The Impact of UVX on Traffic in Provo

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The Utah Valley Express (UVX) entered service in August 2018, the culmination of years of effort by Utah's leaders. The newly established bus lines were created to increase urban commuting options and to reduce traffic in the Orem/Provo area. UVX has experienced high take up, providing one million rides within five months of starting service (Ashcraft, 2019). Within a year 12,000 to 14,000 people were riding UVX every day (*The Daily Universe*, 2019). These ridership numbers indicate that UVX is fulfilling its first goal, but only hint at the second. Did UVX accomplish its goal of reducing traffic in the Provo area? This question is increasingly important because the federal grant that provides free fares for all riders is expiring soon (Davidson, 2019). While BYU and UVU have made deals with the Utah Transit Authority to ensure that students will continue to ride free, Utah's leaders will need information about UTX's traffic impact before they make a decision about funding future rides for the general population. Furthermore, information about the potential reduction in traffic caused by UVX will be important for other areas in and outside of Utah that are looking to implement similar programs.

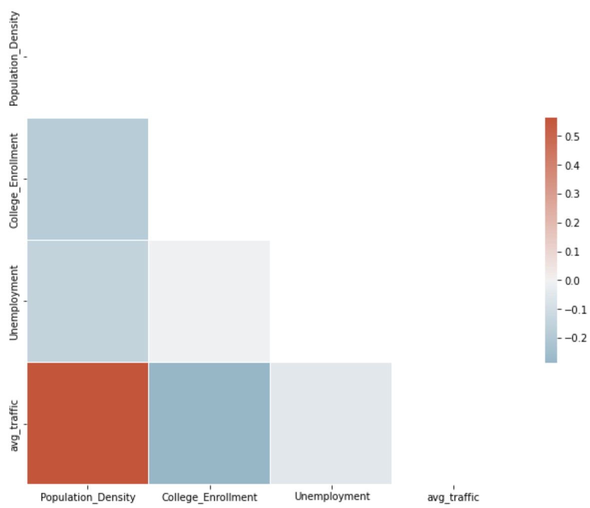
DATA

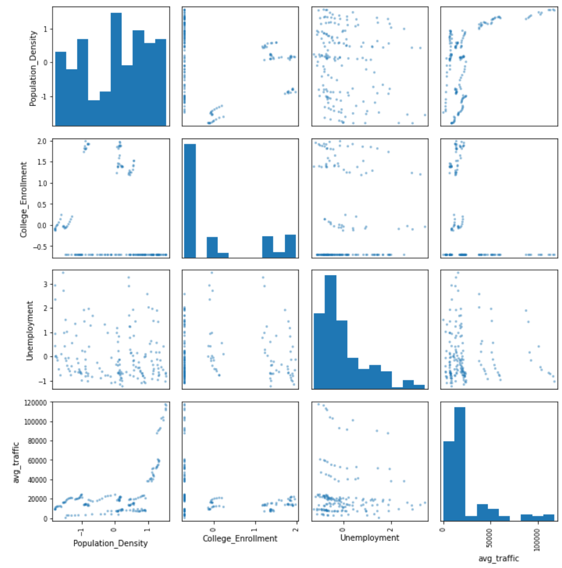
The dependent variable in this study will be the number of cars using key roads in Provo. Thankfully, the Utah Department of Transportation publishes average annual daily traffic measurements for many key roads. The measurement selected for this analysis is measured in the number of cars that use a road by day, averaged over the year. This should reduce concerns about seasonality and reduce the role that accidents and minor construction play. Since this analysis requires speculating about what Provo would look like without the UVX treatment, data were collected from cities around Utah to compare. Orem was deliberately excluded from the sample because it also received the UVX treatment. We selected features that we felt would help explain traffic in each city. The model's features include population, population density, GDP of the county, college enrollment, the number of registered cars in the county, the city unemployment rate, and racial makeup of the city. Measurements of population, population density, GDP, college enrollment, unemployment, and racial makeup were all collected from the Bureau of Labor Statistics. Car registration data were taken from the Utah State Tax Commission's reports.

In the interest of building a robust model, the years of study were limited to 2010 to 2020. While most features were available in earlier years, some were unavailable or had methodology changes that made them incomparable. The traffic measurements for streets in each city were collapsed into a single average traffic number due to the computational power that would have been required to go street by street. Despite these limitations, the data are sufficient for the methods that will be used. The average value of each variable is presented in the table below.

