Fort Collins Tax Revenue Forecast

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Abstract

This report aims to develop a Vector Error Correction Model (VECM) to forecast monthly sales tax revenue for the City of Fort Collins. The model utilizes a set of cointegrated economic indicators, including retail trade, education and health services, accommodation and food services, leisure and hospitality, transportation-related employment, and traffic volume. After applying the Johansen cointegration test, five significant long-run relationships were identified for the model, justifying the use for a VECM framework. The model was estimated using real, inflation-adjusted sales tax revenue, with some adjustments to account for the 2024 change in the local tax rate. Out-of-sample forecasts for 2024 were evaluated against observed data to obtain a mean absolute error (MAE) of 3.24, indicating a reasonable predictive performance from the model. The resulting model should offer a useful tool for budget forecasting and planning, while also pointing out the importance of sector specific dynamics that can shape local tax outcomes.

Introduction

The objective of this study is to forecast Fort Collins' monthly sales tax revenue for 11 months into the future using a Vector Error Correction Model (VECM) on time series data. This prediction is highly valuable for city planners and policymakers, as accurate revenue forecasts enable better budgeting, infrastructure planning, and response to economic changes.

Fort Collins levies a total city sales and use tax rate of 4.35% as of 2024, which includes a base rate of 1.0% established in 1979 and several voter-approved add-ons for transportation, natural areas, community enhancements, and the 0.85% "Keep Fort Collins Great" (KFCG) tax. In 2024, a 0.25% General Fund Renewable tax was introduced to support ongoing city services, keeping the total rate stable after the expiration of earlier taxes. The tax is collected by the City of Fort Collins and applies to a wide range of goods and services including retail sales, certain services, and motor vehicle leases—constituting the city's tax base.

The collection process involves monthly tax remittance by businesses to the city, followed by reconciliation, auditing, and eventual incorporation into the city's general fund. With the

2024 structural tax adjustments and continued urban growth, it is increasingly important to anticipate shifts in revenue, which this time series model aims to support.

Data and Methods

Cointegration Method and VECM

This study uses a Vector Error Correction Model (VECM) to forecast the sales tax revenue in Fort Collins. The VECM is well-suited for modeling time series that are cointegrated i.e., they share a long-run equilibrium relationship despite short-run random fluctuations. The approach first tests for cointegration using the Johansen procedure, then estimates the short-run and long-run dynamics accordingly.

Below is the general form of a VECM model:

$$\Delta \mathbf{y}_t = \alpha \beta' \mathbf{y}_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta \mathbf{y}_{t-i} + \mathbf{c} + \varepsilon_t$$

In this model the α values are the "loading" coefficients. After conducting the Johansen test, each α represents the overall speed at which a given variable will respond to disequilibrium in a particular cointegrating relationship. In other words, it essentially measures how strongly a variables rate of return to the long-run equilibrium is when it is the dependent variable in the VECM.

Variables with large and statistically significant α values are said to be actively correcting deviations from equilibrium and are therefore considered strong contributors in the corresponding error correction terms (ECTs). So this coefficient "loads" the significant terms of the ECT's into the VECM.

Data Sources

The following data sources were used to construct and estimate the VECM model:

- **Consumer Price Index (CPI)**:
  U.S. Bureau of Labor Statistics. Used for adjusting nominal sales tax values to real terms. Accessed via:
  https://econforecasting.com/forecast/cpi
- **Traffic Volume Data**:
  Colorado Department of Transportation (CDOT). Monthly traffic data used as a proxy for local economic activity, accessed from CDOT's Online Transportation Information System (OTIS):
  https://dtdapps.coloradodot.info/otis/trafficdata#ui/0/0/1/station/000508/criteria/27425//true/true/

- **Sales Tax Data**:
  Collected from internal city records and compiled in `FinalData.xlsx`, which includes historical tax revenues, sector-level employment, and CPI-adjusted values.

Variable Selection

The following variables were included in the model for forecasting:

- **RT (Retail Trade)**:
  Consumer-facing goods and services
  Retail Trade is a large source of taxable sales in Fort Collins, representing direct consumer spending. It plays a critical role in city revenue collections and is very responsive to economic trends.

- **EDUHS (Private Education and Health Services)**:
  Income stability and long-term growth
  While not heavily taxed, this sector reflects underlying economic stablility. Growth here suggests stable employment and income, which indirectly supports consumer spending.

- **AFS (Accommodation and Food Services)**:
  Restaurants, bars, hotels
  This category is directly taxed and highly sensitive to income amounts and tourism. It is a major driver of monthly variation in tax collections.

- **LH (Leisure and Hospitality)**:
  Arts, entertainment, recreation, lodging
  This sector captures seasonal and discretionary spending. Strong performance in LH often correlates with increased retail and food service activity, making it a valuable leading indicator.

