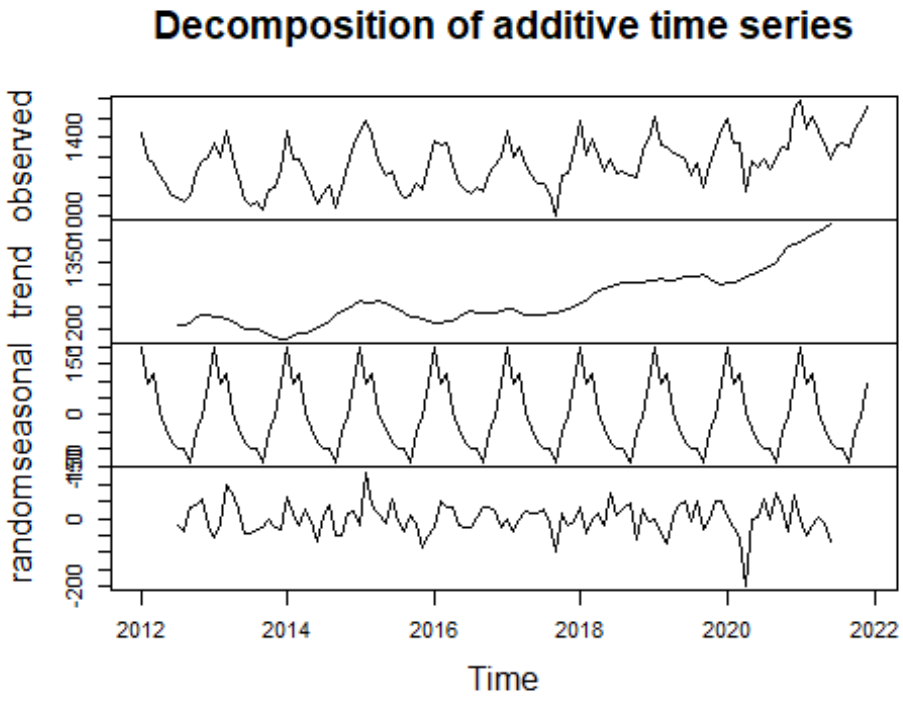
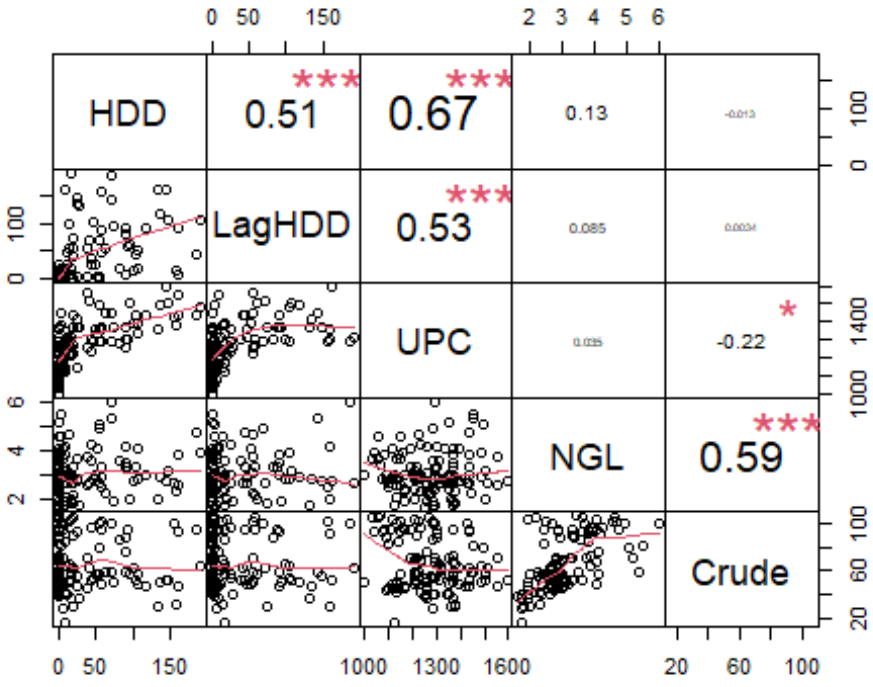
Commercial Use per Customer Forecast

