Financial Forecasting in Public Institutions

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Lecture Overview

Topics covered

- Forecasting and public institutions
- Forecasting models
- Scenarios, sensitivity, and risk analysis

Additional information from the Government Finance Officers Association (GFOA)

- Financial Forecasting in the Budget Preparation Process

Forecasting and Public Institutions

Overview

Financial forecasting

- Process of estimating future financial outcomes based on historical data, economic trends, and assumptions about future policy
- Basis for (1) informed decisions by projecting revenues, expenditures, and service demand, (2) accurate (to the extent possible) budgets, and (3) effective and efficient use of public funds
- Justification for (future) spending and resource allocation
- Ability to model and simulate changes in funding or expenses based on changes in macroeconomic environment and policies

Examples

Revenue

- Sales tax revenue
- Motor fuel tax revenue

Expenditures

- Salary expenditures for teachers
- Road maintenance

Service demand

- Number of garbage bin collections per week
- Number of school places for children

Public Sector Forecasting

Differences between private and public sector financial forecasting

- Focus on service provision over profit, altering approach to forecasts
- Changes in taxes, grants, and appropriations may take longer to change impacting revenue and/or expenditure over multiple years (e.g., changes in the fuel taxes)

Challenges in Forecasting for Public Institutions I

Data availability and quality

- Limited historical data
- Inconsistent data collection methods
- Data gaps and missing values

Complex stakeholder expectations

- Multiple, sometimes conflicting objectives
- Pressure from political entities and public opinion
- Requirement for transparency and accountability

Budget constraints

- Limited funding for comprehensive forecasting tools
- Restricted resources for data acquisition and model development
- High dependency on public funding cycles

Challenges in Forecasting for Public Institutions II

External uncertainties

- Economic volatility (e.g., inflation, recession)
- Policy changes at local, state, and federal levels
- Unpredictable social and demographic shifts

Technological limitations

- Limited access to advanced forecasting software and tools
- Lag in adopting modern data analytics technologies
- Constraints in technical expertise and training

Challenges in Forecasting for Public Institutions III

Long-term forecasting complexity

- Difficulty in capturing long-term trends accurately
- Need to balance short-term adjustments with long-term vision
- Influence of unpredictable events, such as natural disasters or pandemics

Regulatory and compliance requirements

- Need to follow strict legal and regulatory guidelines
- Constraints from standardized reporting formats
- Frequent updates to compliance requirements impacting forecasting processes

Forecasting Models

Overview

Forecasting techniques

- Moving average
- Exponential smoothing
- Regression analysis
- Time series analysis

Considerations for model selection

- Data availability: Type and amount of historical data
- Forecast horizon: Short versus long-term needs
- Complexity versus accuracy: Balancing the ease of use with forecast precision

Examples: Use exponential smoothing for monthly expenditure predictions or regression to estimate revenue changes due to economic shifts

Moving Average Models

Use of averages of past observations to smooth data and identify trends

- Simple Moving Average (SMA): Equal weights for each period.
- Weighted Moving Average (WMA): More weight to recent data points.

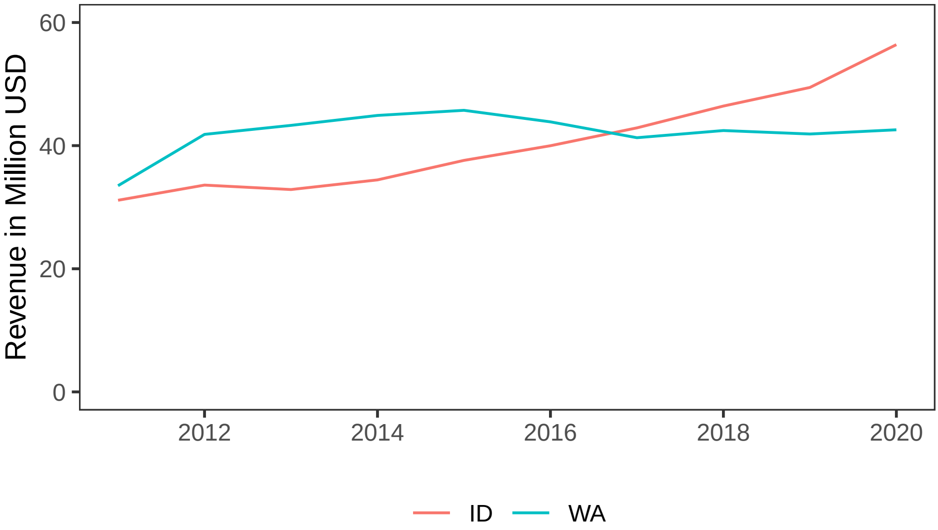
Application

- Moving averages help forecast stable patterns with minimal volatility, such as routine expenses

