

Local Air Quality Effects on Transportation Incentives

Sam Lee

```
provo$t = 1:nrow(provo)
lags = c(1, 7, 14, 21, 28)
provo$log_DailyNumFines = log(provo$DailyNumFines+1)
for(lag in lags){
  provo[str_c("DailyNumFines_Lag", lag)] = lag(provo$DailyNumFines, n=lag)
}

#Missing Data
end = "2019-04-23"
begin = "2017-03-08"

#COVID
covid.begin = "2020-03-14"
covid.end = "2020-09-07"

truncate_provo = function(p){
  p %>% filter(!(DATE >= ymd(begin) & DATE <= ymd(end) |
                DATE >= ymd(covid.begin) & DATE <= ymd(covid.end)))
}

#Add dummy variables
for(m in unique(provo$Month)){
  provo[month.name[m]] = provo$Month == m
}

for(term in unique(provo$Term)){
  provo[term] = provo$Term == term
}
```

```

model.factors = c("MaxTemp", "MinTemp", "MeanTemp", "RainPrecip", "SnowPrecip",
  "Wind", "CO", "NO2", "O3", "PM10", "PM25", "AQI", "Mon",
  "Tues", "Wed", "Thurs", "Fri", "Sun", "t", "FullTime",
  "Holiday", "Exam", "February", "March", "April", "May",
  "June", "July", "August", "September", "October", "November",
  "December", "Spring", "Summer", "Fall", "DailyNumFines_Lag1",
  "DailyNumFines_Lag7",
  "DailyNumFines_Lag14", "DailyNumFines_Lag21",
  "DailyNumFines_Lag28")

log.factors = c("RainPrecip", "SnowPrecip", "Wind", "FullTime")
for(factor in log.factors){
  provo[factor] = log(provo[factor]+1)
}

polynomial.factors = c("MaxTemp", "MinTemp", "MeanTemp", "RainPrecip", "SnowPrecip",
  "Wind", "CO", "NO2", "O3", "PM10", "PM25", "AQI",
  "t", "FullTime", "DailyNumFines_Lag1",
  "DailyNumFines_Lag7",
  "DailyNumFines_Lag14", "DailyNumFines_Lag21",
  "DailyNumFines_Lag28"
)

for(factor in polynomial.factors){
  provo[str_c(factor, "_2")] = provo[factor]^2
}

polynomial.factors = str_c(polynomial.factors, "_2")

env.lag.factors = c()
add_interaction_factors = function(){
  interaction.factors = c()

  env.factors = c("MaxTemp", "MinTemp", "MeanTemp", "RainPrecip", "SnowPrecip",
    "Wind", "CO", "NO2", "O3", "PM10", "PM25", "AQI")

  days = c("Mon", "Tues", "Wed", "Thurs", "Fri", "Sun")

  months = c("February", "March", "April", "May", "June", "July", "August",
    "September", "October", "November", "December")

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seasons = c("Spring", "Summer", "Fall")
lag_factors = c("DailyNumFines_Lag1",
                 "DailyNumFines_Lag7",
                 "DailyNumFines_Lag14", "DailyNumFines_Lag21",
                 "DailyNumFines_Lag28")

combinations = combn(env.factors, 2)
for(i in 1:ncol(combinations)){
  factor = paste(combinations[,i], collapse = "_")
  interaction.factors = c(interaction.factors, factor)
  provo[factor] = provo[combinations[1,i]]*provo[combinations[2,i]]
}

for(day in days){
  factor = str_c(day, "_", "DailyNumFines_Lag1")
  env.lag.factors <- c(env.lag.factors, factor)
  interaction.factors = c(interaction.factors, factor)
  provo[factor] = provo[day]*provo["DailyNumFines_Lag1"]
}

for(env.factor in env.factors){
  for(lag_factor in lag_factors){
    factor = str_c(env.factor, "_", lag_factor)
    env.lag.factors <- c(env.lag.factors, factor)
    interaction.factors = c(interaction.factors, factor)
    provo[factor] = provo[env.factor]*provo[lag_factor]
  }
  for(month in months){
    factor = str_c(env.factor, "_", month)
    interaction.factors = c(interaction.factors, factor)
    provo[factor] = provo[env.factor]*provo[month]
  }
  for(season in seasons){
    factor = str_c(env.factor, "_", season)
    interaction.factors = c(interaction.factors, factor)
    provo[factor] = provo[env.factor]*provo[season]
  }
}

provo <- provo

```

```

    return(interaction.factors)
}

interaction.factors = add_interaction_factors()

model.factors = c(model.factors, interaction.factors, polynomial.factors)

provo[(max(lags)+1):nrow(provo),] -> provo_reduced

provo_reduced = truncate_provo(provo_reduced)

#Basic Linear Model (Robust)
provo.lm = lm(log_DailyNumFines ~ .,
              provo_reduced[c(model.factors, "log_DailyNumFines")])
summary(provo.lm)

```

Call:

```
lm(formula = log_DailyNumFines ~ ., data = provo_reduced[c(model.factors,
  "log_DailyNumFines")])
```

Residuals:

Min	1Q	Median	3Q	Max
-4.1144	-0.5648	0.0388	0.6350	4.1942

Coefficients: (5 not defined because of singularities)

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-3.290e+01	2.671e+01	-1.232	0.21824
MaxTemp	-1.538e-01	2.541e-01	-0.605	0.54502
MinTemp	-8.138e-02	2.433e-01	-0.334	0.73806
MeanTemp	2.987e-01	4.541e-01	0.658	0.51082
RainPrecip	3.401e-01	6.810e-01	0.500	0.61748
SnowPrecip	1.044e+00	7.794e-01	1.339	0.18071
Wind	1.051e+00	1.313e+00	0.801	0.42320
CO	1.365e+00	1.295e+00	1.054	0.29190
NO2	5.439e-02	3.916e-02	1.389	0.16499
O3	1.365e+01	4.848e+01	0.282	0.77831
PM10	-3.612e-02	2.259e-02	-1.599	0.11002
PM25	9.852e-02	1.122e-01	0.878	0.37987
AQI	-2.720e-02	3.913e-02	-0.695	0.48703
Mon	2.174e+00	1.456e-01	14.931	< 2e-16 ***
Tues	2.052e+00	1.555e-01	13.195	< 2e-16 ***