Overall Commercial Customers Forecast Analysis

Customer Time-Series Decomposition



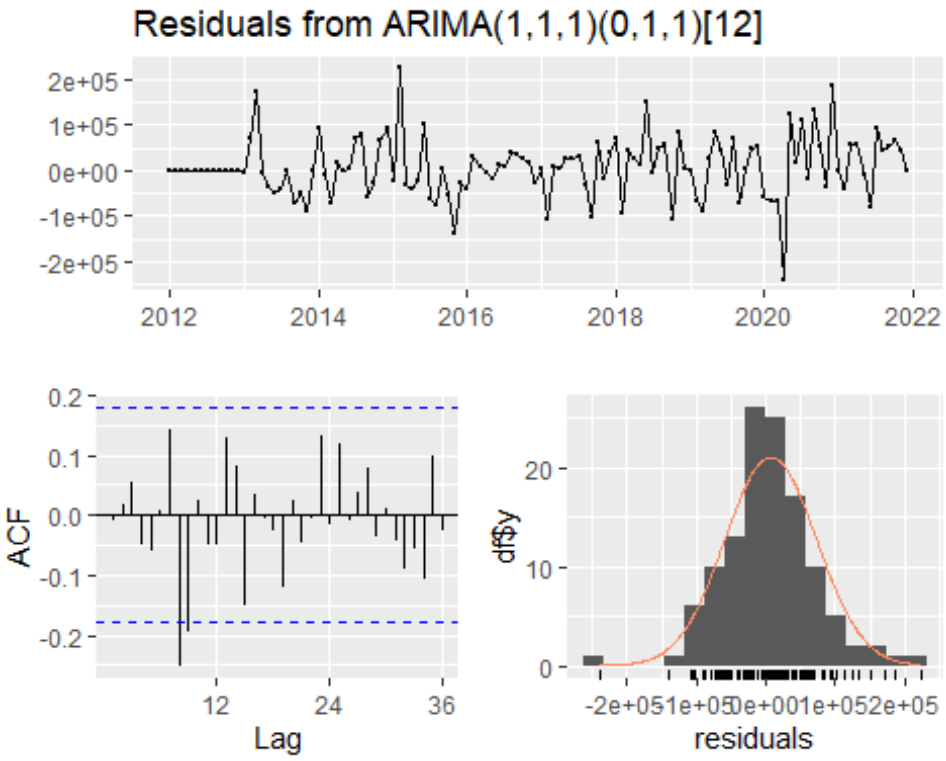


ARIMA Model: Expected Accuracy

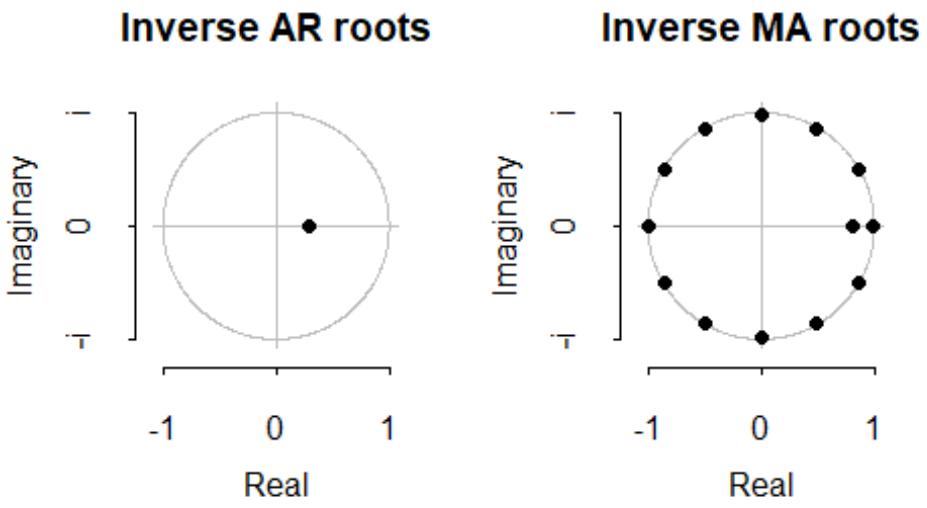
```
                     ME RMSE MAE
Forecast Horizon  1  13   71  53
Forecast Horizon  2  15   64  50
Forecast Horizon  3  22   60  48
Forecast Horizon  4  18   71  49
Forecast Horizon  5  20   72  52
Forecast Horizon  6  21   75  58
Forecast Horizon  7  22   75  58
Forecast Horizon  8  22   79  61
Forecast Horizon  9  25   74  60
Forecast Horizon  10 33   77  61
Forecast Horizon  11 35   79  65
Forecast Horizon  12 39   78  66
Forecast Horizon  13 46   86  71
Forecast Horizon  14 46   82  68
Forecast Horizon  15 53   83  71
Forecast Horizon  16 56   83  69
Forecast Horizon  17 61   89  76
Forecast Horizon  18 60   92  80
Forecast Horizon  19 58   91  79
Forecast Horizon  20 59   93  76
Forecast Horizon  21 60   89  76
Forecast Horizon  22 66   93  83
Forecast Horizon  23 72   96  83
Forecast Horizon  24 72   99  87
```

