
Parking Meters

— A baseline assessment of
San Diego parking meter trends —

Introduction

The City of San Diego uses parking meters to encourage parking turnover and maximize utilization by disincentivizing long-term street parking:

- There are **3,882 parking meters** in use during 2023 calendar year
- No payment required on Sundays, holidays, and other special occasions
- Enforcement requires staffing

Parking meter transactions seem to have **decreased over time**, leading to questions about whether more enforcement is required. But **transaction volume is variable**, so we need to find underlying trends

We demonstrate here a method to reliably forecast parking meter volume so that we can find anomalous periods of high delinquency, and so we can assess the need for more parking enforcement staffing to encourage utilization compliance

Datasets

Parking Meter dataset is sourced from the City of San Diego OpenData portal, including 5.75 million daily listings from January 2018 to November 2023:

- Pole ID
- Number of transactions
- Total dollar amount

Average 14,700 daily transactions generating \$20,800 in revenue

Daily weather data is sourced from the National Oceanic Atmospheric Administration (NOAA). Weather can affect parking behavior, e.g. staying inside during cold or rainy days

- Precipitation
- Temperature (avg / min / max) in Celsius



date	PRCP	TAVG	TMAX	TMIN	transactions	dollar_amount
2018-01-01	0.0	13.8	18.9	10.6	1332.0	204.30
2018-01-02	0.0	15.8	22.2	12.2	34094.0	33024.55
2018-01-03	0.0	16.4	19.4	13.3	35104.0	34259.14
2018-01-04	0.0	16.6	21.1	12.2	36098.0	35627.75
2018-01-05	0.0	17.4	22.8	13.3	36553.0	36737.15
...
2023-11-22	0.0	17.2	25.6	10.0	17183.0	24783.07
2023-11-23	0.0	16.2	20.0	10.6	181.0	46.20
2023-11-24	0.3	17.4	18.9	12.8	13007.0	19177.49
2023-11-25	0.0	15.0	19.4	10.0	15388.0	24139.33
2023-11-26	0.0	13.9	21.7	7.8	190.0	48.75



