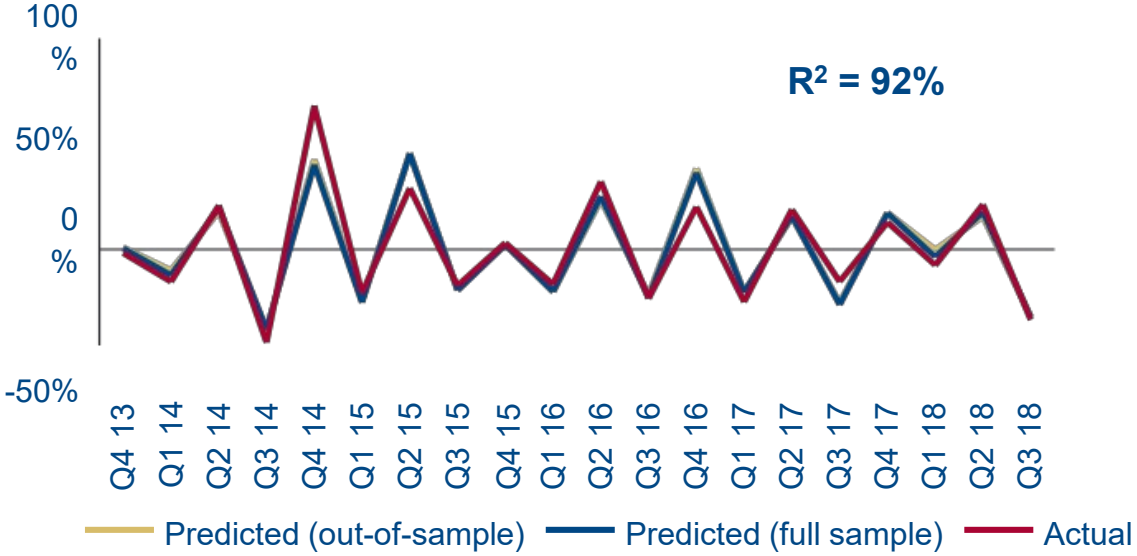
**Selected model**

# Step 3: Select model

## Top models capture much of the variation in changes in visitation

**Non-member attendance**

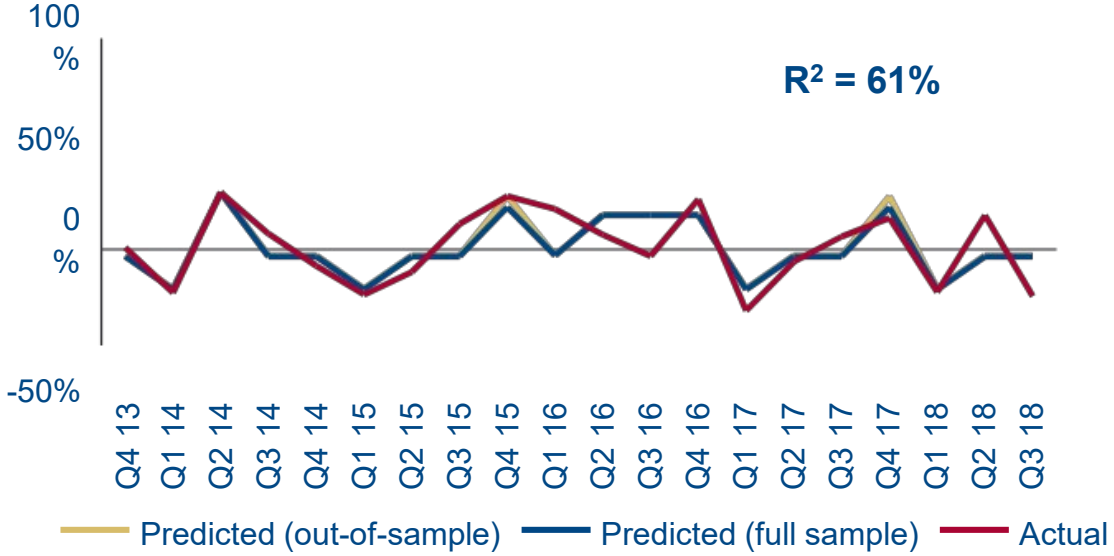
QoQ percent change, actual vs predicted




| | | | |
|---|---|---|---|
| Constant | (29%) | 3% | (22%) - (36%) |
| QoQ %Δ in price | (153%) | 28% | (96%) - (209%) |
| New exhibit starting | 10% | 5% | 1% - 20% |
| Quarter 2 | 52% | 6% | 40% - 64% |
| Quarter 4 | 29% | 6% | 18% - 41% |