ARIMA Model: Diagnostics

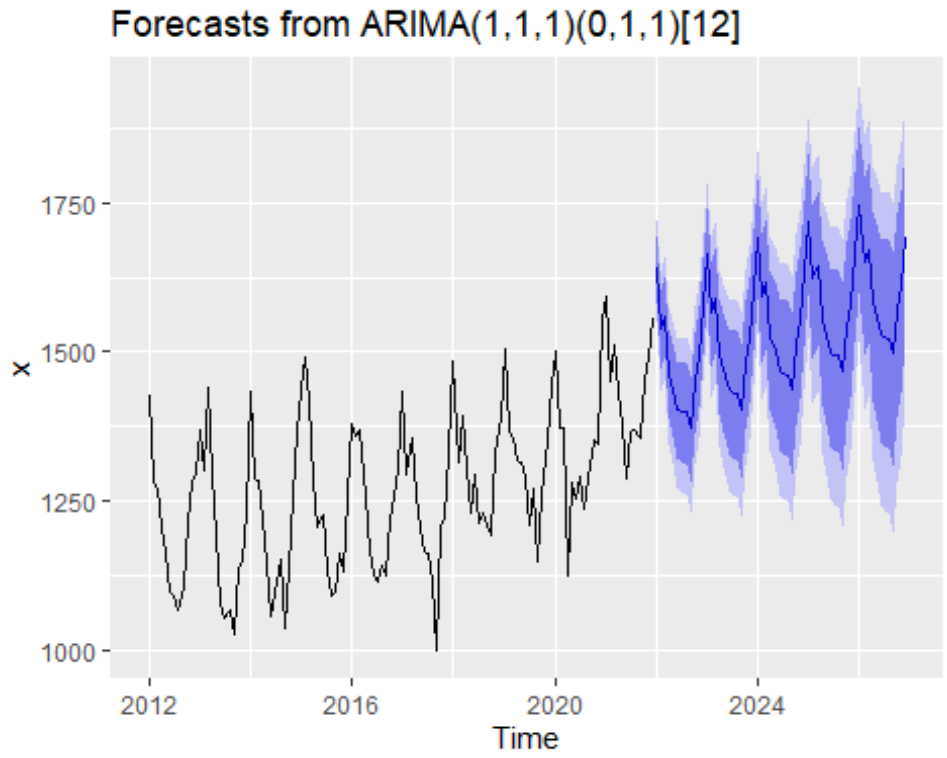
```
Series: x
ARIMA(1,1,1)(0,1,1)[12]
Box Cox transformation: lambda= 1.999927

Coefficients:
          ar1      ma1     sma1
      0.2968  -0.8163  -0.8483
s.e.  0.1618   0.1145   0.1445

sigma^2 estimated as 5.032e+09:  log likelihood=-1353.23
AIC=2714.47   AICc=2714.86   BIC=2725.16

Training set error measures:
                    ME     RMSE      MAE       MPE    MAPE      MASE
Training set 4.544727 51.77026 37.23134 0.2084759 2.95672 0.5627128
                     ACF1
Training set -0.001244041
```



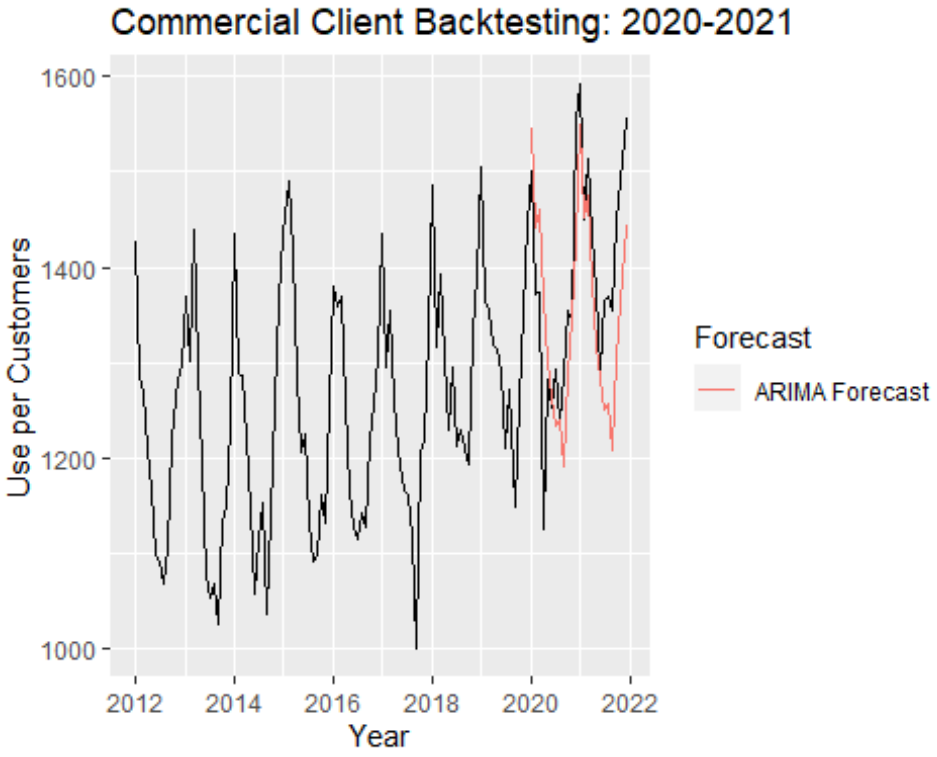

```
 Ljung-Box test

data:  Residuals from ARIMA(1,1,1)(0,1,1)[12]
Q* = 29.672, df = 21, p-value = 0.09878

Model df: 3.   Total lags used: 24
```