- **TWU / TTU (Transportation, Warehousing, and Utilities / Trade, Transportation, and Utilities)**:
  Business-to-business and logistics activity
  These sectors support the broader economy through supply chain and distribution functions. While not always directly taxed, their activity reflects demand conditions across other taxable industries.

- **TrafficVolume**:
  Economic mobility and consumer activity proxy
  This variable tracks the movement of people and goods. Higher traffic levels generally indicate stronger in-person commerce and retail activity, reinforcing trends seen in other variables.

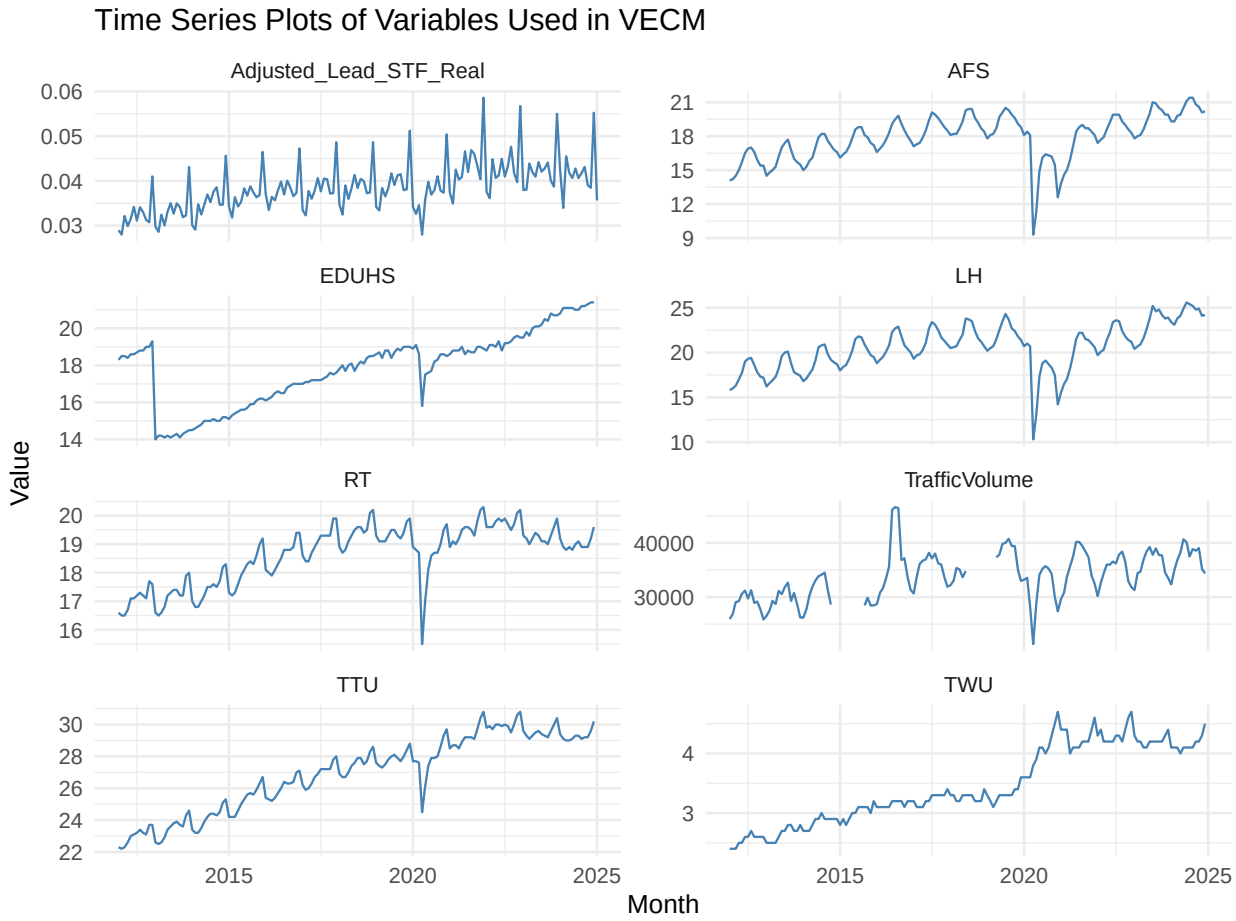
- **Adjusted_Lead_STF_Real**:
  Target variable – real adjusted sales tax revenue

This is the dependent variable in the forecasting model, shifted forward in time and adjusted for inflation to better reflect underlying trends in taxable activity.

Data Transformations

- All series were log-transformed to linearize exponential growth and attempt to stabilize variance.
- Sales tax revenue was adjusted using CPI to produce real values.
- 2024 structural tax rate change (from 3.85% to 4.35%) was normalized using a factor of $\frac{3.85}{4.35}$.
- Lead_STF_Real was led forward by 12 months to align with the overall forecasting horizon.
- Final predictions then were re-inflated, exponentiated and transformed to real unit dollar values utilizing the corresponding CPI value.

