FORECASTING IN A CHANGING ECONOMIC ENVIRONMENT – KENTUCKY EXPERIENCE WITH TIME SERIES AND STRUCTURAL MODELS

A presentation to the FTA Revenue Estimation Conference

Salt Lake City, Utah

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Hypothesis and Theory Regarding Model Selection

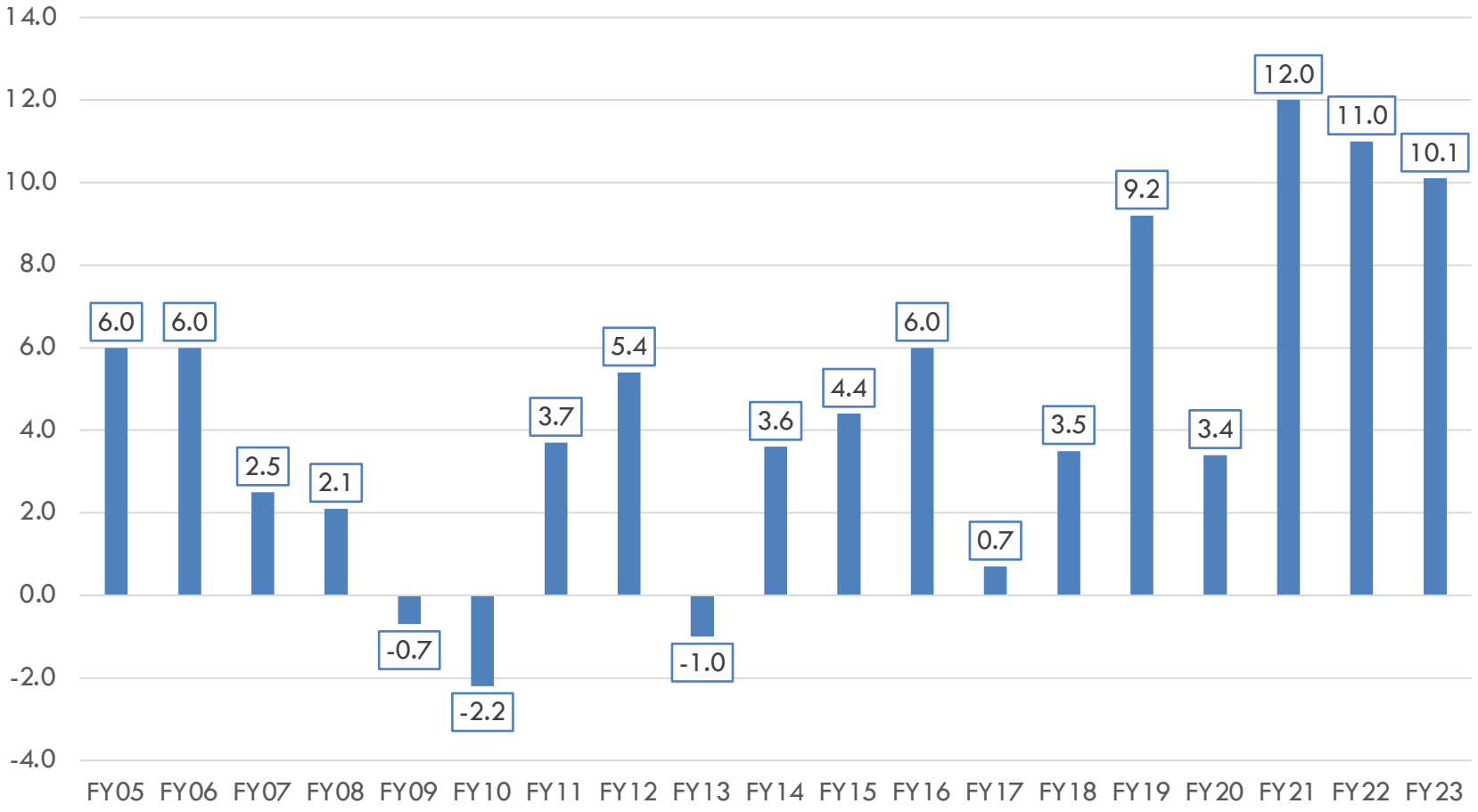
- The dichotomy is between structural and time series models
- Hypothesis from many years ago: Different periods in time call for different modeling strategies to reduce modeling errors (increase efficiency of estimators)
- Theory from the last three years:
  - If revenue patterns stray from economic norms, then time series models for revenue estimation work better than structural models
  - If revenue patterns return to long-run trends or when turning points occur (that are anticipated by S&P Global Markit), then structural models work better
- Application of the Theory:
  - To properly choose revenue models for inference, you must know whether your revenue trends in the future will follow economic norms – or –
  - You should consider blending forecasts if you are uncertain

Evidence to Support the Theory

- The forecasting laboratory is the Kentucky Sales Tax (as well as the experiences of many other states at this conference)
- Many states, including Kentucky, have experienced a disconnect between tax receipts and the underlying economy
- The theory suggests that time series models forecast tax receipts better during times of disconnection
- In-sample and out-of-sample forecasts strongly suggest that time series models reduce forecasting errors in these instances
- The theory part II: Do structural models perform better when tax receipts normalize vis-à-vis the economy?