ARIMA Model: 5 Year Forecast



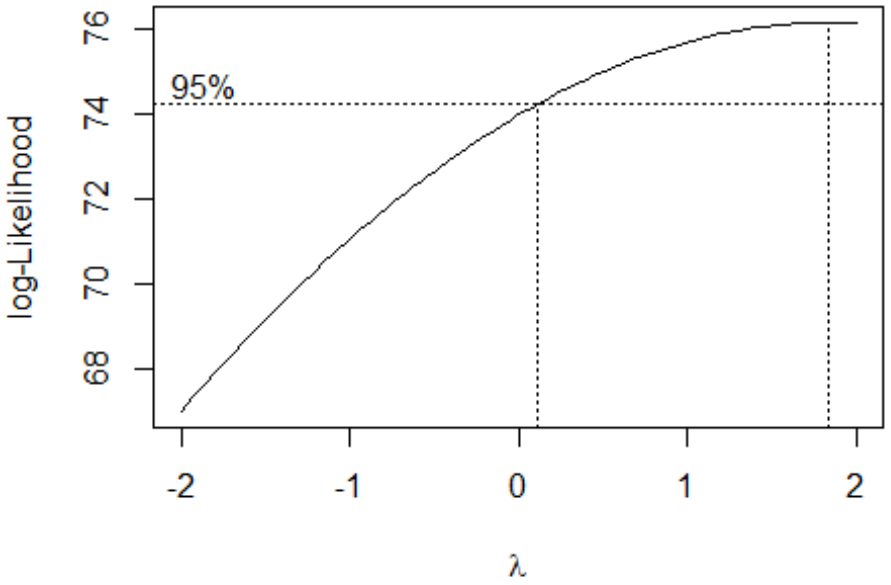
Back-Testing



Test Results

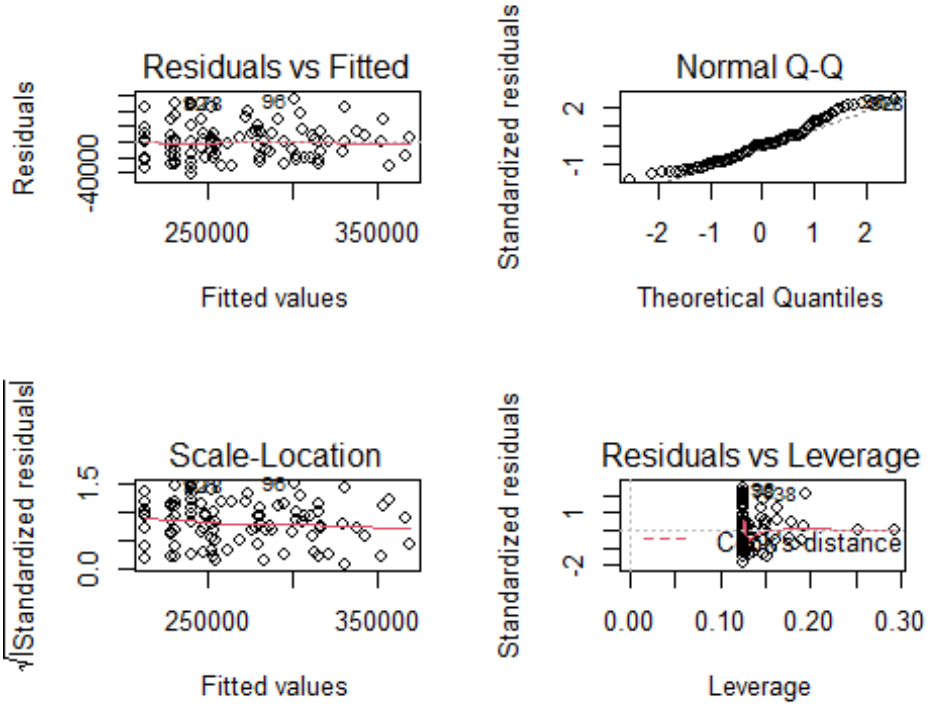
Below we see that the model performs roughly as expected for a "normal" year of 2019, and continues to have a high degree of accuracy in 2020 and 2021.

```
 [1] "Overall MAE: 74.12"

 [1] "Overall Accuracy: 94.58"

           Actual Forecast Absolute_Error Accuracy
 Jan 2020 1501.225     1547          45.28     97.0
 Feb 2020 1371.346     1441          69.54     94.9
 Mar 2020 1374.135     1460          85.57     93.8
 Apr 2020 1124.538     1367         242.64     78.4
 May 2020 1282.435     1301          18.63     98.5
 Jun 2020 1252.632     1264          11.35     99.1
 Jul 2020 1292.807     1233          59.67     95.4
 Aug 2020 1236.492     1239           2.95     99.8
 Sep 2020 1286.285     1191          95.50     92.6
 Oct 2020 1353.730     1289          65.03     95.2
 Nov 2020 1346.571     1345           1.36     99.9
 Dec 2020 1554.006     1427         127.15     91.8
 Jan 2021 1592.253     1550          42.09     97.4
 Feb 2021 1449.506     1453           3.49     99.8
 Mar 2021 1513.020     1475          37.92     97.5
 Apr 2021 1432.365     1384          48.51     96.6
 May 2021 1376.667     1318          58.43     95.8
 Jun 2021 1287.550     1281           6.20     99.5
 Jul 2021 1365.826     1251         115.25     91.6
 Aug 2021 1368.814     1257         111.90     91.8
 Sep 2021 1354.013     1208         145.75     89.2
 Oct 2021 1449.381     1306         143.19     90.1
 Nov 2021 1491.364     1363         128.66     91.4
 Dec 2021 1557.252     1444         112.90     92.8

 [1] "train_data<-zzz[1:96,]\ntest_data<-zzz[97:120,]\n\nhdd_avg<-
round(rep(hdd_summary$CommercialHDDAvg,10),4)\nlag_hdd_avg<-
lag(hdd_avg,1)\n\n\ntest_data$HDD<-hdd_avg[97:120]\ntest_data$LagHDD<-
lag_hdd_avg[85:115]"
```




```
[1] 1.84


Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Coefficients:
(Intercept)          HDD       month2       month3       month4       month5
   301225.7        354.2     -18765.6      -5571.1     -25803.6     -48720.2
     month6       month7       month8       month9      month10      month11
   -61184.9     -73327.8     -70709.4     -88493.4     -55377.2     -46476.4
    month12
   -21972.3


Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Residuals:
   Min     1Q Median     3Q    Max
-40922 -18099   -937  11416  53301

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 301225.7    16589.7  18.157  < 2e-16 ***
HDD            354.2      100.7   3.518 0.000713 ***
month2      -18765.6    14152.6  -1.326 0.188539
month3       -5571.1    14680.7  -0.379 0.705308
month4      -25803.6    17881.2  -1.443 0.152812
month5      -48720.2    18476.6  -2.637 0.010007 *
month6      -61184.9    18663.0  -3.278 0.001533 **
month7      -73327.8    18664.1  -3.929 0.000177 ***
```

```
month8      -70709.4    18664.1  -3.789 0.000288 ***
month9      -88493.4    18662.8  -4.742 8.82e-06 ***
month10     -55377.2    18096.1  -3.060 0.002989 **
month11     -46476.4    15543.6  -2.990 0.003681 **
month12     -21972.3    14266.9  -1.540 0.127389
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 24190 on 82 degrees of freedom
Multiple R-squared:  0.7662, Adjusted R-squared:  0.7319
F-statistic: 22.39 on 12 and 82 DF,  p-value: < 2.2e-16
```