Example

- 2011–2020 hunt & fish licence tax revenue for Washington and Idaho
- Use of 2-year (2018–2019) and 3-year (2017–2019) data to predict 2020

Hunt & Fish Tax Revenue Graph



Hunt & Fish Tax Revenue Data

	Idaho			Washington		
2017	42.89			41.29		
2018	46.43			42.45		
2019	49.45	2 Years	3 Years	41.89	2 Years	3 Years
2020	56.40	47.94	46.25	42.57	42.17	41.87
Difference	-15.01%	-18.00%		-0.95%	-1.64%	

Example

$$\frac{46.43 + 49.45}{2} = 47.94$$

Underestimation due to increasing licence tax revenue in Idaho

SMA Considerations

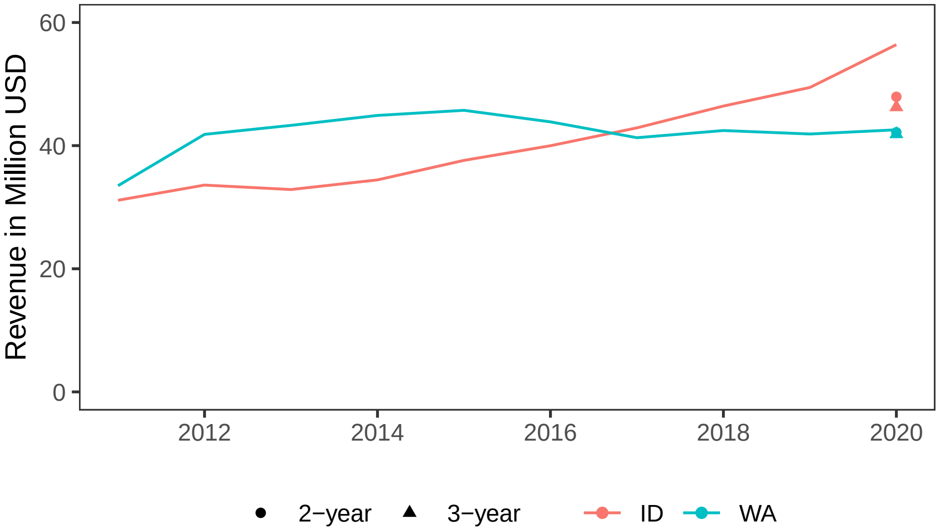
Data with upward or downward trend

- Upward (downward) trend leads to under- (over-) estimation of the next period's data point

Determinants of lengths of periods used for moving average calculation (assuming no data trend)

- Length of available data
- Desired smoothness of the data (if used for predictions of more than one period), i.e., longer periods used to average result in smoother results

Hunt & Fish Tax Revenue Results



Exponential Smoothing

Type of moving average that applies decreasing weights to older data points

- Simple exponential smoothing: For data without trend or seasonality
- Holt's method: For data with a trend
- Holt-Winters method: For data with trend and seasonality

Smoothing short-term fluctuations while maintaining a long-term trend for more accurate forecasting

Simple Exponential Smoothing

Overview

- Data with no clear trend or seasonality
- Next period's forecast ($\hat{y}_{t+1}$) as a weighted average of the previous period's forecast and observed value

Equation

$$\hat{y}_{t+1} = \alpha \cdot y_t + (1 - \alpha) \cdot \hat{y}_t$$

where

- y_t as the observed value at time t
- $\hat{y}_t$ as forecast for time t
- $0 < \alpha < 1$ as the smoothing parameter controlling responsiveness of the forecast is to changes in the data with higher values giving more weight to recent observations

Simple Exponential Smoothing in Excel

Setup

- Time series data in column A (e.g., `A2` downward for time periods 1, 2, . . .) with column B as *Observed* and column C as *Forecast*

Smoothing parameter (α):

- Value of $0 < \alpha < 1$ (e.g., 0.3) in cell `D1`

Initial forecast:

- First forecast equal to the first observed data point in cell `C2` (i.e., `=B2`)

Formula for forecast

- In cell `C3`, enter the exponential smoothing formula `=$D$1*B2+(1-$D$1)*C2`

Weighted average of last observed value (`B2`) and previous forecast (`C2`)