Graphs of Variables Included



The above figure displays the time series plots for each variable that was included in the

VECM. Most variables exhibit long-run upward trends (e.g., RT, EDUHS, TTU), supporting the use of cointegration-based modeling for all variables. Clear seasonal patterns are visible in sectors like LH and AFS, this highlights the importance of short-run dynamics. Notably, all consumer-facing industries experienced sharp contractions around 2020 due to the COVID-19 pandemic, followed by recovery, showing the value of incorporating both short and long-term components in the model. TrafficVolume appears more volatile and cyclical, while EDUHS reflects a structural shift around 2014, which may affect its role in the model's cointegrating relationships.

Results

Johansen Procedure Results

To determine whether a cointegrated relationship exists among the chosen variables, the Johansen cointegration test was applied to the variables. This method uses the maximum eigenvalue (measure strength of relationship)and trace statistics (taken and summed from the eigen values to find how many cointegrated relationships there are in the data) to test for the number of cointegrating vectors r. In this study, the test identified $r \leq 5$ significant cointegrating vectors at the 5% level, indicating a strong long-run relationship among the selected variables.

The Johansen test outputs the cointegrating vectors (the β matrix), which define stationary linear combinations of the non-stationary time series. These vectors were normalized such that the first five variables each anchor one vector.

Cointegration Matrix and Short-Run Coefficients

The estimated cointegrating vector matrix (β) from the Johansen test is:

$$\beta = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0.189 & -4.662 & -4.905 & -3.445 & -1.372 \\ -0.578 & 2.395 & 1.737 & 1.781 & 0.313 \\ -0.384 & 3.510 & 2.923 & 2.676 & -1.139 \end{bmatrix}$$

These vectors represent long-term equilibrium relationships. For example, the first vector implies the equation:

$$\text{ECT}_1 = RT_{t-12} + 0.189 \cdot TTU_{t-12} - 0.578 \cdot TrafficVolume_{t-12} - 0.384 \cdot Adjusted\_Lead\_STF\_Real_{t-12}$$

Each of these cointegration relationships feeds into the VECM as an error correction term (ECT), allowing short-run deviations from the long-run path to influence the direction of change.

Based on the summary statistics, the variables EDUHS, TTU, TrafficVolume, and Adjusted_Lead_STF_Real displayed significant adjustment in multiple vectors, implying they actively have a role in reestablishing equilibrium in the system over the long run and contribute most strongly to the predictive power of the model.

Model Accuracy Assessment

To evaluate model accuracy, the VECM was re-estimated using data up to January 2024. Out-of-sample forecasts were then generated for February through December 2024 and compared against the actual observed values of real, adjusted sales tax revenue. The mean absolute error (MAE) for this forecast period was calculated to assess average prediction accuracy across all the forecasted months. The resulting value was MAE = 3.24, this indicates that the model's forecasts deviates from actual values by approximately $3.24 million on average per month.

This level of error suggests that the model captures the overall trend, though the short-term fluctuations or noise is still present and should be kept in mind. In future applications, incorporating some external shock index or additional leading indicators may further improve the accuracy or power of the model.

Forecasting Process and Conversion to Sales Tax

To convert forecasted values of Adjusted_Lead_STF_Real into dollar sales tax revenue:

1. Exponentiate the forecasted log values.
2. Multiply by the ratio of the new to old tax rate ($\frac{0.0435}{0.0385}$) to scale for the 2024 structural change.
3. Multiply by CP to express in revenue dollars.
4. Un-lag the values.

This adjustment ensures comparability and practical interpretability of the forecast results so it can be compared to the previous data.