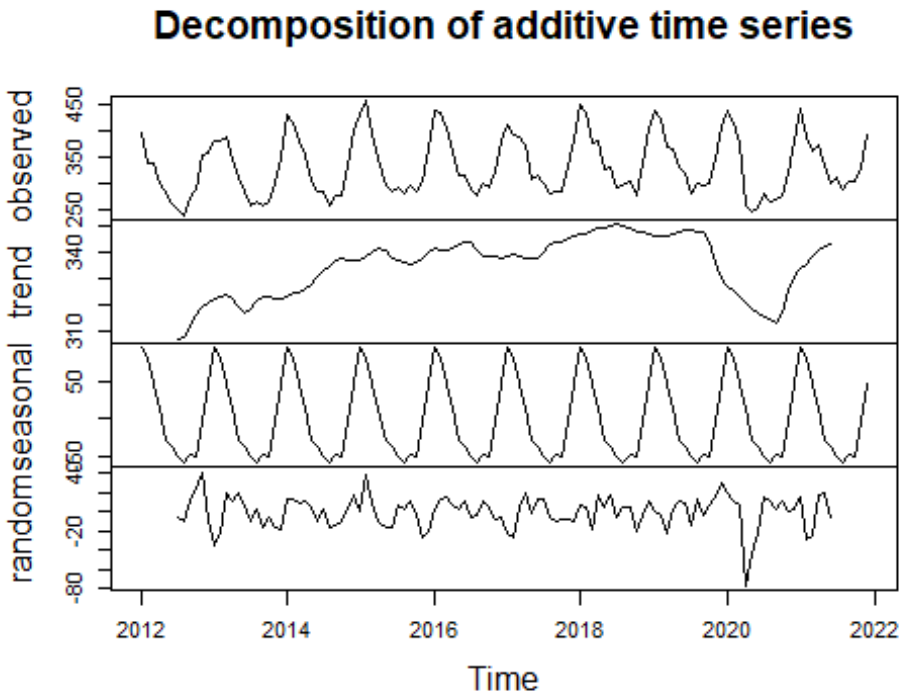


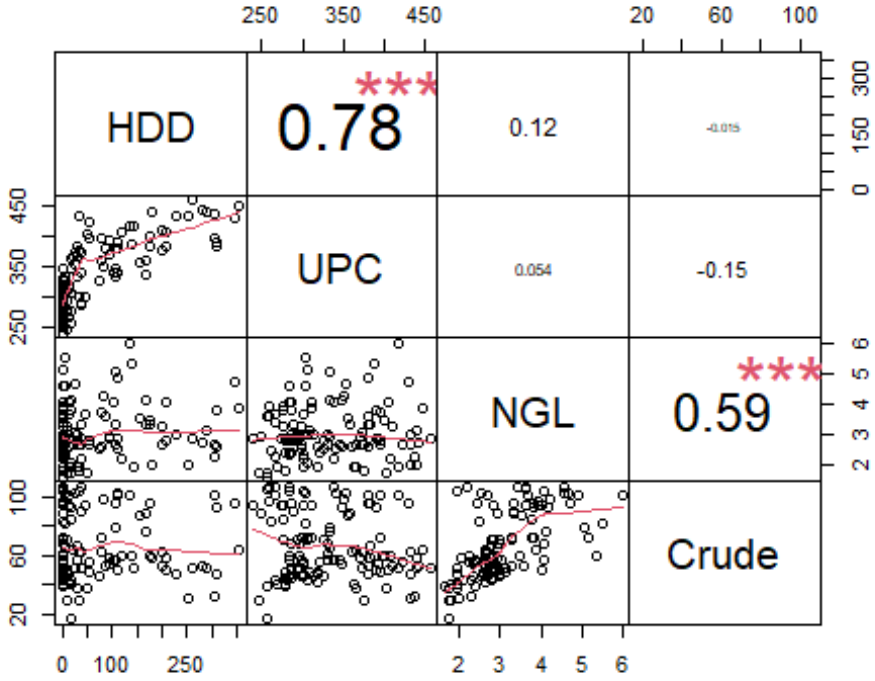

```
[1] "24 Month Mean Absolute Error (MAE): 148.38"

[1] "24 Month Accuracy: 0.89"

        Date Actual.UPC Predicted.UPC Absolute.Error Accuracy
97   Jan 2019    1501.23       1446.01          55.22     0.96
98   Feb 2019    1371.35       1354.06          17.29     0.99
99   Mar 2019    1374.14       1356.78          17.35     0.99
100 Apr 2019    1124.54       1274.64         150.10     0.87
101 May 2019    1282.43       1204.21          78.22     0.94
102 Jun 2019    1252.63       1169.50          83.14     0.93
103 Jul 2019    1292.81       1136.94         155.86     0.88
104 Aug 2019    1236.49       1144.02          92.47     0.93
105 Sep 2019    1286.29       1095.23         191.05     0.85
106 Oct 2019    1353.73       1192.89         160.84     0.88
107 Nov 2019    1346.57       1249.41          97.16     0.93
108 Dec 2019    1554.01       1352.94         201.07     0.87
109 Jan 2020    1592.25       1446.01         146.24     0.91
110 Feb 2020    1449.51       1354.06          95.45     0.93
111 Mar 2020    1513.02       1356.78         156.24     0.90
112 Apr 2020    1432.37       1274.64         157.72     0.89
```