Parking Influences - Annual Trends

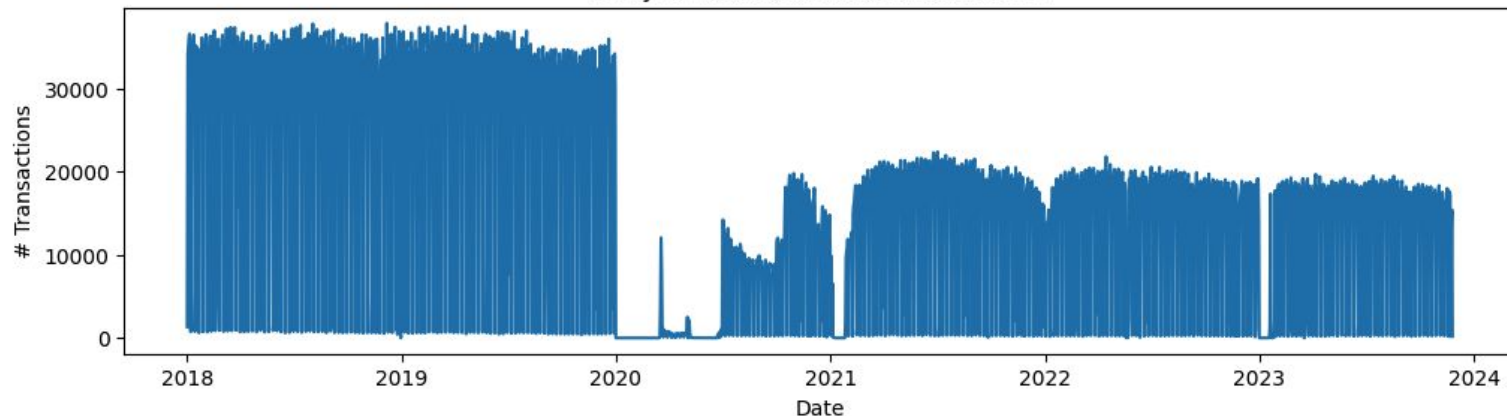
Regular annual shutdown in January

Appears to be a slight decline over time

Summer months have more action than winter months

COVID shutdown in 2020, thus all following analysis starts at January 31, 2021

Daily transactions volume over time



Parking Influences - Day of Week

Mondays

Fewest regular parking meter transactions

Wednesdays

Generate the most revenue

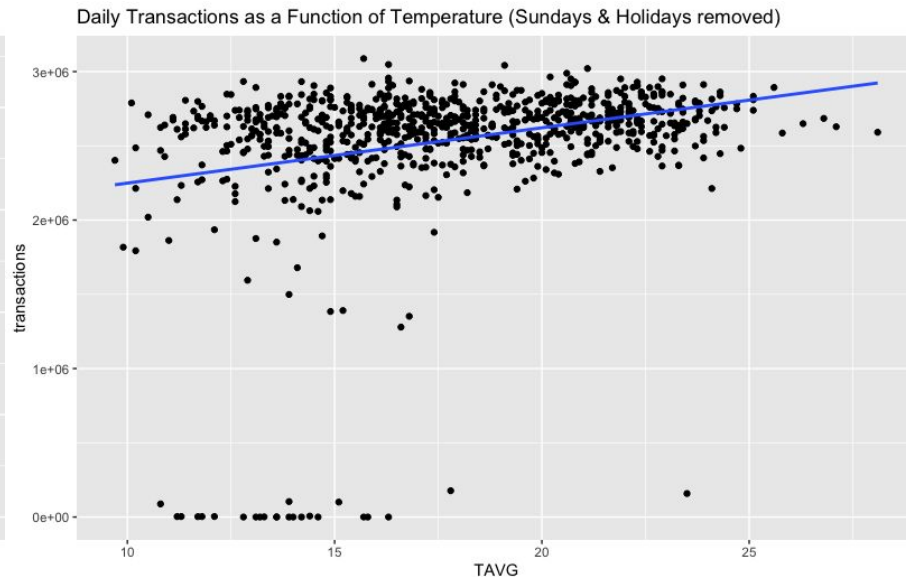
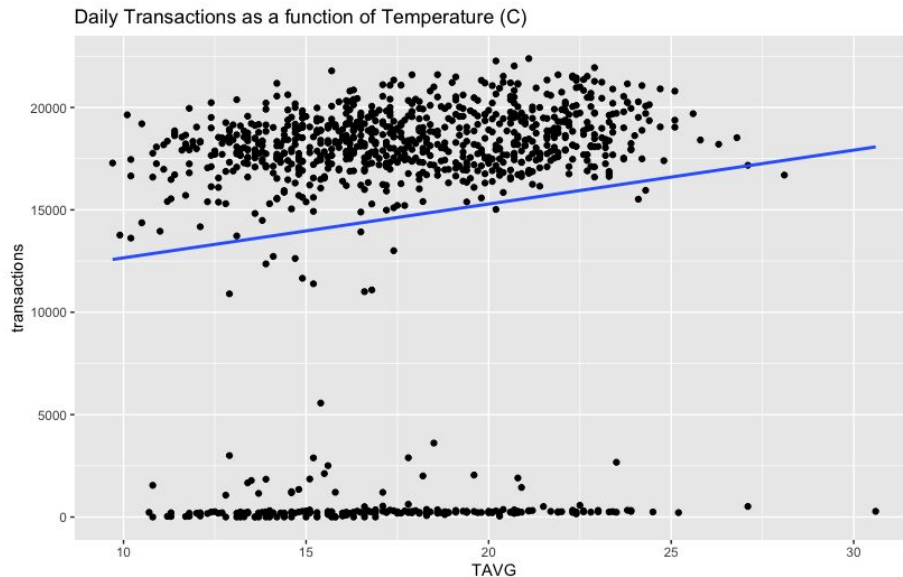
Saturdays