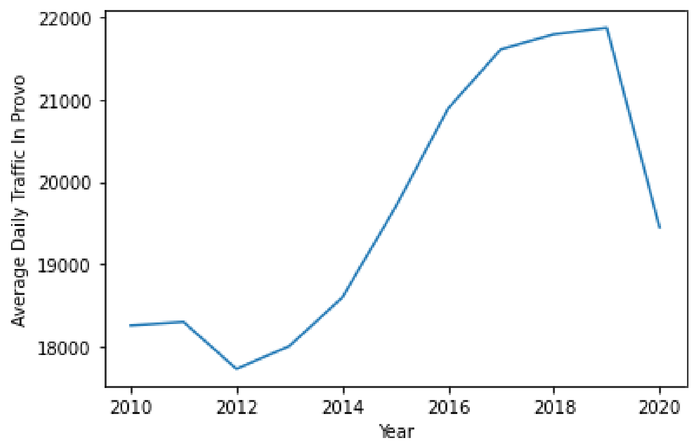
City	Traffic	Pop.	Pop. Density	GDP	College Students	Cars	Unemploy.	% White	% Black	% Asian	% Native
Cedar	10673.73737	845.5656209	31142.18182	1502377.636	9229.454545	38831.36364	5.193636364	0.907499328	0.005225393	0.008200867	0.028753238
Draper	21340.90909	1537.134309	46237	80075109.82	0	815921.9091	3.974545455	0.922184065	0.010162415	0.035919871	0.007971934
Herriman	2868.181818	1711.651792	34695.18182	80075109.82	0	815921.9091	3.885454545	0.937011841	0.012278191	0.011283264	0.011405675
Layton	20728.74693	3342.892562	73543.63636	12481251.82	0	234688.0909	4.125454545	0.911108474	0.016168158	0.025952922	0.012894298
Lehi	20320.10909	2261.593152	59570.36364	21731546.91	0	353177.9091	4.314545455	0.947658592	0.00292855	0.015319546	0.012365023
Logan	7826.915888	2791.856694	50085.90909	4743911	27790.90909	85355.45455	3.5	0.906071438	0.012473024	0.040915581	0.013935394
Murray	54946.9697	3943.509135	48465.72727	80075109.82	0	815921.9091	4.324848545	0.919569806	0.017503908	0.021934075	0.013385545
Ogden	14023.42105	3154.934729	85467.18182	9926629.455	27000.54545	178349.1818	5.712121091	0.910249737	0.023796772	0.018711216	0.015799697
Provo	19652.46154	2780.784083	115875.2727	21731546.91	33790	353177.9091	3.635606	0.906293467	0.00744887	0.029998196	0.020800818
Sandy	102465.9091	4112.636642	94056	80075109.82	0	815921.9091	4.240151545	0.930127695	0.006889636	0.034896092	0.007476527
Salt Lake City	13659.51594	1752.645617	194736.4545	80075109.82	34166.54545	815921.9091	4.273484818	0.838368517	0.035772345	0.061631082	0.036951579
South Jordan	7652.727273	2954.326943	65142.90909	80075109.82	0	815921.9091	3.825757545	0.931049814	0.006326259	0.027713563	0.011174512
Saint George	18107.59358	1151.234504	81046.90909	4876434.545	9504.363636	127748.0909	5.248484909	0.932654689	0.008036995	0.010155108	0.025476218
West Jordan	7345.454545	3433.582591	111454.0909	80075109.82	0	815921.9091	4.132575636	0.902723828	0.013924473	0.032839672	0.02589399
West Valley	41272.72727	3771.970549	134131.2727	80075109.82	0	815921.9091	4.762878727	0.779556022	0.030507619	0.082550625	0.07153198

The plots below give the correlation heat map and the scatterplot matrix for some of the more significant variables.





Examining a graph of Provo's traffic patterns (see below) shows a correlation between the implementation of UVX and a decrease in traffic, a promising first step. Traffic does not decrease in absolute terms until after 2019, but its rate of growth slows starting in 2017 and slows more quickly after 2018. With UVX being implemented partway through 2018, this seems to hint at a causal role. While this information is promising, the drop in cars traveling on Provo's roads could be due to other factors. The substantial difference between cars in 2019 and 2020 was likely at least partially due to the coronavirus pandemic, which resulted in lockdowns that stopped most travel for some of the year.