113	May 2020	1376.67	1204.21	172.45	0.87
114	Jun 2020	1287.55	1169.50	118.05	0.91
115	Jul 2020	1365.83	1136.94	228.88	0.83
116	Aug 2020	1368.81	1144.02	224.79	0.84
117	Sep 2020	1354.01	1095.23	258.78	0.81
118	Oct 2020	1449.38	1192.89	256.49	0.82
119	Nov 2020	1491.36	1249.41	241.95	0.84
120	Dec 2020	1557.25	1352.94	204.31	0.87

FPUC General Service 2 (FPU-GS2 & FPU-GST2)

Customer Time-Series Decomposition





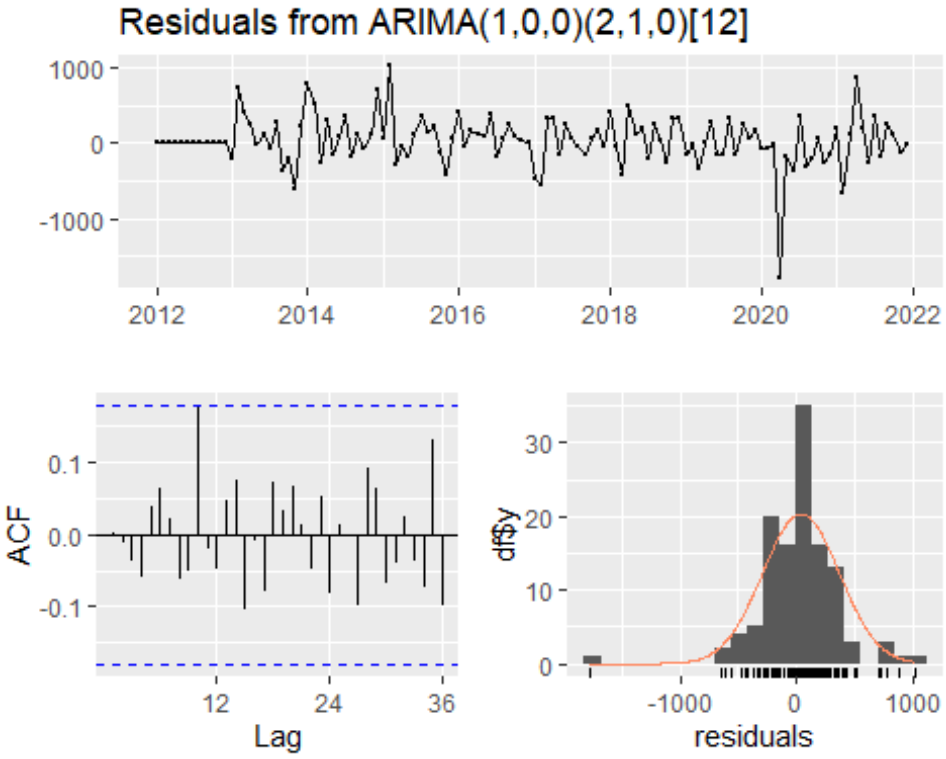
ARIMA Model: Expected Accuracy

		ME	RMSE	MAE
Forecast Horizon	1	-1	15	12
Forecast Horizon	2	-1	18	13
Forecast Horizon	3	0	13	10