Sales Tax Growth Rates

(Percentage Change, FY05 through FY23)

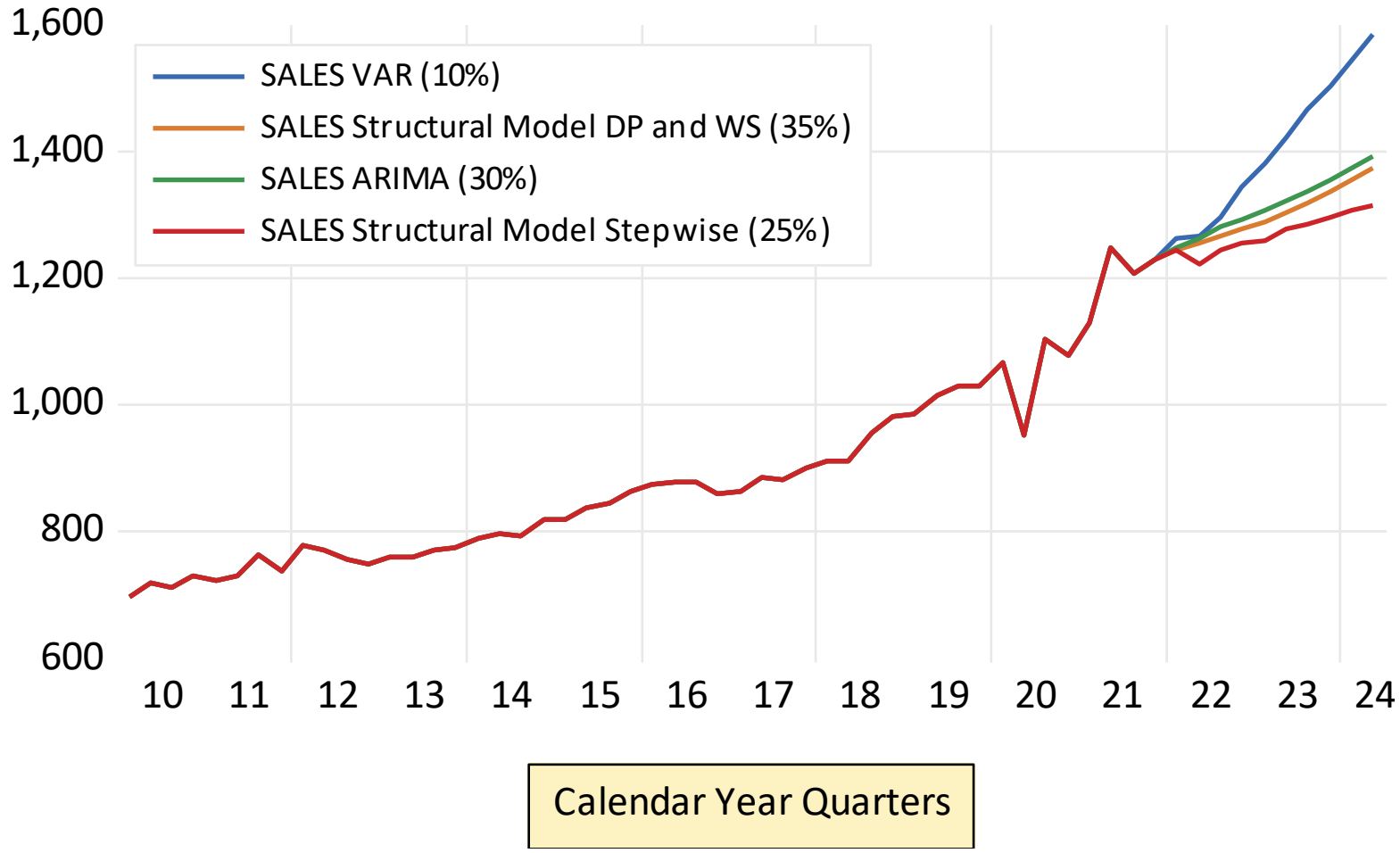


Recent Sales Tax Estimates

- Underestimated the sales tax for two consecutive years (FY21 grew 12.0% and FY22 grew 11.0%)
- Underestimated the sales tax in December 2021 (FY22, FY23)
- Overestimated the sales tax in December 2022 (FY23)
  - Used a much higher percentage of time series models
  - Blended with structural models from optimistic scenario
- Continued composite forecasting for the sales tax
- Time series models have performed better in-sample during the high-growth years, but …
- Receipts are beginning to soften relative to the recent past
- Structural models predicted the softening