Wed	1.975e+00	1.547e-01	12.767	< 2e-16	***
Thurs	1.742e+00	1.560e-01	11.163	< 2e-16	***
Fri	1.712e+00	1.453e-01	11.775	< 2e-16	***
Sun	1.120e+00	1.248e-01	8.972	< 2e-16	***
t	-7.574e-05	1.695e-04	-0.447	0.65510	
FullTime	6.808e+00	5.881e+00	1.158	0.24717	
Holiday	-1.623e+00	1.112e-01	-14.595	< 2e-16	***
Exam	-4.780e-01	1.326e-01	-3.605	0.00032	***
FebruaryTRUE	1.414e+00	1.481e+00	0.955	0.33977	
MarchTRUE	3.258e+00	1.742e+00	1.870	0.06165	.
AprilTRUE	-2.146e+00	2.459e+00	-0.873	0.38284	
MayTRUE	2.980e+00	3.374e+00	0.883	0.37724	
JuneTRUE	2.302e+00	4.028e+00	0.571	0.56775	
JulyTRUE	1.144e+00	5.327e+00	0.215	0.82999	
AugustTRUE	4.412e+00	5.355e+00	0.824	0.41010	
SeptemberTRUE	6.403e+00	5.901e+00	1.085	0.27805	
OctoberTRUE	6.901e+00	5.761e+00	1.198	0.23111	
NovemberTRUE	6.163e+00	5.724e+00	1.077	0.28178	
DecemberTRUE	7.015e+00	5.723e+00	1.226	0.22047	
SpringTRUE	-4.599e-01	2.820e+00	-0.163	0.87046	
SummerTRUE	-4.418e+00	4.592e+00	-0.962	0.33604	
FallTRUE	-6.433e+00	5.562e+00	-1.157	0.24760	
DailyNumFines_Lag1	-7.016e-03	6.840e-03	-1.026	0.30515	
DailyNumFines_Lag7	1.002e-02	8.527e-03	1.175	0.24012	
DailyNumFines_Lag14	3.222e-03	8.198e-03	0.393	0.69433	
DailyNumFines_Lag21	1.909e-02	8.072e-03	2.364	0.01815	*
DailyNumFines_Lag28	-2.344e-03	8.234e-03	-0.285	0.77595	
MaxTemp_MinTemp	-1.142e-02	2.155e-02	-0.530	0.59637	
MaxTemp_MeanTemp	2.980e-02	4.579e-02	0.651	0.51526	
MaxTemp_RainPrecip	1.893e-02	4.272e-02	0.443	0.65782	
MaxTemp_SnowPrecip	7.114e-02	5.519e-02	1.289	0.19756	
MaxTemp_Wind	-2.607e-04	8.463e-02	-0.003	0.99754	
MaxTemp_CO	-1.043e-01	1.073e-01	-0.971	0.33147	
MaxTemp_NO2	7.098e-03	3.073e-03	2.310	0.02100	*
MaxTemp_O3	-2.857e+00	4.297e+00	-0.665	0.50625	
MaxTemp_PM10	-4.645e-03	1.907e-03	-2.435	0.01497	*
MaxTemp_PM25	-1.210e-02	8.442e-03	-1.434	0.15187	
MaxTemp_AQI	6.259e-03	3.267e-03	1.916	0.05549	.
MinTemp_MeanTemp	2.391e-02	4.383e-02	0.546	0.58540	
MinTemp_RainPrecip	2.065e-02	4.564e-02	0.453	0.65094	
MinTemp_SnowPrecip	8.489e-02	5.772e-02	1.471	0.14154	
MinTemp_Wind	1.854e-02	7.733e-02	0.240	0.81057	
MinTemp_CO	-1.587e-01	1.043e-01	-1.522	0.12825	

MinTemp_NO2	6.137e-03	2.745e-03	2.236	0.02547 *
MinTemp_O3	-2.727e+00	4.117e+00	-0.662	0.50782
MinTemp_PM10	-2.869e-03	1.395e-03	-2.056	0.03989 *
MinTemp_PM25	-1.217e-02	7.386e-03	-1.648	0.09961 .
MinTemp_AQI	4.587e-03	2.731e-03	1.680	0.09318 .
MeanTemp_RainPrecip	-3.017e-02	8.147e-02	-0.370	0.71114
MeanTemp_SnowPrecip	-1.733e-01	1.058e-01	-1.638	0.10151
MeanTemp_Wind	-4.683e-02	1.509e-01	-0.310	0.75630
MeanTemp_CO	2.794e-01	2.016e-01	1.386	0.16592
MeanTemp_NO2	-1.224e-02	5.486e-03	-2.231	0.02578 *
MeanTemp_O3	5.145e+00	7.928e+00	0.649	0.51640
MeanTemp_PM10	7.061e-03	3.035e-03	2.326	0.02010 *
MeanTemp_PM25	2.590e-02	1.467e-02	1.765	0.07777 .
MeanTemp_AQI	-1.148e-02	5.549e-03	-2.070	0.03863 *
RainPrecip_SnowPrecip	5.754e-02	1.353e-01	0.425	0.67066
RainPrecip_Wind	-2.018e-01	1.849e-01	-1.091	0.27521
RainPrecip_CO	-2.944e-01	2.721e-01	-1.082	0.27944
RainPrecip_NO2	5.479e-03	6.625e-03	0.827	0.40831
RainPrecip_O3	-7.574e+00	1.088e+01	-0.696	0.48660
RainPrecip_PM10	-9.589e-05	4.025e-03	-0.024	0.98100
RainPrecip_PM25	1.643e-02	1.720e-02	0.955	0.33957
RainPrecip_AQI	8.796e-03	8.149e-03	1.079	0.28054
SnowPrecip_Wind	-3.471e-01	2.479e-01	-1.400	0.16174
SnowPrecip_CO	-8.307e-01	2.978e-01	-2.789	0.00533 **
SnowPrecip_NO2	1.042e-04	8.669e-03	0.012	0.99041
SnowPrecip_O3	-1.971e+01	1.318e+01	-1.495	0.13497
SnowPrecip_PM10	5.113e-03	6.838e-03	0.748	0.45477
SnowPrecip_PM25	-2.710e-02	3.111e-02	-0.871	0.38389
SnowPrecip_AQI	1.854e-02	1.302e-02	1.423	0.15478
Wind_CO	1.210e-01	4.130e-01	0.293	0.76955
Wind_NO2	-1.556e-02	1.100e-02	-1.415	0.15720
Wind_O3	6.274e+00	1.682e+01	0.373	0.70918
Wind_PM10	9.542e-03	6.209e-03	1.537	0.12449
Wind_PM25	-4.637e-02	3.103e-02	-1.494	0.13528
Wind_AQI	7.164e-03	1.196e-02	0.599	0.54940
CO_NO2	-1.872e-02	1.617e-02	-1.158	0.24714
CO_O3	-1.500e+01	1.855e+01	-0.808	0.41891
CO_PM10	-1.066e-03	1.062e-02	-0.100	0.92007
CO_PM25	4.054e-02	4.068e-02	0.997	0.31905
CO_AQI	-6.634e-03	1.749e-02	-0.379	0.70460
NO2_O3	-3.447e-01	5.686e-01	-0.606	0.54446
NO2_PM10	5.331e-05	2.003e-04	0.266	0.79021
NO2_PM25	-6.152e-05	1.001e-03	-0.061	0.95101