Cost the most per transaction

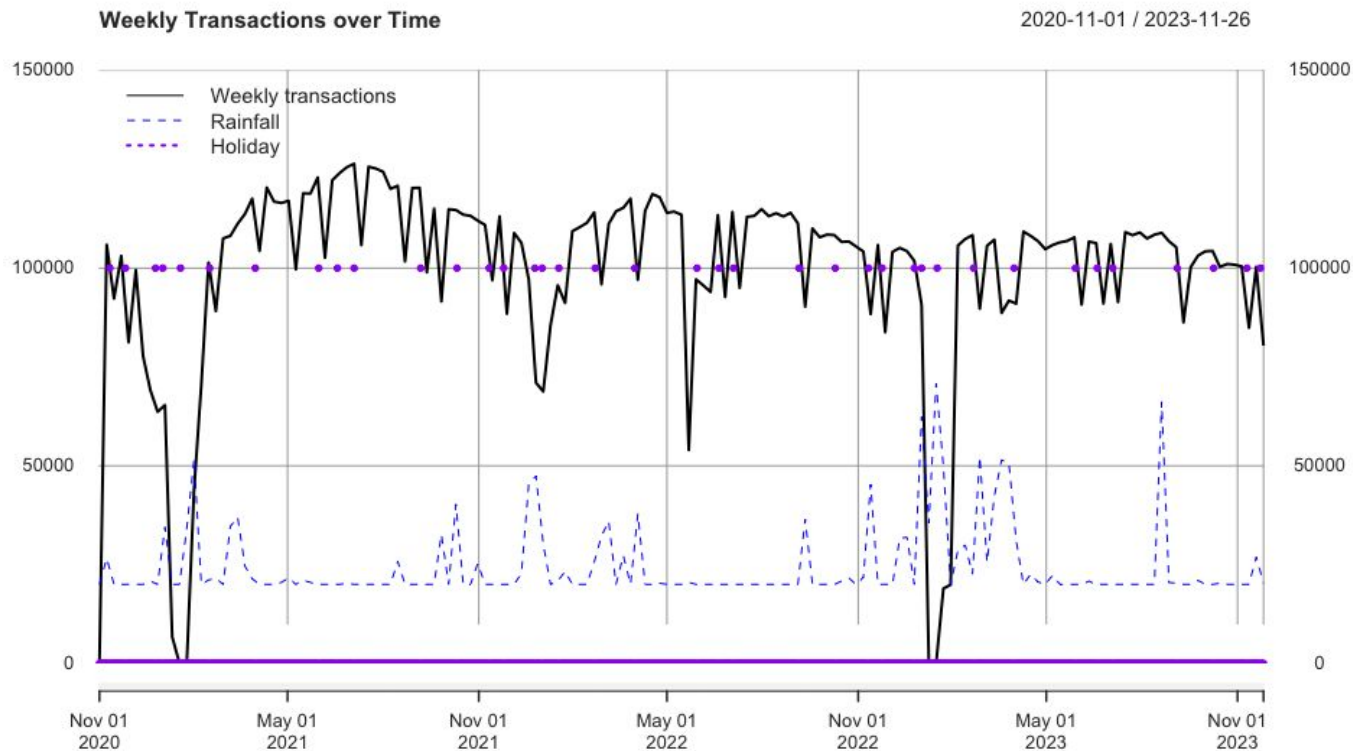
Day	Average Transactions	Average Cost	Transaction Share %	Revenue Share %
Sunday	232	\$0.34	0.2%	0.1%
Monday	15,000	\$1.28	14.5%	14.2%
Tuesday	17,500	\$1.39	17.0%	16.7%
Wednesday	17,900	\$1.40	17.4%	17.3%
Thursday	17,500	\$1.37	17.0%	16.9%
Friday	18,200	\$1.37	17.7%	17.7%
Saturday	16,700	\$1.48	16.2%	17.1%

Parking Influences - Weather

There is evidence to show a relationship between parking and temperature, which also illustrates the need to carefully review data (in this case removing Sundays and Holidays)



Parking Influences - Visually Represented



There is a regular rise and fall in parking activity each year

Weeks with a holiday show predictable “dips” in volume

Rain seems to correspond with periods of low parking activity

Time Series Modeling and Predictions

We used **multiple time series models** to assess the usefulness of forecasting transactions over a 90-day period, including:

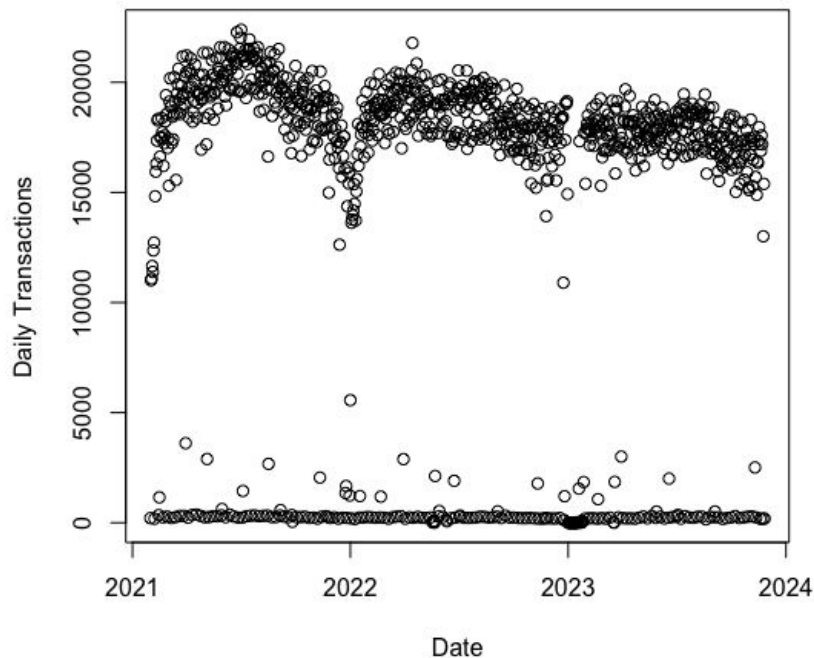
- Seasonal decomposition
- Linear Regression
- ARIMA