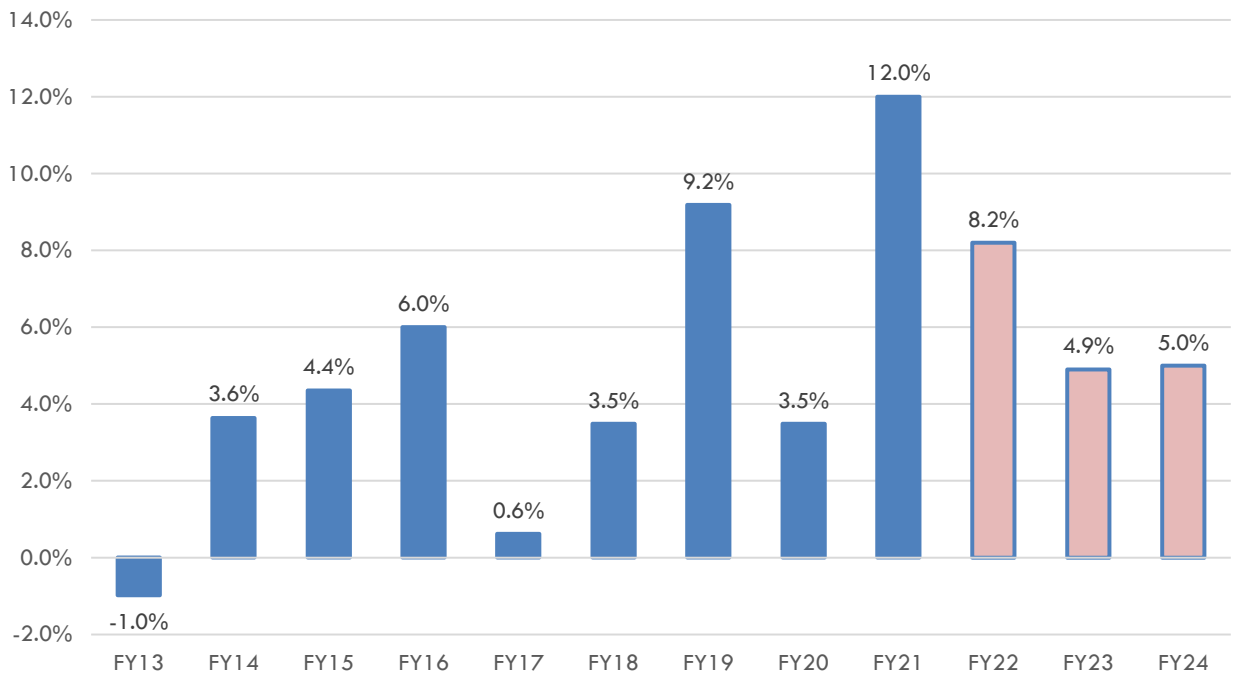
Dec 2021 Blended Sales Tax Model

(Quarterly Data, Calendar Year, Seasonally Adjusted, Millions $)



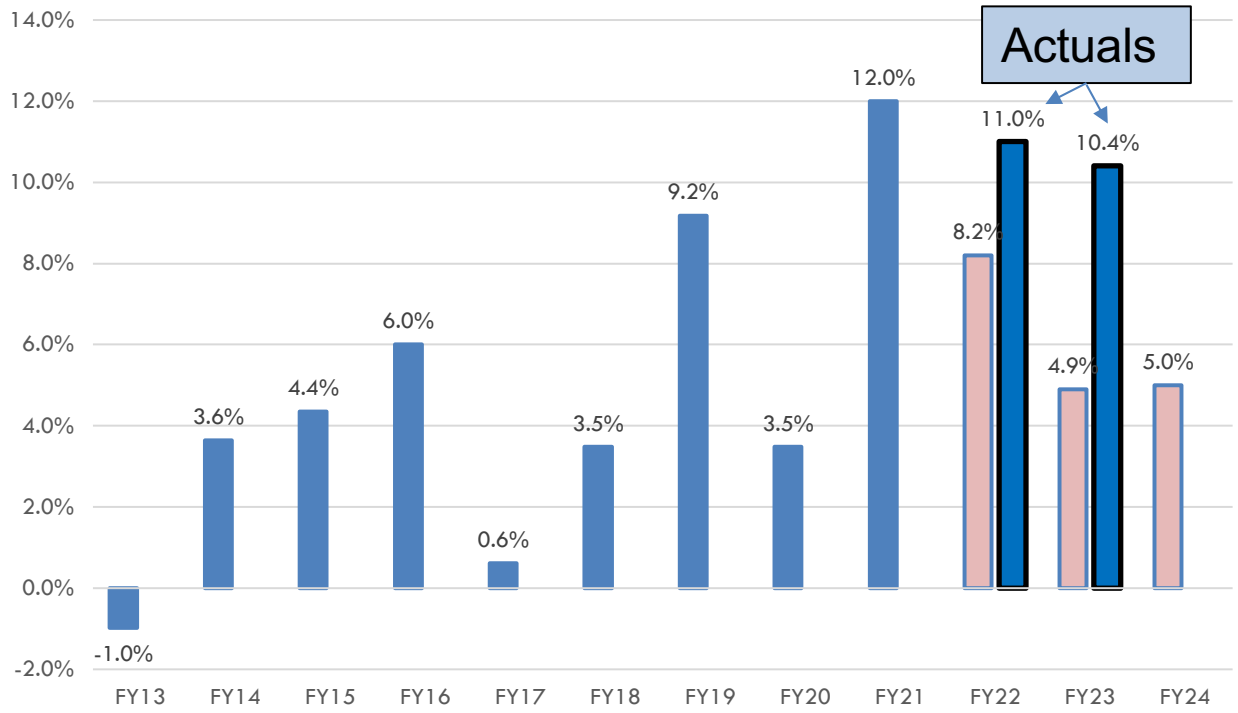
Sales Tax Control Forecast Using Blend

(Fiscal Year growth rates)