NO2_AQI	3.672e-04	3.270e-04	1.123	0.26158	
O3_PM10	4.171e-01	3.307e-01	1.261	0.20737	
O3_PM25	-5.434e-01	1.173e+00	-0.463	0.64317	
O3_AQI	4.546e-01	5.662e-01	0.803	0.42210	
PM10_PM25	-3.224e-04	3.927e-04	-0.821	0.41177	
PM10_AQI	1.675e-04	1.907e-04	0.878	0.37991	
PM25_AQI	-1.179e-03	8.079e-04	-1.460	0.14452	
Mon_DailyNumFines_Lag1	4.047e-03	2.755e-03	1.469	0.14197	
Tues_DailyNumFines_Lag1	1.022e-02	2.248e-03	4.546	5.79e-06	***
Wed_DailyNumFines_Lag1	1.077e-02	2.114e-03	5.096	3.82e-07	***
Thurs_DailyNumFines_Lag1	1.204e-02	2.322e-03	5.187	2.36e-07	***
Fri_DailyNumFines_Lag1	1.346e-02	2.229e-03	6.036	1.89e-09	***
Sun_DailyNumFines_Lag1	2.733e-02	9.718e-03	2.813	0.00496	**
MaxTemp_DailyNumFines_Lag1	8.088e-04	5.392e-04	1.500	0.13373	
MaxTemp_DailyNumFines_Lag7	5.662e-04	7.386e-04	0.767	0.44344	
MaxTemp_DailyNumFines_Lag14	4.191e-04	7.109e-04	0.590	0.55552	
MaxTemp_DailyNumFines_Lag21	4.233e-04	7.358e-04	0.575	0.56517	
MaxTemp_DailyNumFines_Lag28	-1.276e-03	6.797e-04	-1.878	0.06056	.
MaxTemp_February	9.003e-02	1.264e-01	0.712	0.47632	
MaxTemp_March	1.128e-01	1.411e-01	0.799	0.42413	
MaxTemp_April	2.163e-01	1.777e-01	1.218	0.22349	
MaxTemp_May	3.395e-01	2.624e-01	1.294	0.19587	
MaxTemp_June	5.579e-01	2.973e-01	1.876	0.06075	.
MaxTemp_July	5.817e-01	3.905e-01	1.490	0.13650	
MaxTemp_August	5.349e-01	4.008e-01	1.335	0.18215	
MaxTemp_September	-1.130e-01	4.500e-01	-0.251	0.80177	
MaxTemp_October	-7.806e-02	4.377e-01	-0.178	0.85846	
MaxTemp_November	-3.547e-01	4.329e-01	-0.819	0.41271	
MaxTemp_December	-2.955e-01	4.335e-01	-0.682	0.49553	
MaxTemp_Spring	4.981e-03	2.048e-01	0.024	0.98060	
MaxTemp_Summer	6.346e-02	3.354e-01	0.189	0.84996	
MaxTemp_Fall	3.650e-01	4.211e-01	0.867	0.38620	
MinTemp_DailyNumFines_Lag1	-1.238e-04	5.238e-04	-0.236	0.81319	
MinTemp_DailyNumFines_Lag7	1.741e-04	7.051e-04	0.247	0.80499	
MinTemp_DailyNumFines_Lag14	5.114e-04	6.975e-04	0.733	0.46352	
MinTemp_DailyNumFines_Lag21	-1.806e-04	6.957e-04	-0.260	0.79523	
MinTemp_DailyNumFines_Lag28	-2.517e-04	6.525e-04	-0.386	0.69967	
MinTemp_February	-1.080e-01	1.295e-01	-0.834	0.40449	
MinTemp_March	-1.441e-01	1.415e-01	-1.018	0.30859	
MinTemp_April	-1.753e-01	1.658e-01	-1.057	0.29054	
MinTemp_May	-2.664e-01	2.557e-01	-1.042	0.29750	
MinTemp_June	-1.957e-01	2.747e-01	-0.712	0.47635	
MinTemp_July	-1.644e-03	3.155e-01	-0.005	0.99584	

MinTemp_August	-1.730e-02	3.226e-01	-0.054	0.95723
MinTemp_September	-5.964e-01	3.513e-01	-1.698	0.08968 .
MinTemp_October	-4.996e-01	3.406e-01	-1.467	0.14257
MinTemp_November	-6.856e-01	3.358e-01	-2.042	0.04129 *
MinTemp_December	-6.698e-01	3.358e-01	-1.994	0.04625 *
MinTemp_Spring	3.448e-01	2.035e-01	1.694	0.09038 .
MinTemp_Summer	2.460e-01	2.596e-01	0.947	0.34361
MinTemp_Fall	5.679e-01	3.142e-01	1.807	0.07088 .
MeanTemp_DailyNumFines_Lag1	-8.058e-04	9.807e-04	-0.822	0.41136
MeanTemp_DailyNumFines_Lag7	-7.207e-04	1.326e-03	-0.543	0.58691
MeanTemp_DailyNumFines_Lag14	-9.194e-04	1.299e-03	-0.708	0.47925
MeanTemp_DailyNumFines_Lag21	-5.484e-06	1.322e-03	-0.004	0.99669
MeanTemp_DailyNumFines_Lag28	1.449e-03	1.220e-03	1.188	0.23514
MeanTemp_February	4.552e-02	2.417e-01	0.188	0.85063
MeanTemp_March	7.344e-02	2.642e-01	0.278	0.78105
MeanTemp_April	-3.925e-02	3.212e-01	-0.122	0.90275
MeanTemp_May	-3.320e-01	4.792e-01	-0.693	0.48857
MeanTemp_June	-6.383e-01	5.288e-01	-1.207	0.22756
MeanTemp_July	-8.156e-01	6.458e-01	-1.263	0.20681
MeanTemp_August	-8.544e-01	6.655e-01	-1.284	0.19935
MeanTemp_September	3.202e-01	7.423e-01	0.431	0.66623
MeanTemp_October	1.157e-01	7.205e-01	0.161	0.87240
MeanTemp_November	6.185e-01	7.114e-01	0.869	0.38470
MeanTemp_December	5.125e-01	7.142e-01	0.718	0.47313
MeanTemp_Spring	-6.442e-02	3.773e-01	-0.171	0.86444
MeanTemp_Summer	5.781e-02	5.439e-01	0.106	0.91537
MeanTemp_Fall	-4.716e-01	6.835e-01	-0.690	0.49030
RainPrecip_DailyNumFines_Lag1	-2.694e-03	1.420e-03	-1.897	0.05803 .
RainPrecip_DailyNumFines_Lag7	2.798e-03	1.769e-03	1.582	0.11380
RainPrecip_DailyNumFines_Lag14	-2.528e-03	1.855e-03	-1.363	0.17305
RainPrecip_DailyNumFines_Lag21	-2.276e-04	1.580e-03	-0.144	0.88552
RainPrecip_DailyNumFines_Lag28	-1.475e-03	1.798e-03	-0.820	0.41227
RainPrecip_February	2.065e-01	4.048e-01	0.510	0.61005
RainPrecip_March	2.132e-01	4.379e-01	0.487	0.62644
RainPrecip_April	-2.392e-01	5.052e-01	-0.473	0.63599
RainPrecip_May	-6.199e-01	5.943e-01	-1.043	0.29703
RainPrecip_June	-2.979e-01	6.439e-01	-0.463	0.64372
RainPrecip_July	2.332e-01	8.667e-01	0.269	0.78791
RainPrecip_August	-6.981e-01	8.584e-01	-0.813	0.41612
RainPrecip_September	-6.103e-01	9.210e-01	-0.663	0.50766
RainPrecip_October	-9.219e-01	9.068e-01	-1.017	0.30945
RainPrecip_November	-6.474e-01	9.091e-01	-0.712	0.47645
RainPrecip_December	-9.665e-01	9.060e-01	-1.067	0.28621