Holt's Method

Extension of simple exponential smoothing by adding trend component but no seasonality. Two equations for level (L_t) and trend (T_t)

$$L_t = \alpha \cdot y_t + (1-\alpha) \cdot (L_{t-1} + T_{t-1})$$
$$T_t = \beta \cdot (L_t - L_{t-1}) + (1-\beta) \cdot T_{t-1}$$

Forecast

$$\hat{y}_{t+h} = L_t + h \cdot T_t$$

where

- L_t and T_t as estimated level and trend at time t
- α and β as smoothing parameters for the level and trend, respectively
- h as the forecast horizon

Holt's Method in Excel I

Setup

- Observed data in column B with labels *Level*, *Trend*, *Forecast* for C–E

Parameters (α) and (β)

- Entering values for (α) and (β) (e.g., 0.3 and 0.1) in cells `F1` and `G1` with labels *Alpha* and *Beta*.

Initial level and trend

- Level (`C2`) equal to observed data (`=B2`)
- Trend (`D2`) as the difference between the first two observed values (`=B3-B2`)

Holt's Method in Excel II

Level calculation

- Cell `C3` as `=$F$1*B2+(1-$F$1)*(C2+D2)`
- Calculation of new level based on the observed value, previous level, and trend

Trend calculation

- Cell `D3` as `=$G$1*(C3-C2)+(1-$G$1)*D2`

Forecast calculation:

- Cell `E3` as `=C3+D3`

Holt-Winters Method

Extension of Holt's Method by adding a seasonal component. Three equations for level (L_t), trend (T_t), and seasonality (S_t) components

$$L_t = \alpha \cdot \left(\frac{y_t}{S_{t-s}}\right) + (1-\alpha) \cdot (L_{t-1} + T_{t-1})$$

$$T_t = \beta \cdot (L_t - L_{t-1}) + (1-\beta) \cdot T_{t-1}$$

$$S_t = \gamma \cdot \frac{y_t}{L_t} + (1-\gamma) \cdot S_{t-s}$$

$$\hat{y}_{t+h} = (L_t + h \cdot T_t) \cdot S_{t+h-s(k)}$$

where

- S_t as the seasonal component at time t
- s as the seasonal period and k as the integer part of $(h-1)/s$
- α, β, and γ as smoothing parameters for level, trend, and seasonality

Regression Analysis

Relationship between a dependent variable y and one or more independent variables (x)

- Simple linear regression: Predictions using one independent variable
- Multiple regression: Predictions using multiple independent variable

Public institutions can use regression to forecast factors influenced by multiple variables, like demand for services or costs

Scenarios, Sensitivity, and Risk Analysis

Scenario Analysis and What-If Analysis I

Scenario analysis involves evaluating the impact of different hypothetical situations on financial forecasts

- Helps public institutions plan for uncertainties by modeling various outcomes
- Commonly used for budget forecasting under different economic or funding conditions (e.g., budget cuts, increased grant funding)

Key components of scenario analysis

- Best-case scenario: Assumes optimal conditions (e.g., increased funding, reduced costs)
- Worst-case scenario: Assumes challenging conditions (e.g., revenue shortfalls, unexpected expenses)
- Baseline: Most likely outcome based on current information

Scenario Analysis and What-If Analysis II

What-if analysis examines how changes in specific variables impact financial forecasts.

- Provides insights into sensitivity of forecasts to changes in key factors (e.g., inflation rates, employee count)

Key benefits of scenario and what-if analysis

- Improved planning: Enables institutions to prepare for a range of outcomes, reducing risk
- Enhanced decision-making: Informs decisions by illustrating financial impacts of possible changes
- Transparency: Allows stakeholders to understand potential budgetary impacts of different assumptions

Risk and Sensitivity Analysis I

Risk analysis and sensitivity assesses the likelihood and potential impact of uncertain events on financial forecasts

- Helps identify areas where financial forecasts may be vulnerable to external factors or changes in assumptions
- Essential for public institutions facing funding volatility, regulatory changes, or economic shifts

Risk and Sensitivity Analysis II

Types of risks in public sector forecasting

- Revenue risks: Potential for revenue sources (e.g., taxes, grants) to under perform
- Expenditure risks: Unplanned costs or overruns in budgeted expenses
- External risks: Economic downturns, policy changes, or unexpected crises affecting financial stability
- Operational risks: Risks associated with internal processes, staffing, or resource constraints