December 2021 Estimate Performance

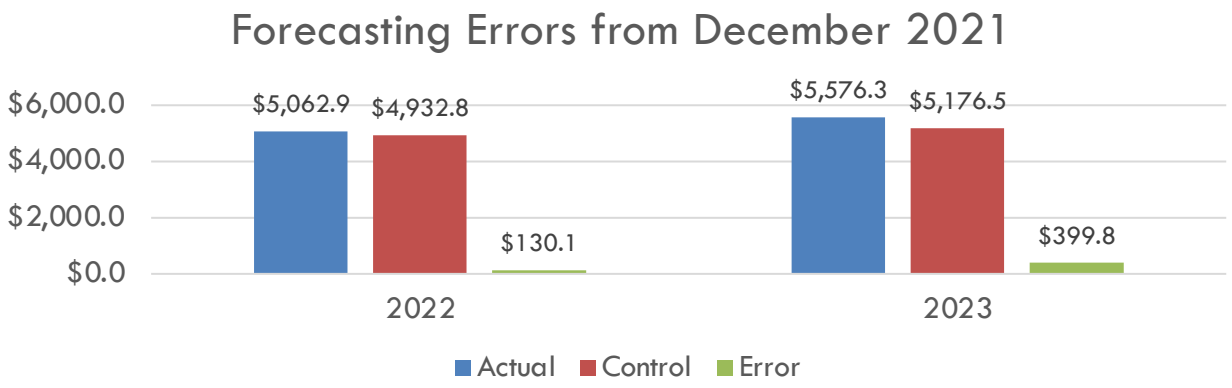
(Fiscal Year growth rates)



December 2021Sales Tax Projections

(Millions $)

Fiscal Year	Control	Optimistic	Pessimistic
FY 2021	$4,561.0 12.0%	$4,561.0 12.0%	$4,561.0 12.0%
FY 2022	$4,932.8 8.2%	$4,968.6 8.9%	$4,881.7 7.0%
FY 2023	$5,176.5 4.9%	$5,302.2 6.7%	$5,007.7 2.6%
FY 2024	$5,434.4 5.0%	$5,603.7 5.7%	$5,151.6 2.9%

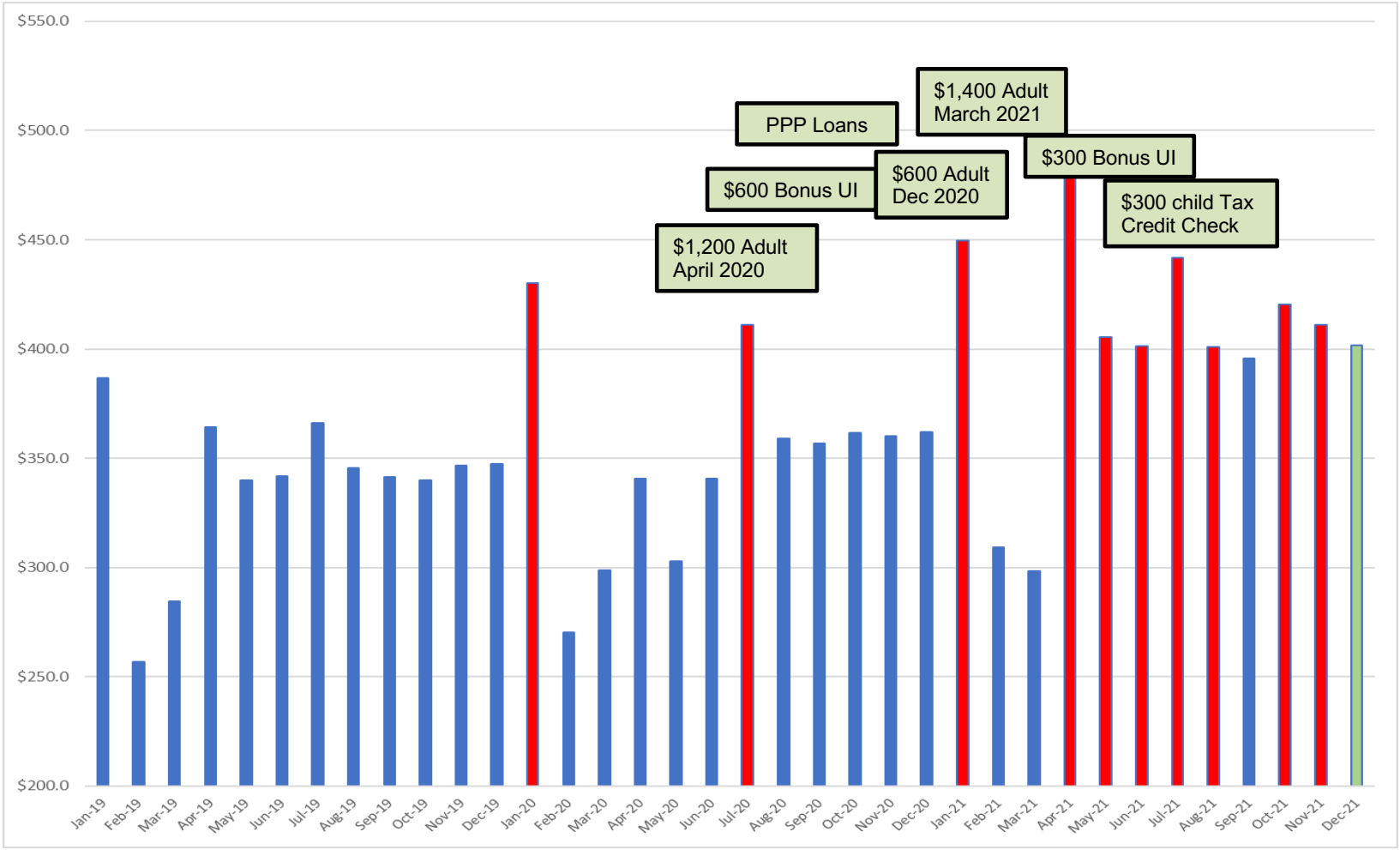


Conclusions from the 2021 Estimates

- Should have trusted the time series models more and given them larger weights
- The thinking at the time was that the FY21 growth of 12.0% growth in FY21 was transitory and that a turning point was coming
- Exogenous shocks occurring that bolstered consumer spending
- Exposing the weakness of the theory
  - Difficult to determine, at the time, whether a return to normalcy will occur, and when it will happen
  - The stories are more compelling with structural models