RainPrecip_Spring	3.915e-01	3.870e-01	1.012	0.31189
RainPrecip_Summer	1.826e-02	6.864e-01	0.027	0.97878
RainPrecip_Fall	8.925e-01	8.222e-01	1.085	0.27787
SnowPrecip_DailyNumFines_Lag1	3.897e-03	1.479e-03	2.634	0.00850 **
SnowPrecip_DailyNumFines_Lag7	2.178e-03	1.819e-03	1.197	0.23129
SnowPrecip_DailyNumFines_Lag14	-1.312e-03	1.942e-03	-0.676	0.49938
SnowPrecip_DailyNumFines_Lag21	-1.759e-03	1.866e-03	-0.942	0.34611
SnowPrecip_DailyNumFines_Lag28	-3.562e-03	1.758e-03	-2.026	0.04288 *
SnowPrecip_February	-1.149e-01	2.669e-01	-0.430	0.66698
SnowPrecip_March	4.039e-01	3.619e-01	1.116	0.26451
SnowPrecip_April	7.492e-01	4.286e-01	1.748	0.08066 .
SnowPrecip_May	-3.844e-01	8.158e-01	-0.471	0.63753
SnowPrecip_June	3.915e+01	1.859e+01	2.107	0.03528 *
SnowPrecip_July	NA	NA	NA	NA
SnowPrecip_August	NA	NA	NA	NA
SnowPrecip_September	NA	NA	NA	NA
SnowPrecip_October	5.531e-01	3.944e-01	1.402	0.16095
SnowPrecip_November	2.532e-01	3.234e-01	0.783	0.43370
SnowPrecip_December	4.529e-01	2.461e-01	1.840	0.06586 .
SnowPrecip_Spring	7.065e-01	6.777e-01	1.043	0.29726
SnowPrecip_Summer	NA	NA	NA	NA
SnowPrecip_Fall	NA	NA	NA	NA
Wind_DailyNumFines_Lag1	2.829e-03	2.241e-03	1.263	0.20680
Wind_DailyNumFines_Lag7	-1.069e-03	2.716e-03	-0.394	0.69381
Wind_DailyNumFines_Lag14	1.661e-03	2.722e-03	0.610	0.54182
Wind_DailyNumFines_Lag21	-2.894e-03	2.697e-03	-1.073	0.28353
Wind_DailyNumFines_Lag28	1.589e-03	2.718e-03	0.585	0.55883
Wind_February	3.711e-01	5.304e-01	0.700	0.48415
Wind_March	-2.978e-01	5.717e-01	-0.521	0.60250
Wind_April	9.063e-01	6.727e-01	1.347	0.17807
Wind_May	7.262e-01	9.686e-01	0.750	0.45349
Wind_June	8.225e-01	1.068e+00	0.770	0.44128
Wind_July	2.161e-01	1.323e+00	0.163	0.87027
Wind_August	3.896e-01	1.331e+00	0.293	0.76975
Wind_September	-5.656e-02	1.481e+00	-0.038	0.96953
Wind_October	2.115e-01	1.442e+00	0.147	0.88340
Wind_November	1.791e-01	1.436e+00	0.125	0.90078
Wind_December	-2.940e-01	1.423e+00	-0.207	0.83634
Wind_Spring	-9.823e-01	7.365e-01	-1.334	0.18245
Wind_Summer	-2.984e-01	1.088e+00	-0.274	0.78392
Wind_Fall	1.376e-01	1.339e+00	0.103	0.91812
CO_DailyNumFines_Lag1	-9.282e-03	3.157e-03	-2.940	0.00332 **
CO_DailyNumFines_Lag7	-1.194e-03	3.498e-03	-0.341	0.73278

CO_DailyNumFines_Lag14	-3.256e-03	3.623e-03	-0.899	0.36895
CO_DailyNumFines_Lag21	2.594e-03	3.525e-03	0.736	0.46187
CO_DailyNumFines_Lag28	1.774e-03	3.386e-03	0.524	0.60025
CO_February	-3.252e-01	6.085e-01	-0.534	0.59312
CO_March	-8.009e-01	7.971e-01	-1.005	0.31512
CO_April	-1.257e+00	1.363e+00	-0.922	0.35662
CO_May	-6.498e-01	2.217e+00	-0.293	0.76953
CO_June	4.248e-01	2.613e+00	0.163	0.87090
CO_July	1.086e+00	3.356e+00	0.324	0.74631
CO_August	3.760e+00	3.364e+00	1.118	0.26373
CO_September	3.804e+00	3.600e+00	1.057	0.29082
CO_October	4.580e+00	3.511e+00	1.304	0.19231
CO_November	4.570e+00	3.463e+00	1.319	0.18716
CO_December	5.765e+00	3.446e+00	1.673	0.09452 .
CO_Spring	-3.976e-01	1.964e+00	-0.202	0.83957
CO_Summer	-3.641e+00	3.055e+00	-1.192	0.23346
CO_Fall	-5.418e+00	3.436e+00	-1.577	0.11497
N02_DailyNumFines_Lag1	8.098e-05	8.684e-05	0.933	0.35118
N02_DailyNumFines_Lag7	-7.635e-05	9.233e-05	-0.827	0.40839
N02_DailyNumFines_Lag14	-1.107e-04	1.044e-04	-1.061	0.28905
N02_DailyNumFines_Lag21	-1.908e-04	9.716e-05	-1.964	0.04971 *
N02_DailyNumFines_Lag28	1.187e-04	9.591e-05	1.238	0.21594
N02_February	3.220e-03	1.988e-02	0.162	0.87133
N02_March	-2.623e-02	2.249e-02	-1.167	0.24351
N02_April	3.957e-03	2.386e-02	0.166	0.86829
N02_May	-2.302e-02	3.807e-02	-0.605	0.54558
N02_June	-5.609e-02	4.416e-02	-1.270	0.20420
N02_July	-5.758e-02	5.034e-02	-1.144	0.25288
N02_August	-6.499e-02	5.121e-02	-1.269	0.20462
N02_September	-8.683e-02	5.534e-02	-1.569	0.11678
N02_October	-8.092e-02	5.334e-02	-1.517	0.12940
N02_November	-7.745e-02	5.230e-02	-1.481	0.13881
N02_December	-7.576e-02	5.175e-02	-1.464	0.14335
N02_Spring	4.113e-02	2.987e-02	1.377	0.16875
N02_Summer	5.992e-02	3.958e-02	1.514	0.13025
N02_Fall	7.408e-02	4.846e-02	1.529	0.12651
O3_DailyNumFines_Lag1	-6.099e-02	1.055e-01	-0.578	0.56334
O3_DailyNumFines_Lag7	6.768e-02	1.231e-01	0.550	0.58247
O3_DailyNumFines_Lag14	3.440e-02	1.207e-01	0.285	0.77572
O3_DailyNumFines_Lag21	-2.533e-01	1.313e-01	-1.929	0.05387 .
O3_DailyNumFines_Lag28	1.631e-01	1.266e-01	1.288	0.19793
O3_February	-4.295e+01	2.415e+01	-1.779	0.07545 .
O3_March	-5.007e+01	3.627e+01	-1.381	0.16758