**Member attendance**

QoQ percent change, actual vs predicted




| | | | |
|---|---|---|---|
| Constant | (4%) | 5% | (13%) - 5% |
| Exhibition Preview | 30% | 15% | 0% - 59% |
| First Sunday | 20% | 8% | 4% - 36% |
| Student Night | 24% | 11% | 2% - 45% |
| Quarter 1 | (20%) | 7% | (35%) - (5%) |

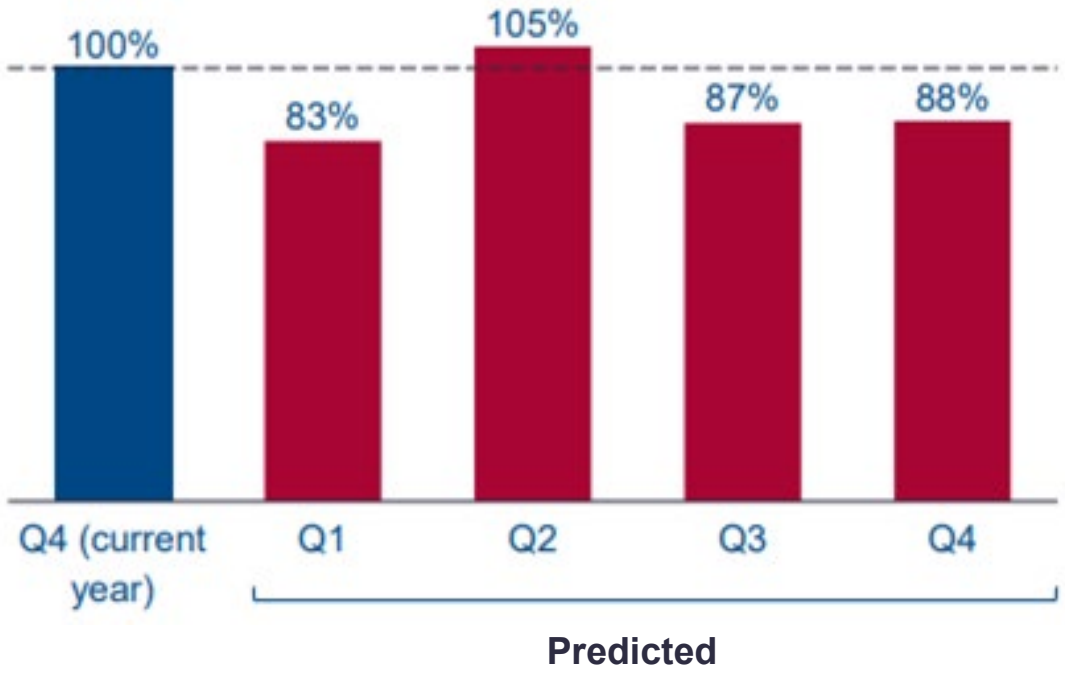
Note: Out-of-sample testing removes the last year of data and recalibrates model

# Implication 1: Expect non-member attendance to decline ~10% year-on-year in a “do-nothing” scenario

## Scenario

- No price changes / changes in discounts (i.e., average price remains constant at initial Q4 levels)
- 2 special exhibitions per year (in Q1 and Q3)