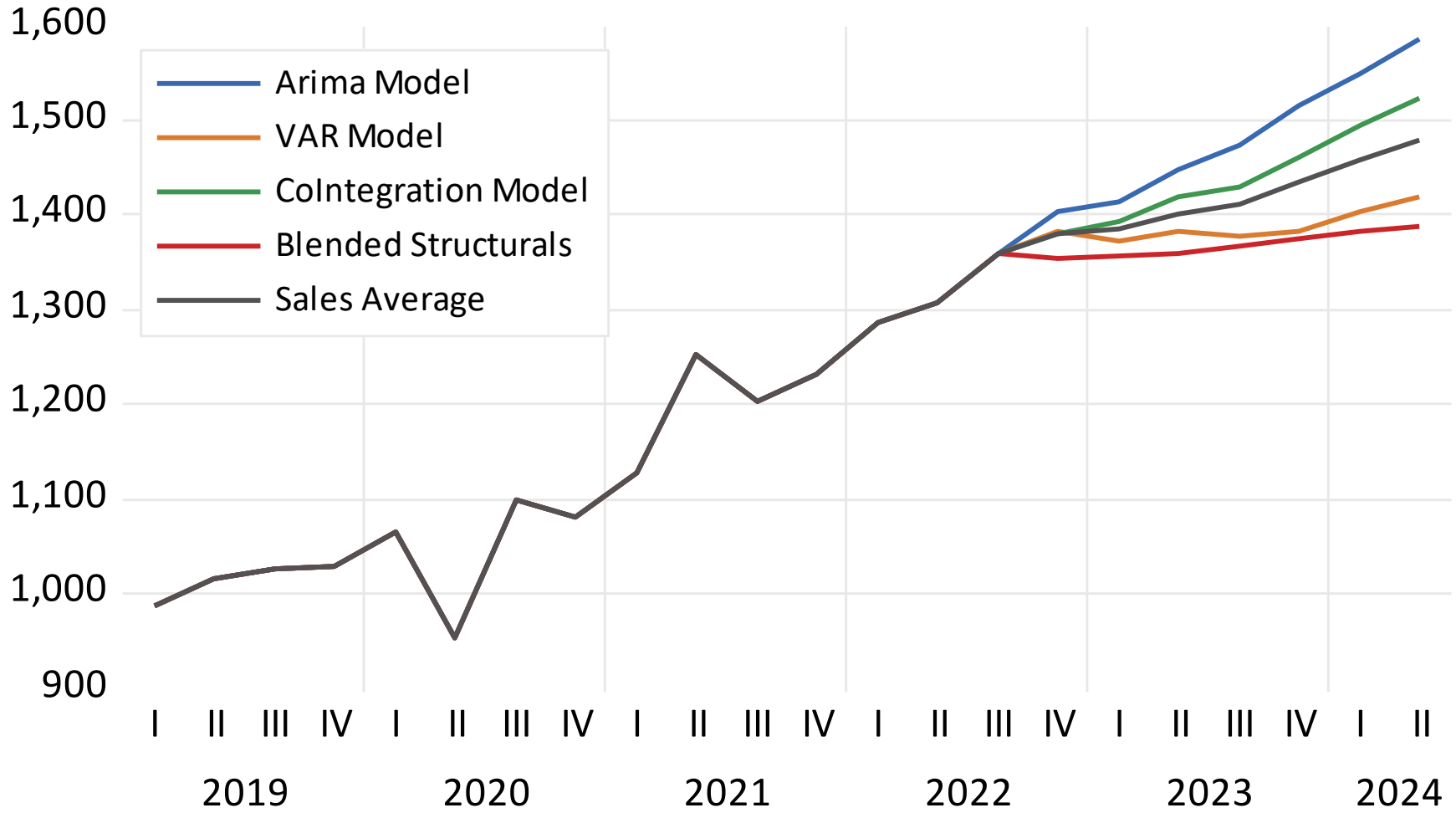
Monthly Sales Tax Collections

(Millions $, Influenced by Federal Stimulus efforts from CARES, CAA, and ARP)