03_April	-1.250e+01	4.881e+01	-0.256	0.79785
03_May	-1.200e+02	8.320e+01	-1.442	0.14947
03_June	-1.362e+02	9.588e+01	-1.421	0.15548
03_July	-6.867e+01	1.259e+02	-0.545	0.58548
03_August	-7.545e+01	1.246e+02	-0.605	0.54496
03_September	-5.268e+01	1.329e+02	-0.396	0.69189
03_October	-5.004e+01	1.309e+02	-0.382	0.70221
03_November	-4.579e+01	1.304e+02	-0.351	0.72556
03_December	-5.162e+01	1.303e+02	-0.396	0.69209
03_Spring	3.671e+01	7.247e+01	0.507	0.61248
03_Summer	3.429e+01	1.162e+02	0.295	0.76790
03_Fall	1.260e+01	1.281e+02	0.098	0.92161
PM10_DailyNumFines_Lag1	7.062e-05	5.883e-05	1.200	0.23012
PM10_DailyNumFines_Lag7	2.502e-05	5.446e-05	0.459	0.64596
PM10_DailyNumFines_Lag14	-1.634e-05	6.668e-05	-0.245	0.80640
PM10_DailyNumFines_Lag21	4.029e-05	6.395e-05	0.630	0.52876
PM10_DailyNumFines_Lag28	2.917e-05	6.545e-05	0.446	0.65582
PM10_February	-9.911e-03	1.417e-02	-0.699	0.48446
PM10_March	9.667e-03	1.673e-02	0.578	0.56336
PM10_April	2.897e-03	1.917e-02	0.151	0.87990
PM10_May	-1.183e-02	2.973e-02	-0.398	0.69079
PM10_June	-1.170e-02	3.202e-02	-0.365	0.71486
PM10_July	-2.287e-02	3.472e-02	-0.659	0.51011
PM10_August	-1.589e-02	3.479e-02	-0.457	0.64791
PM10_September	-2.672e-02	3.609e-02	-0.740	0.45916
PM10_October	-2.437e-02	3.429e-02	-0.711	0.47735
PM10_November	-3.056e-02	3.399e-02	-0.899	0.36870
PM10_December	-3.097e-02	3.358e-02	-0.922	0.35649
PM10_Spring	9.724e-03	2.348e-02	0.414	0.67885
PM10_Summer	2.978e-02	2.777e-02	1.072	0.28374
PM10_Fall	3.301e-02	3.025e-02	1.091	0.27531
PM25_DailyNumFines_Lag1	1.174e-04	2.312e-04	0.508	0.61171
PM25_DailyNumFines_Lag7	2.717e-04	2.640e-04	1.029	0.30351
PM25_DailyNumFines_Lag14	9.951e-05	2.823e-04	0.352	0.72450
PM25_DailyNumFines_Lag21	-3.347e-04	3.047e-04	-1.098	0.27219
PM25_DailyNumFines_Lag28	-8.448e-05	2.762e-04	-0.306	0.75975
PM25_February	1.279e-01	6.028e-02	2.122	0.03393 *
PM25_March	8.976e-03	8.470e-02	0.106	0.91561
PM25_April	-4.050e-02	1.096e-01	-0.369	0.71185
PM25_May	1.046e-02	1.499e-01	0.070	0.94434
PM25_June	-6.312e-02	1.661e-01	-0.380	0.70399
PM25_July	-7.903e-02	1.782e-01	-0.444	0.65742
PM25_August	-5.853e-02	1.765e-01	-0.332	0.74029