There is one other drop of traffic in the sample, occurring in 2012. This was likely due to the construction of the I-15 CORE project, which added additional lanes to southbound I-15 in the area around Provo (Verdict Traffic). Construction of this project was started in April of 2012 and finished in December of the same year. It is probable that ongoing construction deterred some people from traveling to or through Provo but proving causality would require a similar analysis to that of this paper, so we leave it to other researchers.

METHODS

In our synthetic control research design, a weighted average of cities other than Provo is used to approximate the Provo counterfactual traffic levels without the presence of UVX. This involves weighing the covariates that predict traffic by their feature importance and then weighting cities with a separate optimization to create the synthetic version of Provo. We used Lasso and Elastic Net approaches to create the covariate weights, and the default algorithm from a synthetic control package to create the city weights.

Several assumptions are required of the data in order to employ this synthetic control approach. We assume that Provo traffic is explained by the control variables while the control variables are not affected by the implementation of the treatment. It seems reasonable to assume that the demographic and economic characteristics would not be affected by the construction of the UVX bus line. We must also assume that the relationship between Provo and the other cities is stable on either side of the treatment. We think it is reasonable to assume that Provo's relationship with other cities did not become significantly different in the time surrounding the construction.

To implement machine learning to get covariate weights, we first used a Lasso model to try and identify how each variable should be weighted in order to most accurately predict traffic levels. After our data were divided into training and test portions, we performed a grid search to identify the best value of the tuning parameter to predict traffic levels in the pre-UVX period. After the grid search, we found that the out of sample mean square error of our model was still rather high, at 2002993614.6088178.

Switching to an Elastic Net model with similar fivefold cross validation of the tuning parameter, we were able to obtain a lower out of sample mean square error of 204540122.6442126. This was smaller than our Lasso error by a factor of 10, so we used the coefficients from our Elastic Net model as the weights for our final synthetic control. The final

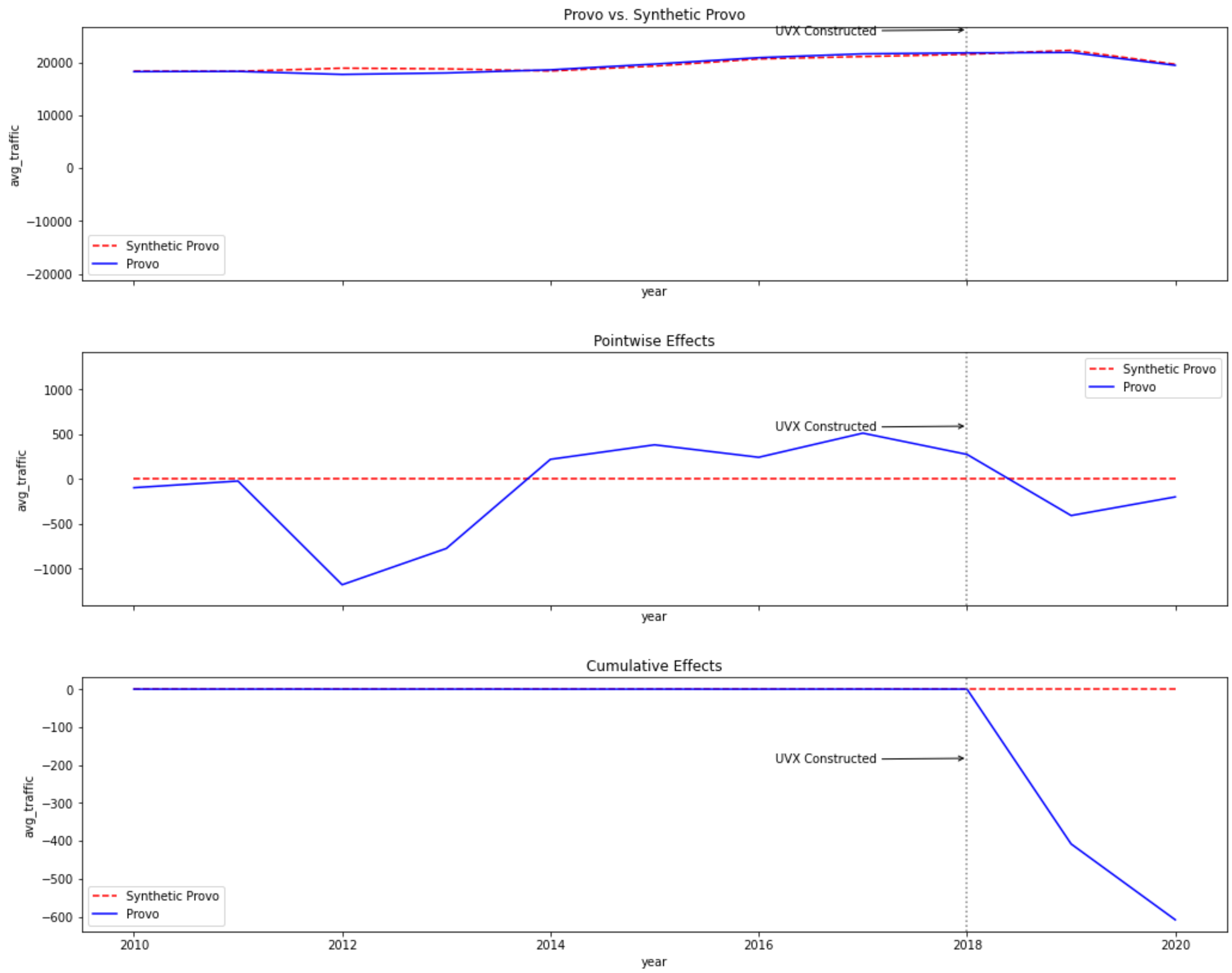
Variable	Weighting	Variable	Weighting
Pop. Density	891.11	% Native	291.6
Pop.	41.71	Cache	337.36
GDP	559.14	Davis	110.72
College Enrollment	523.21	Iron	239.08
Cars	534.67	Salt Lake	437.74
Unemployment	161.57	Washington	28.58
% White	201.61	Weber	42.27
% Black	246.24	Utah	102.83
% Asian	176.12		