Sales Tax Models December 2022

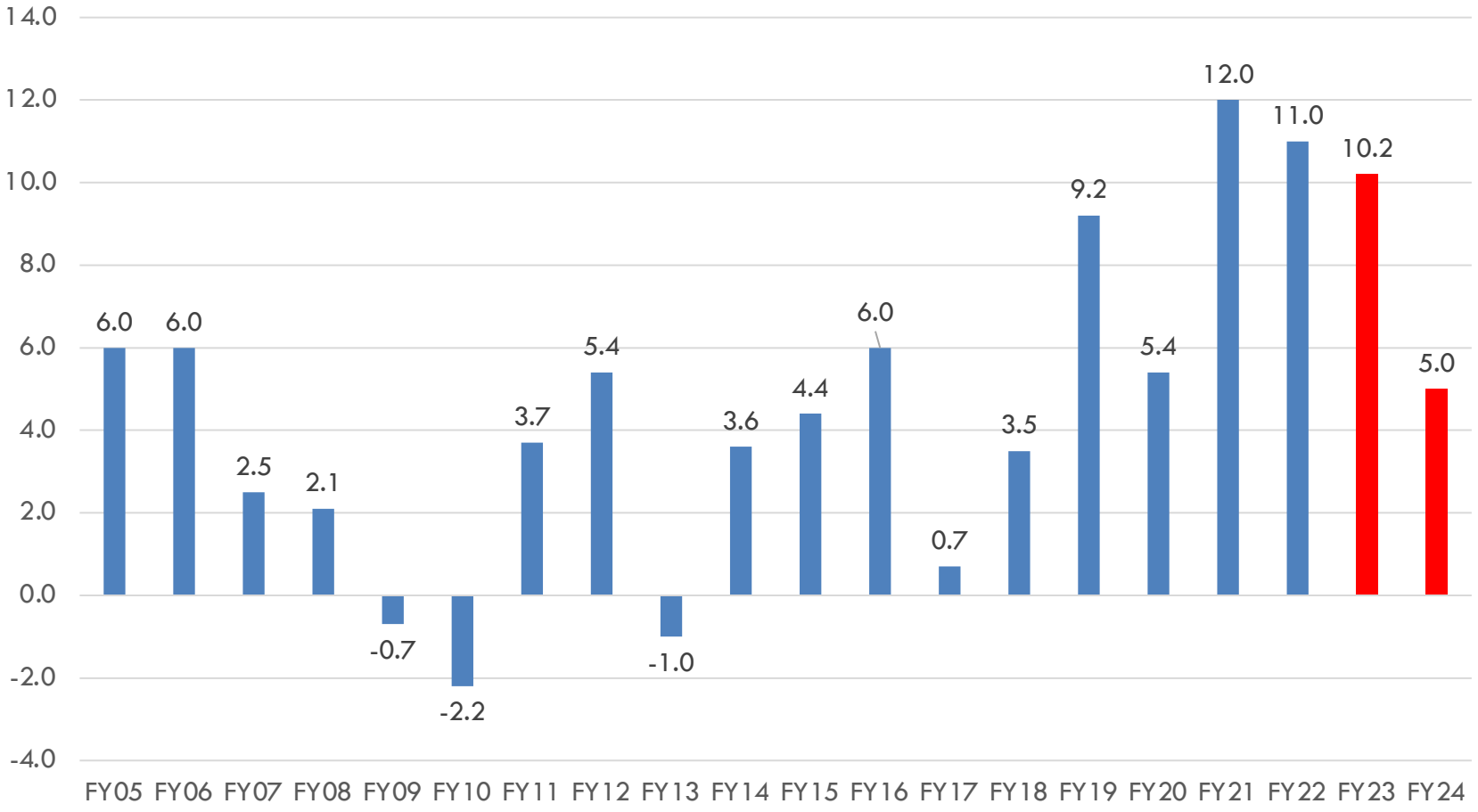
(Control Scenario, $ millions)



Model Specifications, December 2022

- Time Series for Estimation: 2010q1 to 2022q3
  - Have data back to 1990q1
  - Policy neutral time series, tax credits and law changes
- All models use seasonally-adjusted data
- Arima {AR (1,3); 1st difference; MA (1,4,5)}
- Cointegration (Sales and Withholding)
- VAR (Sales and KY Wages & Salaries), TXPGSL (State & Local Personal Taxes)
- Structural Models (SRTAFS_0 Nominal Retail Sales); (CDFHE_0 Consumer Spending Furniture and Durable Home); (DOMPURCH_0) Final Sales to Domestic Purchasers;

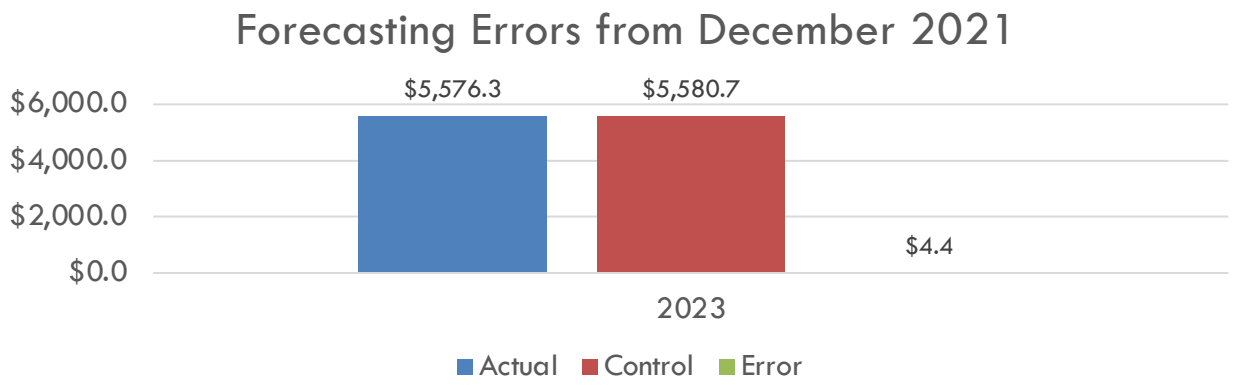
Sales Tax Growth Rates



December 2022 Sales Tax Projections

(Millions $)

Fiscal Year	Control	Optimistic	Pessimistic
FY 2022	$5,062.9 11.0%	$5,062.9 11.0%	$5,062.9 11.0%
FY 2023	$5,580.7 10.2%	$5,689.4 12.4%	$5,538.6 9.4%
FY 2024	$5,906.2 5.8%	$6,059.3 6.5%	$5,801.6 5.0%



Conclusions from the 2022 Estimates

- Actual growth in FY23 was 10.1%
- Blended model growth projected for FY23 was 10.2%
- Used equal weights on all types of models
  - ARIMA
  - Cointegration
  - VAR
  - Blended Structural Models
- The blending of Structural Models and Time Series Models noticeably reduced forecasting error