PM25_September	-3.694e-02	1.784e-01	-0.207	0.83597	
PM25_October	-6.714e-02	1.727e-01	-0.389	0.69756	
PM25_November	-6.521e-02	1.735e-01	-0.376	0.70713	
PM25_December	-7.373e-02	1.696e-01	-0.435	0.66377	
PM25_Spring	9.606e-02	1.229e-01	0.782	0.43458	
PM25_Summer	7.589e-02	1.528e-01	0.497	0.61956	
PM25_Fall	7.175e-02	1.591e-01	0.451	0.65212	
AQI_DailyNumFines_Lag1	4.580e-05	8.547e-05	0.536	0.59216	
AQI_DailyNumFines_Lag7	-1.106e-04	9.982e-05	-1.108	0.26807	
AQI_DailyNumFines_Lag14	2.679e-05	1.072e-04	0.250	0.80269	
AQI_DailyNumFines_Lag21	3.390e-05	1.170e-04	0.290	0.77203	
AQI_DailyNumFines_Lag28	-6.498e-05	1.078e-04	-0.603	0.54688	
AQI_February	-5.865e-02	2.707e-02	-2.167	0.03037	*
AQI_March	-4.018e-02	3.619e-02	-1.110	0.26705	
AQI_April	-4.837e-02	3.830e-02	-1.263	0.20670	
AQI_May	-1.933e-03	6.380e-02	-0.030	0.97584	
AQI_June	3.182e-02	6.712e-02	0.474	0.63555	
AQI_July	1.688e-02	7.373e-02	0.229	0.81894	
AQI_August	8.508e-03	7.376e-02	0.115	0.90818	
AQI_September	-9.387e-03	7.734e-02	-0.121	0.90341	
AQI_October	-5.960e-03	7.521e-02	-0.079	0.93684	
AQI_November	1.435e-02	7.476e-02	0.192	0.84776	
AQI_December	-2.064e-04	7.402e-02	-0.003	0.99778	
AQI_Spring	-1.723e-02	5.342e-02	-0.323	0.74709	
AQI_Summer	-2.921e-02	6.366e-02	-0.459	0.64634	
AQI_Fall	-9.185e-03	6.868e-02	-0.134	0.89363	
MaxTemp_2	-1.520e-02	1.378e-02	-1.103	0.27021	
MinTemp_2	-1.063e-02	1.246e-02	-0.853	0.39396	
MeanTemp_2	-1.641e-02	4.310e-02	-0.381	0.70346	
RainPrecip_2	2.267e-02	7.333e-02	0.309	0.75723	
SnowPrecip_2	-8.975e-02	1.103e-01	-0.814	0.41584	
Wind_2	-1.620e-01	2.438e-01	-0.664	0.50657	
CO_2	7.882e-02	3.186e-01	0.247	0.80461	
NO2_2	-1.578e-04	2.461e-04	-0.641	0.52131	
O3_2	1.655e+02	5.069e+02	0.327	0.74403	
PM10_2	-8.196e-05	6.425e-05	-1.276	0.20226	
PM25_2	2.014e-03	1.625e-03	1.239	0.21541	
AQI_2	-2.087e-05	1.737e-04	-0.120	0.90437	
t_2	4.495e-08	4.606e-08	0.976	0.32924	
FullTime_2	-3.679e-01	3.218e-01	-1.143	0.25304	
DailyNumFines_Lag1_2	-6.939e-05	1.134e-05	-6.118	1.14e-09	***
DailyNumFines_Lag7_2	-3.208e-05	1.110e-05	-2.890	0.00390	**
DailyNumFines_Lag14_2	-1.167e-05	1.144e-05	-1.021	0.30750	

DailyNumFines_Lag21_2	-1.996e-05	1.159e-05	-1.722	0.08514	.
DailyNumFines_Lag28_2	-5.900e-06	1.140e-05	-0.517	0.60495	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.076 on 1943 degrees of freedom

Multiple R-squared: 0.691, Adjusted R-squared: 0.6345

F-statistic: 12.24 on 355 and 1943 DF, p-value: < 2.2e-16

```
provo.base = lm(log_DailyNumFines ~ 1,
                 data=provo_reduced[c(model.factors, "log_DailyNumFines")])

# provo.step = step(provo.base,
#                   direction = "both",
#                   k = log(nrow(provo_reduced)),
#                   scope = list(lower=provo.base, upper=provo.lm))
# summary(provo.step)

provo.x = as.matrix(provo_reduced[model.factors])
provo.y = as.matrix(provo_reduced["log_DailyNumFines"])

lasso_cv <- cv.glmnet(x = provo.x,
                     y = provo.y,
                     type.measure = "mse",
                     alpha = 1)

d = coef(lasso_cv, s = "lambda.1se")[1:length(model.factors)]

provo.lasso = lm(log_DailyNumFines ~ .,
                 provo_reduced[c(model.factors[which(d != 0)-1],
                                "log_DailyNumFines")], fast.s.large.n = Inf)
```

Warning: In lm.fit(x, y, offset = offset, singular.ok = singular.ok, ...) :
extra argument 'fast.s.large.n' will be disregarded

```
summary(provo.lasso)
```

Call:

```
lm(formula = log_DailyNumFines ~ ., data = provo_reduced[c(model.factors[which(d !=
```

```
0) - 1], "log_DailyNumFines")], fast.s.large.n = Inf)
```

Residuals:

Min	1Q	Median	3Q	Max
-4.2765	-0.6201	0.0603	0.6810	4.4351

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-9.254e+00	1.239e+01	-0.747	0.455161
N02	-7.131e-03	8.692e-03	-0.820	0.412038
Mon	2.099e+00	1.096e-01	19.152	< 2e-16 ***
Tues	2.084e+00	1.281e-01	16.272	< 2e-16 ***
Wed	1.972e+00	1.324e-01	14.894	< 2e-16 ***
Thurs	1.754e+00	1.320e-01	13.282	< 2e-16 ***
Fri	1.731e+00	1.237e-01	14.001	< 2e-16 ***
Sun	1.018e+00	9.341e-02	10.903	< 2e-16 ***
FullTime	2.186e+00	2.734e+00	0.800	0.423941
Holiday	-1.480e+00	8.703e-02	-17.001	< 2e-16 ***
Exam	-4.980e-01	1.128e-01	-4.417	1.05e-05 ***
DailyNumFines_Lag7	-8.388e-04	3.933e-03	-0.213	0.831151
SnowPrecip_CO	-3.628e-01	1.486e-01	-2.441	0.014722 *
Wind_N02	1.274e-03	3.649e-03	0.349	0.726955
N02_O3	8.863e-02	1.205e-01	0.736	0.462085
Mon_DailyNumFines_Lag1	8.116e-03	2.180e-03	3.723	0.000202 ***
Tues_DailyNumFines_Lag1	1.219e-02	1.787e-03	6.821	1.16e-11 ***
Wed_DailyNumFines_Lag1	1.349e-02	1.838e-03	7.343	2.91e-13 ***
Thurs_DailyNumFines_Lag1	1.505e-02	1.894e-03	7.948	2.97e-15 ***
Fri_DailyNumFines_Lag1	1.522e-02	1.928e-03	7.895	4.50e-15 ***
Sun_DailyNumFines_Lag1	3.994e-02	9.293e-03	4.298	1.80e-05 ***
MaxTemp_DailyNumFines_Lag14	9.805e-05	7.539e-05	1.301	0.193523
MaxTemp_DailyNumFines_Lag21	1.326e-04	4.426e-05	2.997	0.002760 **
MinTemp_DailyNumFines_Lag1	-1.870e-05	6.478e-05	-0.289	0.772875
MinTemp_February	-3.048e-02	1.483e-02	-2.055	0.039954 *
MinTemp_November	2.946e-02	1.470e-02	2.004	0.045190 *
MinTemp_Spring	-3.255e-02	1.137e-02	-2.862	0.004244 **
MinTemp_Fall	-6.507e-03	6.263e-03	-1.039	0.298931
RainPrecip_May	-1.691e-01	9.916e-02	-1.706	0.088195 .
RainPrecip_December	-1.204e-01	1.599e-01	-0.753	0.451548
SnowPrecip_DailyNumFines_Lag1	3.979e-03	1.112e-03	3.578	0.000353 ***
SnowPrecip_DailyNumFines_Lag14	-6.104e-04	1.443e-03	-0.423	0.672379
SnowPrecip_DailyNumFines_Lag21	-1.756e-03	1.137e-03	-1.545	0.122604
SnowPrecip_DailyNumFines_Lag28	-1.396e-03	1.244e-03	-1.122	0.262041
SnowPrecip_February	-2.804e-01	1.368e-01	-2.049	0.040553 *