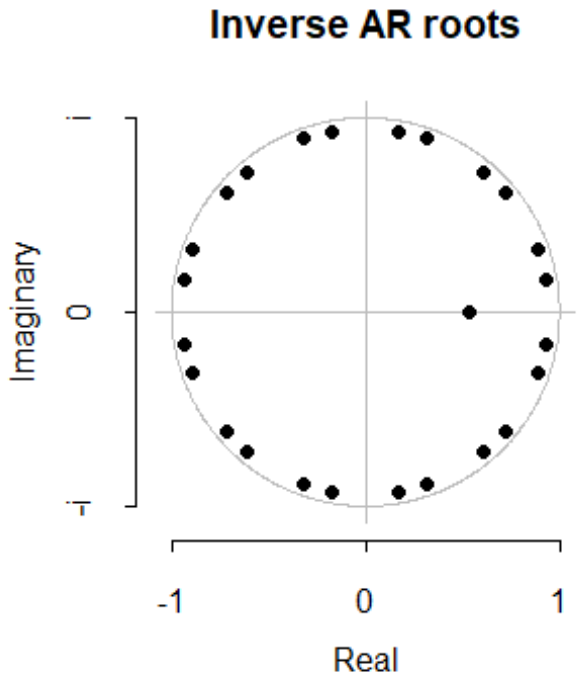
```
Forecast Horizon  4   -3   22  13
Forecast Horizon  5   -5   26  15
Forecast Horizon  6   -6   28  17
Forecast Horizon  7   -7   28  16
Forecast Horizon  8   -7   29  19
Forecast Horizon  9   -8   29  18
Forecast Horizon  10  -8   28  18
Forecast Horizon  11  -9   28  18
Forecast Horizon  12 -11   28  17
Forecast Horizon  13 -12   29  18
Forecast Horizon  14 -14   31  20
Forecast Horizon  15 -14   31  20
Forecast Horizon  16 -14   29  19
Forecast Horizon  17 -14   31  20
Forecast Horizon  18 -14   32  21
Forecast Horizon  19 -14   34  22
Forecast Horizon  20 -14   33  22
Forecast Horizon  21 -14   34  22
Forecast Horizon  22 -14   34  21
Forecast Horizon  23 -14   32  20
Forecast Horizon  24 -16   33  21
```

ARIMA Model: Diagnostics

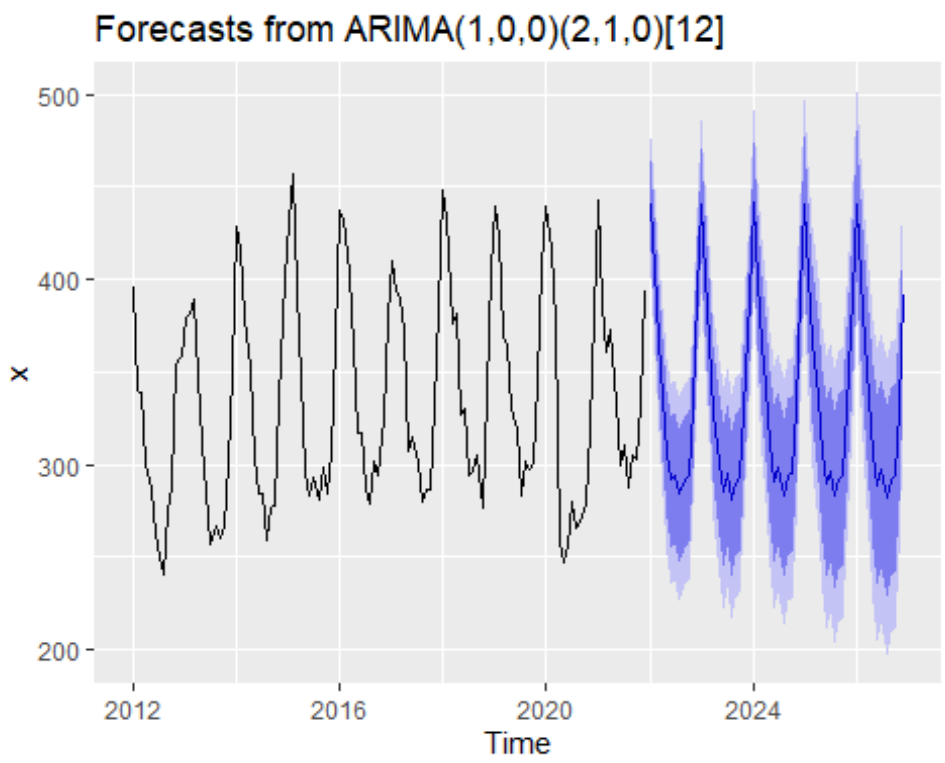
```
Series: x
ARIMA(1,0,0)(2,1,0)[12]
Box Cox transformation: lambda= 1.477589

Coefficients:
         ar1     sar1     sar2
      0.5344  -0.5783  -0.2611
s.e.  0.0808   0.1043   0.1200

sigma^2 estimated as 124123:  log likelihood=-787.52
AIC=1583.05   AICc=1583.43   BIC=1593.77

Training set error measures:
                    ME     RMSE      MAE       MPE     MAPE      MASE        ACF1
Training set 2.12058 20.29326 13.97265 0.3625424 4.254465 0.6638903 0.001375863
```