Limited the training data from January 31, 2021 to August 8, 2023

90-day forecasts from August 9, 2023 to November 25, 2023 were validated against actual parking volume

Isolating Trends via Decomposition

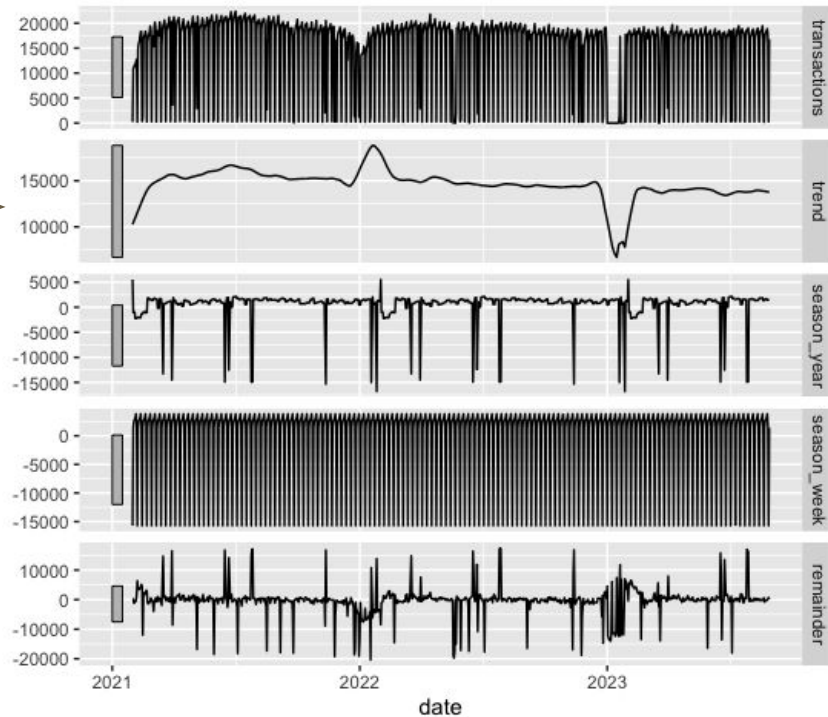
Daily Transactions over Time



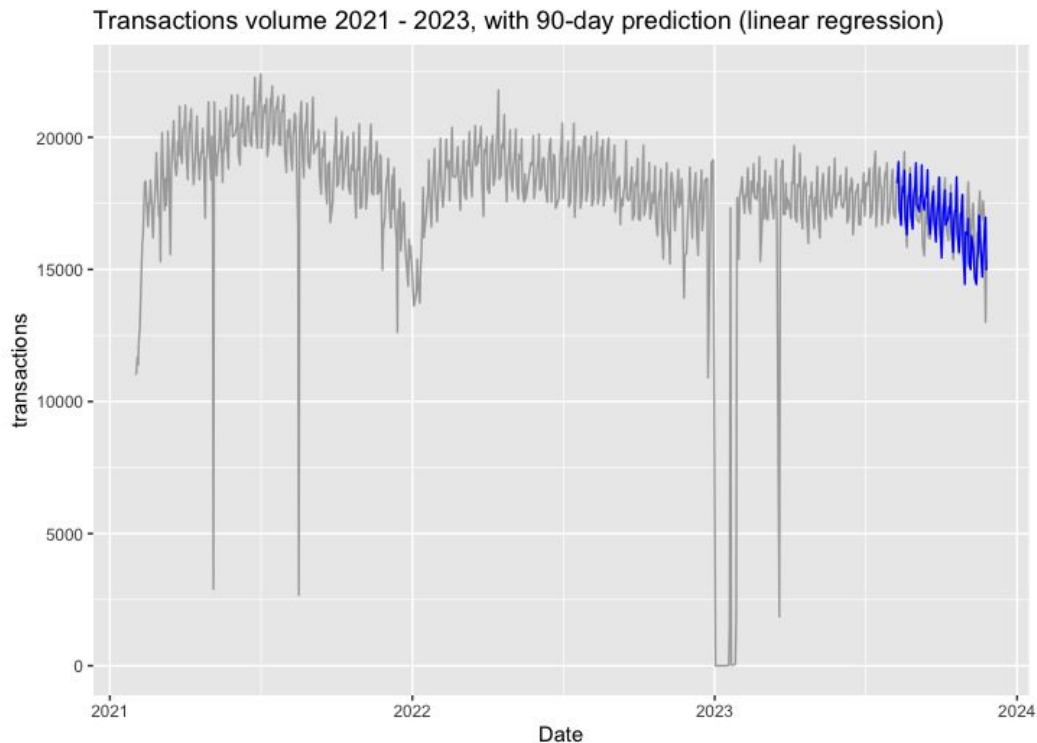
TREND

STL decomposition

$\text{transactions} = \text{trend} + \text{season_year} + \text{season_week} + \text{remainder}$



Linear Regression Forecast



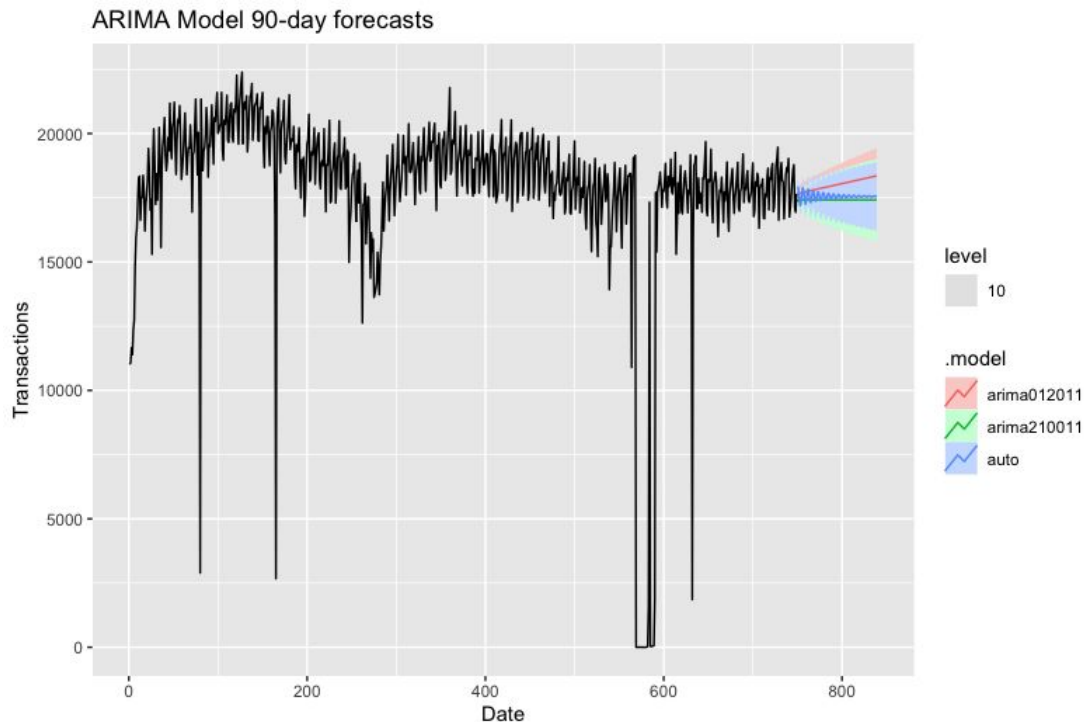
Linear Regression model based on underlying trend, seasonality, and weather information

Volume Forecast: 1,528,437

Volume Actual: 1,539,638

99.3% accuracy!

ARIMA Model Forecast



Multiple ARIMA models predicting future values based on past values

Volume Forecast: 1,587,716

Volume Actual: 1,539,638

Forecast shows 3.1% deviation, but “feels” different from the actual values

Conclusion and Next Steps

We demonstrated the ability to accurately forecast parking meter volume over a 90-day period based on underlying trends and external information. This will allow us to identify periods of deviation which may require more enforcement staffing. Next steps:

- Continue to monitor and update models as new data comes
 - Models are mostly data-driven and can be automated
- Gather hourly parking meter data (if available)
 - Current data is aggregated daily by Pole ID, and we cannot assess peak times
- Review parking meters by location
 - Some neighborhoods may experience different trends from others
- Review the number of parking violations and their time trend
 - Including related review of current enforcement staff
- Assess the economic need for parking garages
 - Trade-offs between construction costs, ongoing rent, impact to city revenue, drivability of streets

Thank you!

For more information:

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GitHub https://github.com/sfreagin/parking_meters

References

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