SnowPrecip_December	4.006e-02	1.171e-01	0.342	0.732208
Wind_DailyNumFines_Lag7	1.822e-03	1.828e-03	0.997	0.318931
Wind_DailyNumFines_Lag14	6.930e-04	9.840e-04	0.704	0.481356
Wind_DailyNumFines_Lag28	7.277e-04	4.725e-04	1.540	0.123690
Wind_July	-2.050e-02	7.581e-02	-0.270	0.786826
Wind_Summer	-2.623e-01	6.985e-02	-3.755	0.000178 ***
CO_DailyNumFines_Lag28	-1.143e-04	1.881e-03	-0.061	0.951539
CO_August	5.880e-01	4.944e-01	1.189	0.234370
CO_November	-2.870e-01	1.478e-01	-1.942	0.052319 .
NO2_August	2.161e-02	9.393e-03	2.301	0.021482 *
O3_DailyNumFines_Lag7	2.863e-02	5.595e-02	0.512	0.608946
O3_DailyNumFines_Lag14	-2.868e-03	6.583e-02	-0.044	0.965247
PM25_July	-2.657e-02	1.919e-02	-1.384	0.166467
PM25_December	-3.082e-02	9.199e-03	-3.350	0.000821 ***
AQI_May	-7.786e-03	2.274e-03	-3.424	0.000629 ***
CO_2	1.794e-01	7.051e-02	2.545	0.010999 *
FullTime_2	-1.166e-01	1.488e-01	-0.784	0.433379
DailyNumFines_Lag1_2	-5.252e-05	7.158e-06	-7.337	3.03e-13 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.092 on 2246 degrees of freedom

Multiple R-squared: 0.632, Adjusted R-squared: 0.6235

F-statistic: 74.18 on 52 and 2246 DF, p-value: < 2.2e-16

```
#First Differences
seasons = c("Spring", "Summer", "Fall")
difference = 1

model.factors = setdiff(model.factors, c(str_c("DailyNumFines_Lag", lags),
                                           str_c("DailyNumFines_Lag", lags, "_2"),
                                           "t", env.lag.factors, "SnowPrecip_Summer"))

for(factor in c("log_DailyNumFines", model.factors)){
  if(!(factor %in% seasons)){
    provo[str_c(factor, "_t-", difference)] = lag(provo[factor], n=difference)
    provo[str_c(factor, "_change")] = provo[factor] -
    provo[str_c(factor, "_t-", difference)]
  }
}
```

```

model.factors.new = str_c(model.factors, "_change")
for(season in seasons){
  for(factor in str_c(setdiff(model.factors, c(month.name, seasons)), "_change")){
    if(!any(str_detect(factor, month.name)) && !any(str_detect(factor, seasons))){
      #interaction terms for seasonal dummies
      provo[str_c(factor, "X", season)] = provo[factor]*provo[season]
      model.factors.new = c(model.factors.new, str_c(factor, "X", season))
    }
  }
}

provo.change = provo[(difference+1):nrow(provo),
                     c("DATE", "DailyNumFines",
                       colnames(provo)[str_detect(colnames(provo), "change")])]]

provo.change = truncate_provo(provo.change)

#Full lm
#provo.change.full = lm(log_DailyNumFines_change ~ 0 + ., provo.change)
#provo.change.base = lm(log_DailyNumFines_change ~ 0, provo.change)

# provo.change.step = step(provo.change.base,
#                           direction = "both",
#                           k = log(nrow(provo.change)),
#                           scope=list(lower=provo.change.base,
#                                       upper= provo.change.full))

# summary(provo.change.step)

model.factors.change = setdiff(colnames(provo)[str_detect(colnames(provo),
                                                         "change")],
                              "log_DailyNumFines_change")

provo.x = as.matrix(provo.change[model.factors.change])
provo.y = as.matrix(provo.change["log_DailyNumFines_change"])

lasso_cv <- cv.glmnet(x = provo.x,
                     y = provo.y,
                     type.measure = "mse",
                     alpha = 1)

```



```
d = coef(lasso_cv, s = "lambda.1se")[1:length(model.factors.change)]

provo.change.lasso = lmrob(log_DailyNumFines_change ~ 0 + .,
                           provo.change[c(model.factors.change[which(d != 0)-1],
                                           "log_DailyNumFines_change")],
                           fast.s.large.n = Inf)
summary(provo.change.lasso)
```

Call:

```
lmrob(formula = log_DailyNumFines_change ~ 0 + ., data = provo.change[c(model.factors.change
  0) - 1], "log_DailyNumFines_change"), fast.s.large.n = Inf)
  \--> method = "MM"
```

Residuals:

Min	1Q	Median	3Q	Max
-6.00785	-0.71573	-0.05424	0.66448	6.92430

Coefficients: (1 not defined because of singularities)

	Estimate	Std. Error	t value	Pr(> t)	
Wind_change	1.027e-01	9.089e-02	1.130	0.258579	
Mon_change	3.207e+00	1.245e-01	25.761	< 2e-16	***
Tues_change	3.289e+00	1.137e-01	28.942	< 2e-16	***
Wed_change	3.341e+00	1.044e-01	31.997	< 2e-16	***
Thurs_change	3.074e+00	1.059e-01	29.041	< 2e-16	***
Fri_change	3.248e+00	9.862e-02	32.932	< 2e-16	***
Sun_change	2.470e+00	1.922e-01	12.851	< 2e-16	***
Holiday_change	-8.715e-01	6.458e-01	-1.350	0.177281	
Exam_change	-3.878e-01	3.091e-01	-1.255	0.209736	
MaxTemp_PM25_change	-2.046e-04	3.554e-04	-0.576	0.564808	
RainPrecip_PM10_change	7.467e-04	6.736e-04	1.108	0.267770	
SnowPrecip_CO_change	-1.456e-01	1.292e-01	-1.127	0.259785	
Wind_NO2_change	-3.185e-04	1.935e-03	-0.165	0.869292	
NO2_O3_change	8.158e-02	1.179e-01	0.692	0.489216	
MaxTemp_December_change	-2.831e-02	4.505e-02	-0.628	0.529835	
MeanTemp_October_change	-2.896e-02	2.125e-02	-1.363	0.173049	
RainPrecip_December_change	-5.382e-01	2.228e-01	-2.416	0.015779	*
SnowPrecip_June_change	2.387e+01	2.061e+01	1.158	0.247032	
SnowPrecip_October_change	-2.326e-01	2.395e-01	-0.971	0.331503	
Wind_April_change	1.044e-01	1.291e-01	0.808	0.418915	
CO_April_change	-6.442e-02	8.870e-01	-0.073	0.942110	
CO_June_change	-5.210e-02	1.215e+00	-0.043	0.965785	
CO_July_change	-8.335e-01	1.181e+00	-0.706	0.480561	