### Predicted attendance as % of Q4 visitation




### Comments

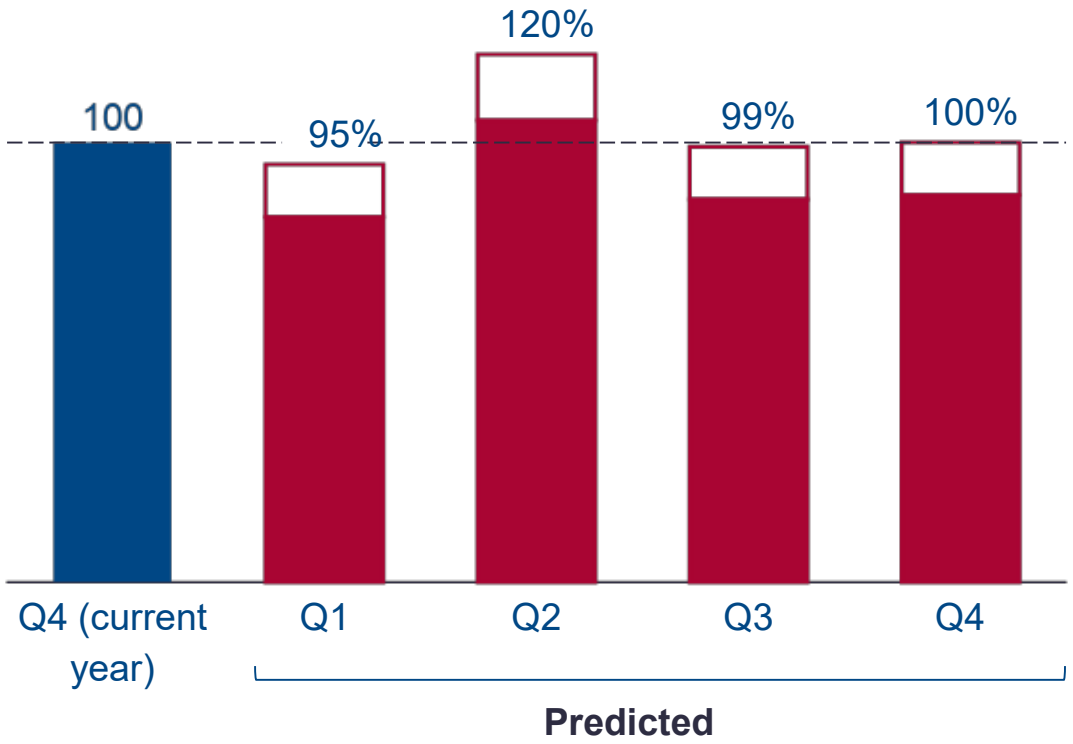
- Anticipate ~10% decline in attendance year-over-year in a “do-nothing” scenario
- Finding **stable** to overweighting recent experience (e.g., only calibrating on data from 2015 Q3 yields same 12% reduction)
- **Caveats**
  - Model reflects experience over calibration period – i.e., it won’t capture stabilization effects that have yet to materialize
  - In the long-run, expect attendance to stabilize – should update model regularly

# Implication 2: Modest reductions in price can stabilize non-member attendance while remaining revenue-neutral

## Scenario

- Reduce average price after discounts by 8.5% (equivalent to reducing undiscounted price from $25 to $22.90)
- 2 special exhibitions per year (in Q1 and Q3)

**Predicted attendance as % of Q4 visitation**




**Comments**

- Model anticipates a 1% reduction in price contributes to a 1.5% increase in attendance – i.e., **price reductions don't reduce revenue**
- Estimate on the high end of a survey conducted by the Morey Group on behalf of Barnes, finding a 1% reduction in price could generate 0.5% to 1.25% greater attendance
- **Caveats**
  - Demand will be less elastic as price falls
  - Should be strategic about the segments in which we use price as a lever

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- **Embedded in current reporting templates**
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# Implementation of Model – Q4 2018

| | Q3 Actual | Q4 Barnes Forecast | Q4 Model Predicted | Q4 Actual |
|---|---|---|---|---|
| Total Visitors | 34,278 | 36,370 | **40,137** | **39,270** |
| Visitation Revenue | $797,055 | $866,485 | **$933,281** | **$903,242** |
| Average Ticket Price | $23.25 | $23.82 | $23.25 | $23.00 |
| | | | | |
| Member Visits | 6,186 | 7,375 | 6,116 | 9,253 |
| Other Free Visits | 10,572 | 11,100 | 10,777 | 10,268 |

# Implementation of Model – Q1 2019

| | Q1 Budget | Q1 Model Predicted With Q3 Data | Q1 Model Predicted with Q4 Data | Q1 Actual |
|---|---|---|---|---|
| Total Visitors | 29,260 | **31,587** | 39,160 | **31,203** |
| Visitation Revenue | **$608,575** | **$734,477** | $801,994 | **$652,935** |
| Average Ticket Price | $20.80 | $23.25 | $20.48 | $20.92 |
| | | | | |
| Member Visits | 5,800 | 4,585 | 7,194 | 7,110 |
| Other Free Visits | 7,050 | 8,878 | 8,310 | 10,617 |

# Implementation – Other Outcomes

- Lowered prices for weekday premium tours
  - Improved participation and increased revenue
- Continuing to evaluate pricing as a way to increase visitation
- Refocused emphasis on data capture
- Model is easy to use and update
- More data will improve outcomes over time