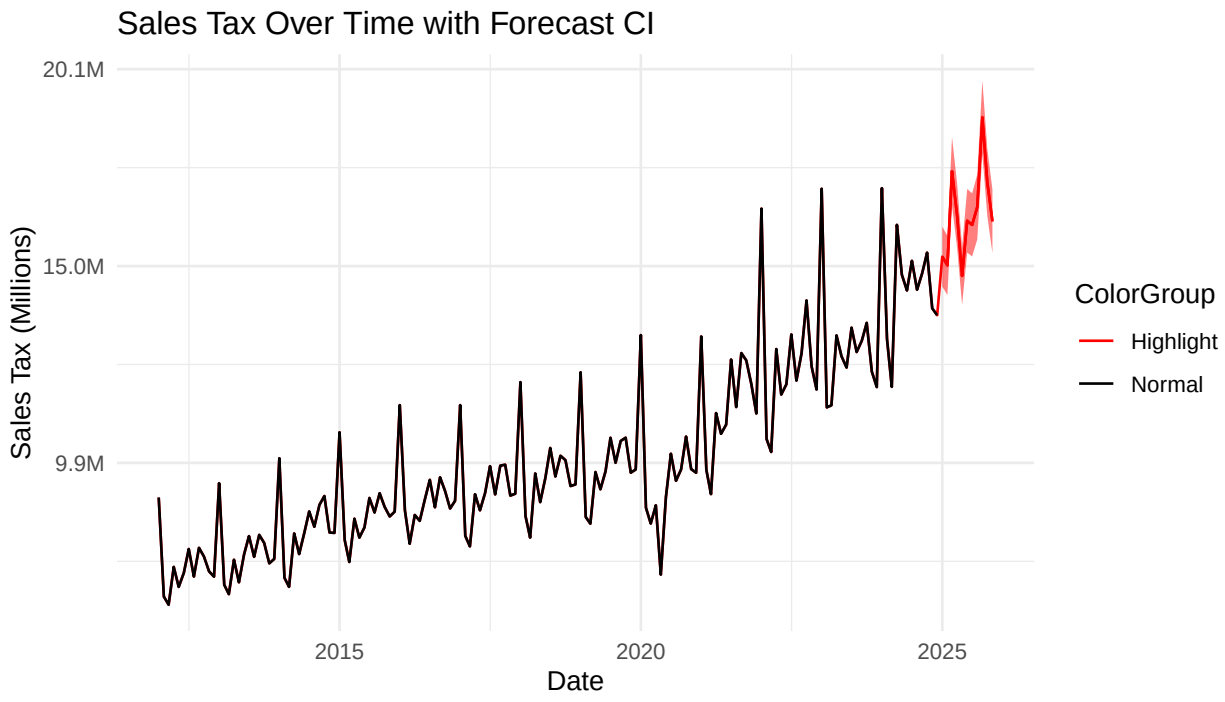
Monthly 2025

The forecasted values of real adjusted sales tax revenue for February through December 2025 are: 0.0476, 0.0470, 0.0558, 0.0520, 0.0470, 0.0516, 0.0512, 0.0525, 0.0597, 0.0543, 0.0511 When adjusted and scaled, these forecasts provide monthly tax revenue projections, which can be summed to provide a full-year revenue estimate for 2025.

Table 1: Forecasted Sales Tax Revenue

Month	Forecasted_Revenue	Revenue_Dollars
Feb	15.23	$15.23M
Mar	15.02	$15.02M
Apr	17.41	$17.41M
May	16.28	$16.28M
Jun	14.73	$14.73M
Jul	16.15	$16.15M
Aug	16.05	$16.05M
Sep	16.50	$16.50M
Oct	18.78	$18.78M
Nov	17.13	$17.13M
Dec	16.13	$16.13M
Total	179.41	$179.41M

Sales Tax Forecast Plot



Discussion and Conclusion

Caveats and Limitations

While the model does provide some meaningful insight into Fort Collins' sales tax dynamics, there are several factors that may limit its accuracy and generalizability:

- **Linearity Assumption**: The VECM framework does assume linear relationships among variables, this may not fully capture the underlying complexity of economic behavior in Fort Collins leading to inacuracies that are not detactable.
- **Historical Data Dependence**: The model relies on past trends and may not reflect recent shifts in consumer behavior, policy changes, or structural economic changes not yet visible in the data.This means that the model is vulnerable to any economic shocks that amy take place.
- **Inflation Adjustment Uncertainty**: The use of CPI for real conversion may not align perfectly with actual price changes, potentially this can effect real revenue estimates.
- **Traffic Data Granularity**: Traffic volume, while useful as a proxy for local economic activity, does not capture all relevant consumption patterns particularly in digital or service based sectors ie. not every car is spending money here this can lead to overestimation in the model.
- **Model Specification Sensitivity**: This model is truley dependent on the lag structure and included variables, even small changes in variables or structure can critically affect the model's and predictive accuracy.

These limitations should be considered when interpreting results and using forecasts for any planning or policy purposes.

Summary of Findings

This report developed and implemented a Vector Error Correction Model (VECM) to forecast monthly sales tax revenue for the City of Fort Collins. Using cointegrated time series data; including adjusted sales tax revenue, traffic volume, and economic indicators the model identified five overall significant long-run relationships among the chosen variables. The Johansen test confirmed cointegration, and the variables showed strong adjustment values within the model. Out-of-sample forecasts for 2024 showed reasonable accuracy, with a mean absolute error (MAE) of 3.24, supporting the model's utility for short to medium-term revenue planning. While some limitations remain, such as some sensitivity to variable selection and the assumptions of linearity, the model offers some critical insights for city to utilize in budget forecasting and financial decision making for the year of 2025.