CO_December_change	5.115e-01	4.227e-01	1.210	0.226389	
CO_Spring_change	1.860e+00	9.924e-01	1.874	0.061047	.
NO2_August_change	9.374e-03	1.222e-02	0.767	0.442901	
O3_February_change	-8.378e+00	9.543e+00	-0.878	0.380121	
PM10_February_change	-3.266e-03	5.774e-03	-0.566	0.571696	
PM10_June_change	7.781e-03	4.292e-03	1.813	0.070002	.
AQI_February_change	-1.552e-02	6.942e-03	-2.236	0.025442	*
AQI_June_change	4.451e-03	3.660e-03	1.216	0.224049	
SnowPrecip_2_change	-5.501e-02	3.317e-02	-1.659	0.097330	.
Fri_changeXSpring	-7.505e-02	1.443e-01	-0.520	0.603175	
Sun_changeXSpring	-2.475e+00	1.878e-01	-13.180	< 2e-16	***
Holiday_changeXSpring	2.350e-01	7.291e-01	0.322	0.747230	
RainPrecip_SnowPrecip_changeXSpring	-4.589e-02	1.159e-01	-0.396	0.692222	
CO_NO2_changeXSpring	-3.564e-02	2.328e-02	-1.531	0.125956	
CO_AQI_changeXSpring	4.981e-03	1.148e-02	0.434	0.664306	
MaxTemp_changeXSummer	4.114e-02	2.227e-02	1.847	0.064905	.
SnowPrecip_changeXSummer	NA	NA	NA	NA	
Tues_changeXSummer	2.643e-01	9.774e-02	2.704	0.006909	**
Thurs_changeXSummer	-6.119e-02	1.295e-01	-0.472	0.636678	
Fri_changeXSummer	-3.825e-01	1.444e-01	-2.650	0.008105	**
Sun_changeXSummer	-2.275e+00	2.020e-01	-11.264	< 2e-16	***
NO2_PM10_changeXSummer	-3.680e-04	8.189e-05	-4.493	7.36e-06	***
CO_2_changeXSummer	-1.358e-01	1.068e+00	-0.127	0.898814	
PM25_changeXFall	-2.168e-02	2.072e-02	-1.046	0.295596	
Mon_changeXFall	9.504e-02	1.060e-01	0.897	0.369887	
Thurs_changeXFall	2.432e-01	8.192e-02	2.968	0.003024	**
Holiday_changeXFall	-2.369e+00	6.839e-01	-3.463	0.000543	***
Exam_changeXFall	-1.592e+00	9.206e-01	-1.729	0.083965	.
MaxTemp_MinTemp_changeXFall	1.412e-03	7.695e-04	1.834	0.066723	.
MaxTemp_PM25_changeXFall	-1.733e-03	1.044e-03	-1.660	0.097153	.
O3_PM25_changeXFall	6.158e-01	6.034e-01	1.021	0.307589	
RainPrecip_2_changeXFall	-9.346e-03	4.050e-02	-0.231	0.817502	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Robust residual standard error: 0.936

Multiple R-squared: 0.6949, Adjusted R-squared: 0.6876

Convergence in 29 IRWLS iterations

Robustness weights:

21 observations c(203,210,355,356,378,480,742,1056,1106,1107,1142,1191,1457,1607,1845,1881,205) are outliers with |weight| <= 1.9e-05 (< 4.3e-05);
205 weights are ~1. The remaining 2100 ones are summarized as

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
0.000492	0.825800	0.940200	0.846000	0.985900	0.999000

Algorithmic parameters:

tuning.chi		bb	tuning.psi	refine.tol
1.548e+00		5.000e-01	4.685e+00	1.000e-07
rel.tol		scale.tol	solve.tol	zero.tol
1.000e-07		1.000e-10	1.000e-07	1.000e-10
eps.outlier		eps.x	warn.limit.reject	warn.limit.meanrw
4.299e-05		1.079e-08	5.000e-01	5.000e-01
nResample	max.it	best.r.s	k.fast.s	k.max maxit.scale
500	50	2	1	200 200
trace.lev	mts	compute.rd		
0	1000	0		
	psi	subsampling		cov
	"bisquare"	"nonsingular"		".vcov.avar1"
compute.outlier.stats				
	"SM"			
seed : int(0)				

```
provo.change$prediction = predict(provo.change.lasso, provo.change)
```

Warning in predict.lmrob(provo.change.lasso, provo.change): prediction from a rank-deficient fit may be misleading

```
provo.change$DailyNumFinesPrediction = exp(provo.change$prediction+log(
  lag(provo.change$DailyNumFines,
    n=difference)+1))
```

```
#Random Forest Model
```

```
model.factors = c("MaxTemp", "MinTemp", "MeanTemp", "RainPrecip", "SnowPrecip",
  "Wind", "CO", "NO2", "O3", "PM10", "PM25", "AQI", "Mon",
  "Tues", "Wed", "Thurs", "Fri", "Sun", "t", "FullTime",
  "Holiday", "Exam", "February", "March", "April", "May",
  "June", "July", "August", "September", "October", "November",
  "December", "Spring", "Summer", "Fall", "DailyNumFines_Lag1",
  "DailyNumFines_Lag7",
  "DailyNumFines_Lag14", "DailyNumFines_Lag21",
  "DailyNumFines_Lag28", interaction.factors, polynomial.factors)
```

```
provo.rf = randomForest(log_DailyNumFines ~ .,
```

```

data = provo_reduced[c(model.factors,
                        "log_DailyNumFines")]

provo_reduced$predicted = provo.rf$predicted
provo_reduced$residuals = provo_reduced$log_DailyNumFines - provo_reduced$predicted

coef.rf = tibble(
  coef = model.factors,
  weight = importance(provo.rf)
)

coef.rf %>% View()

provo_reduced %>% filter(year(DATE) == 2022) %>%
  ggplot()+
  geom_line(aes(x=DATE, y=DailyNumFines), color="#123943")+
  geom_line(aes(x=DATE, y=exp(predict(provo.rf, (provo_reduced %>% filter(year(DATE) == 2022))), color="red")+
  geom_line(aes(x=DATE, y=exp(predict(provo.lasso, (provo_reduced %>% filter(year(DATE) == 2022))), color="blue")+
  geom_line(data=provo.change %>% filter(year(DATE) == 2022), aes(x=DATE, y=DailyNumFines), color="black")+
  theme_minimal()

```