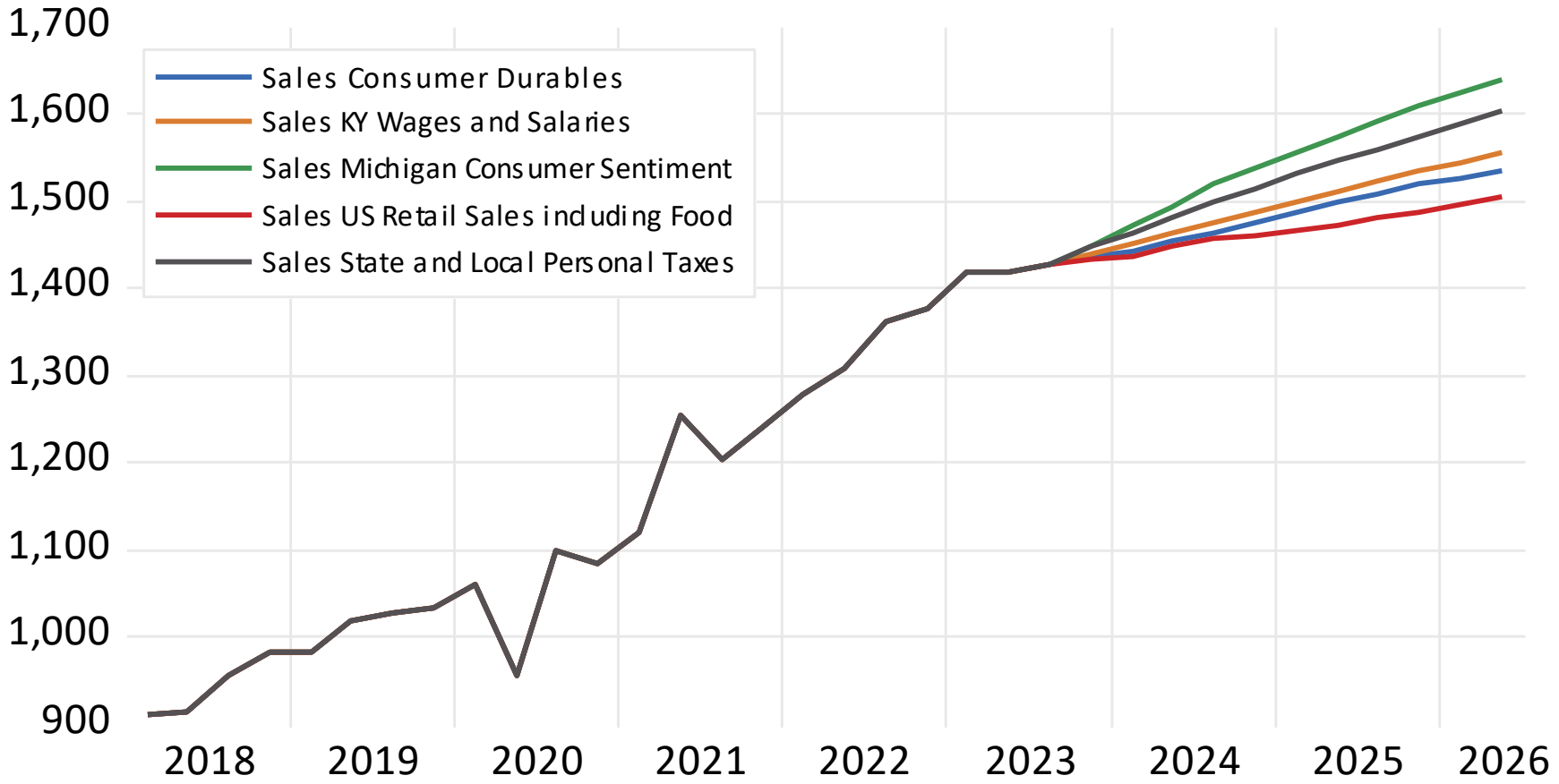
Model Specifications, Current

(Estimates from **September 25**, 2023)

- Time Series for Estimation: 2010q1 to 2023q3
  - Have data back to 1990q1
  - Estimated September to make FY24Q1 historical
- All models use seasonally-adjusted data
- Arima 7,1,1 {AR (1,3,7); 1st difference; MA (1)}
- VAR (Sales and KY Personal Income)
- Structural Models – Blend of these 5 models
  - SRTAFS_0 (Nominal Retail Sales);
  - JSCMICH (Consumer Sentiment Index)
  - TXPGSL (State and Local Personal Taxes)
  - CDO (Consumer Durables)
  - KYWS (Kentucky Wages and salaries)