weights are listed below. These weights were combined with our data values to create a dataset with weighted variable values which was the basis of the construction of our synthetic control.

Using this weighted data set, we used the SyntheticControlMethods analysis package created by Oskar Engelbrektson to create a synthetic control for Provo. The synthetic control generated was composed of a weighted average consisting of 10.27% Cedar, 9.91% Ogden, 46.22% West Jordan, and 33.60% West Valley. This weighting did not seem overly implausible to the members of our group familiar with Utah.

RESULTS AND ROBUSTNESS CHECKS

When compared to the normalized value of traffic in our synthetic control, traffic was shown to be lower in the actual, treated Provo in the years following the implementation of UVX. This would seem to indicate that UVX did indeed impact traffic rates in Provo, decreasing traffic as shown below.

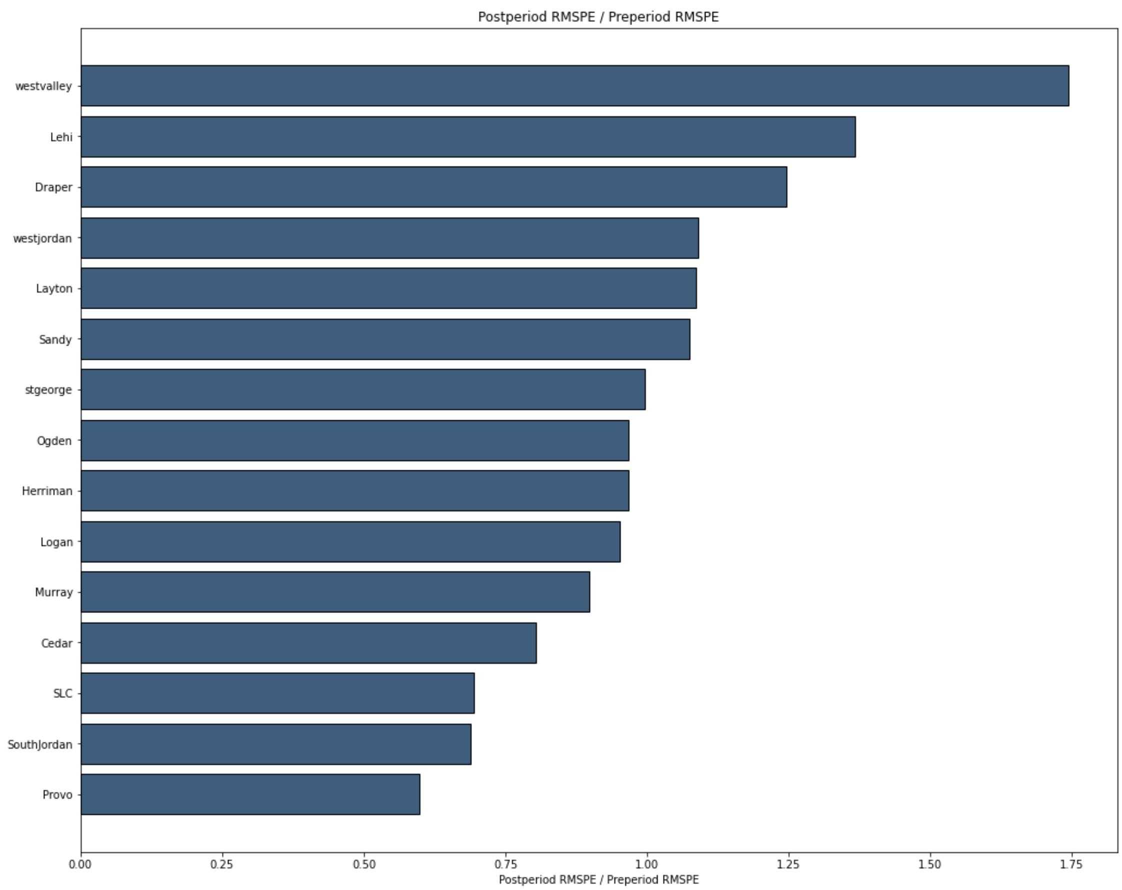


The first check for robustness that we employed was to generate a similar synthetic control for Provo, but with the UVX treatment occurring in an arbitrary year. Given that the year selected (in this case 2015) was not a year where any treatment like the institution of UVX was observed, we would expect the results to be less extreme than the results found with 2018 as our treatment year, if UVX impacted traffic. As shown below, the placebo treatment ended up not showing any large effect on observed traffic trends in Provo. Given the comparably large effect that our synthetic control identified with treatment at the time that UVX opened, this serves to validate our claim that UVX's impact on traffic in Provo was indeed significant.

For our second robustness check, we followed the general practice of running a similarly constructed synthetic control for each of the other 14 cities in our dataset. The Python package allowed us to compare how much the other cities in our sample differed from their respective synthetic versions. To best reinforce the significance of our finding that traffic was reduced by UVX, we would want the difference between Provo and its synthetic control to be more extreme than the differences between the other cities and their synthetic controls. This should hold true if UVX did impact traffic rates, given the fact that neither UVX nor a similar public transit service was established in any of the other cities in our sample in the year 2018, so no similar treatment effect exists.

Unfortunately, the results of our analysis found the synthetic control for Provo to differ from the traffic levels actually observed in Provo less than any of the other synthetic controls.

The fact that the observed difference was in fact smallest for Provo weakens the robustness of our results. One factor that could be affecting this is the irregular traffic patterns for Provo observed in 2012 as well as the preceding years. This means that traffic levels in Provo may have already been reduced when compared to the unusually high levels in 2010 and 2011 (the first periods our synthetic control matched for).



The construction that affected Provo's traffic creates higher variance in its traffic levels as compared to other cities. This means the pre-period MSE will be much higher than for other cities which helps explain why Provo was so low in the placebo table. Ideally, we could control for this using year and city interaction terms in our analysis. However, due to the computational limits of the synthetic control package, the additional covariates would have added several hours onto the computation time each time our code is run. For that reason, we leave the task of controlling for more interactions for future research with more computational resources.

CONCLUSION

The model presented shows a reduction in traffic in Provo in the period the hypothesis predicted it would. The results appear to be robust when considering an in-time placebo test, but an in-space test did not produce the same results. There are plausible reasons that explain this discrepancy, but those are left for other researchers to explore. Our results are neither negative nor entirely positive. Despite the mixed findings on traffic reduction, UVX has still been a valuable public project. The large ridership numbers have allowed more people to travel to Provo without causing an increasing traffic, a major accomplishment for Utah's urban planners. With a growing population in Utah Valley, perhaps this is all we can hope for.

CITATIONS

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