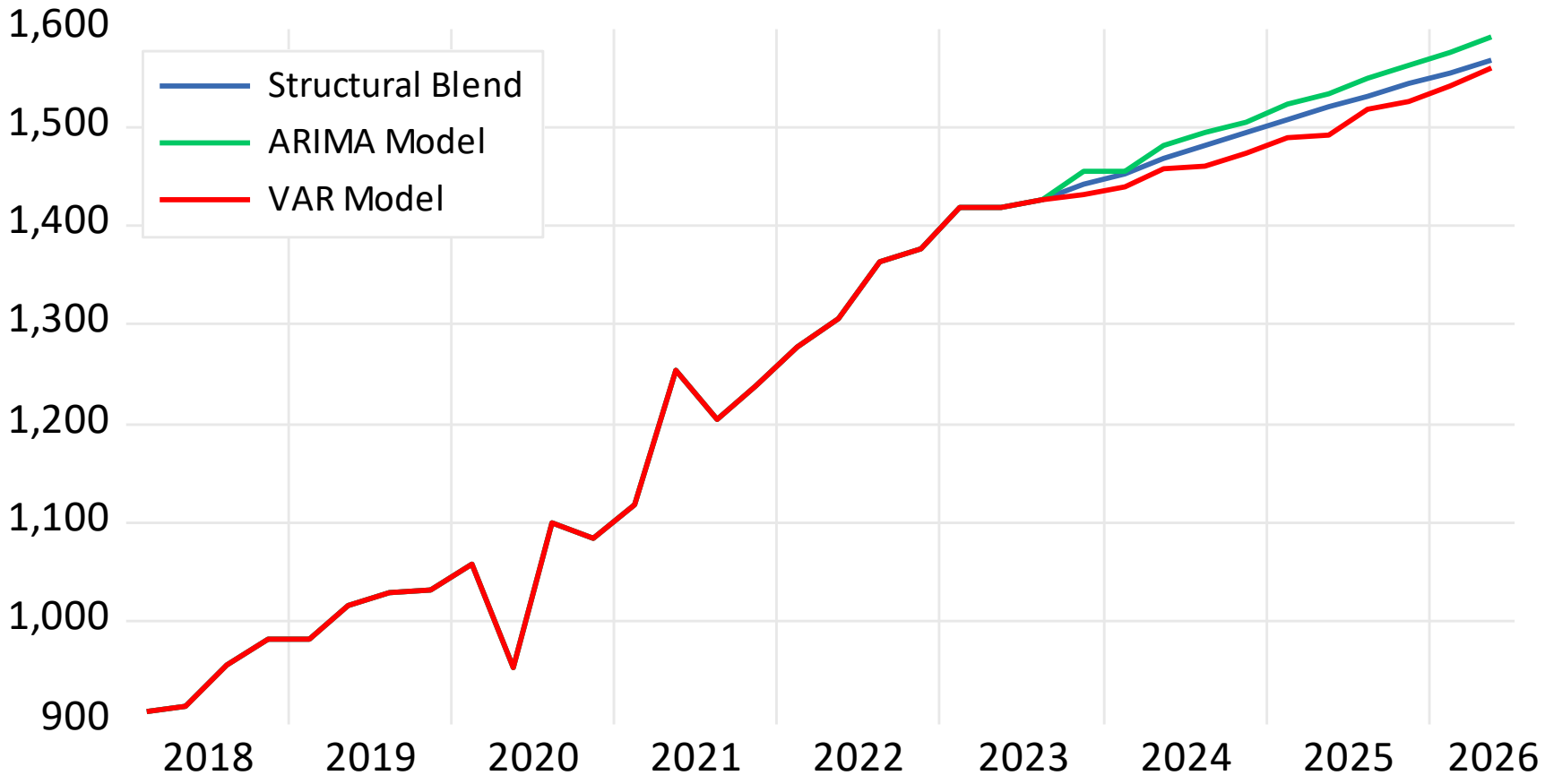
Sales Tax Structural Models September 2023

(Control Scenario, Quarterly, Millions $)



Sales Tax Final Blending Models September 2023

(Control Scenario, Millions $)



Sales Tax Projections

(Millions $)

Fiscal Year	Control	Optimistic	Pessimistic
FY 2024	$5,788.3 3.8%	$5,826.3 4.5%	$5,753.2 3.2%
FY 2025	$5,990.9 3.5%	$6,036.7 3.6%	$5,910.4 2.7%
FY 2026	$6,207.7 3.6%	$6,241.0 3.4%	$6,103.7 3.3%

Observations about Current Estimates

- Nominal growth would have been 1.5% higher but for the fiscal impacts that were added post model
- Conclusions about structural models
  - The current structural models are nearly identical to an equal blend among the three competing models
  - It is entirely possible that all three models are incorrect
  - However, a homogeneity of results leads the analyst to more confidently put forth estimates

Conclusions -- Advocacy for Time Series Models

(Suggest Blending for longer-term forecasting)

- Forecasting is difficult in turbulent times
- Time series models have a place at the table during periods where growth is faster (or slower) than the underlying economy would predict
- Even ARIMA models can be used if the forecasting horizon is short; Avoid a-theoretical models for long term forecasting
- Most VAR and similar models have a built-in check
- Still feel the need to blend in structural models, especially if turning points are indicated

Aside: How to Blend?

- Subjective Methods
  - Averaging or weighted averaging (but how do you determine the weights?)
  - Let the "decider" help determine the weights
    - Decider could be either the chief revenue estimator; or
    - The consensus forecasting group who oversees the process
- Objectively
  - Restricted Least Square where the restriction is that the coefficients must add to 1(Use the forecasts you wish to blend as the regressors to predict the know observations of the dependent variable not used in estimation)
  - Less objectively -- Weight by the MSE or AIC, SIC methods

Restricted Least Squares Method

- Withhold 8 to 12 quarters of data from the estimation sample.
- Get the forecasted values for each equation
- Then forecast the 8 to 12 quarters you withheld
  - Dependent Variable is Sales Tax
  - Independent Variables are your forecasted values you wish too blend
- You must restrict coefficients to equal 1
- Sales = $c + B_1(F1) + B_2(F2) + 1\text{-}B_1\text{ -}B_2\ (F3)$

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