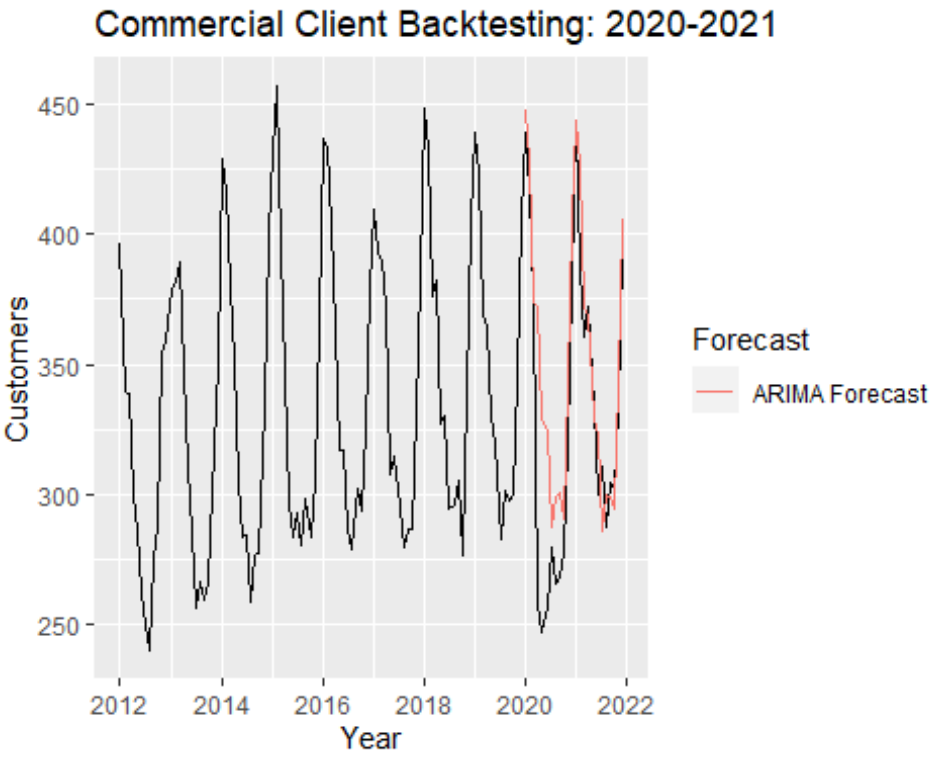

```
 Ljung-Box test

data:  Residuals from ARIMA(1,0,0)(2,1,0)[12]
Q* = 13.782, df = 21, p-value = 0.8788

Model df: 3.   Total lags used: 24
```



ARIMA Model: 5 Year Forecast



Back-Testing



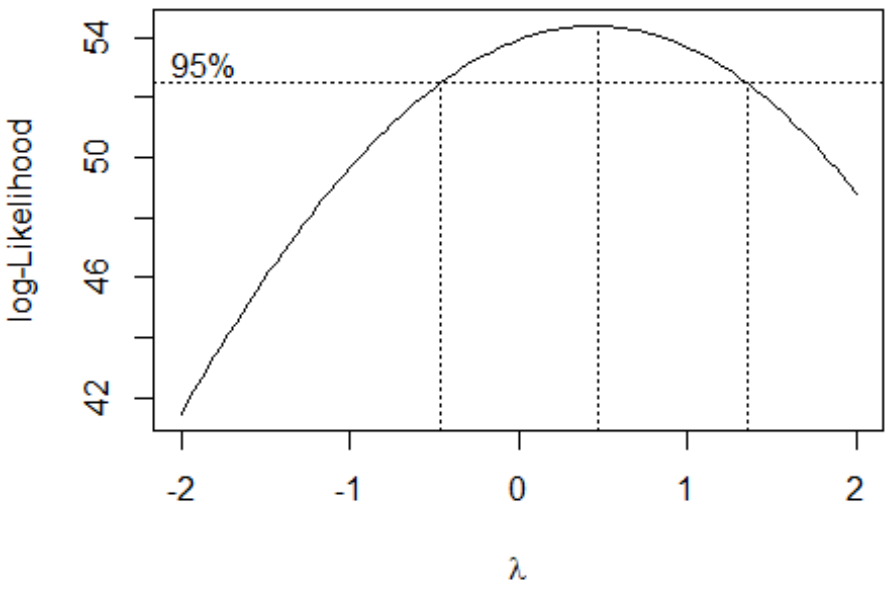
Test Results

Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021.

```
[1] "24 Month Mean Absolute Error (MAE): 24.06"

[1] "24 Month Mean Accuracy: 91.6"
```

	Actual	Forecast	Absolute_Error	Accuracy
Jan 2020	439.0569	447	8.35	98.1
Feb 2020	416.7853	429	12.17	97.1
Mar 2020	375.8292	374	2.26	99.4
Apr 2020	257.5827	372	114.72	55.5
May 2020	246.9702	329	82.11	66.8
Jun 2020	256.1900	324	67.87	73.5
Jul 2020	279.7078	288	8.00	97.1
Aug 2020	265.8760	299	33.15	87.5
Sep 2020	268.3445	300	32.14	88.0
Oct 2020	278.1722	291	12.63	95.5
Nov 2020	318.6624	342	23.77	92.5
Dec 2020	380.6622	406	24.92	93.5
Jan 2021	443.2362	444	0.98	99.8
Feb 2021	386.7656	427	39.76	89.7
Mar 2021	360.2200	372	11.70	96.8
Apr 2021	372.2428	369	2.86	99.2
May 2021	333.5414	330	3.95	98.8
Jun 2021	299.7582	322	22.60	92.5
Jul 2021	310.4089	286	24.61	92.1
Aug 2021	287.2534	300	12.71	95.6
Sep 2021	304.7806	299	5.46	98.2
Oct 2021	302.2719	294	7.89	97.4
Nov 2021	332.7253	343	10.70	96.8
Dec 2021	393.8996	406	12.04	96.9

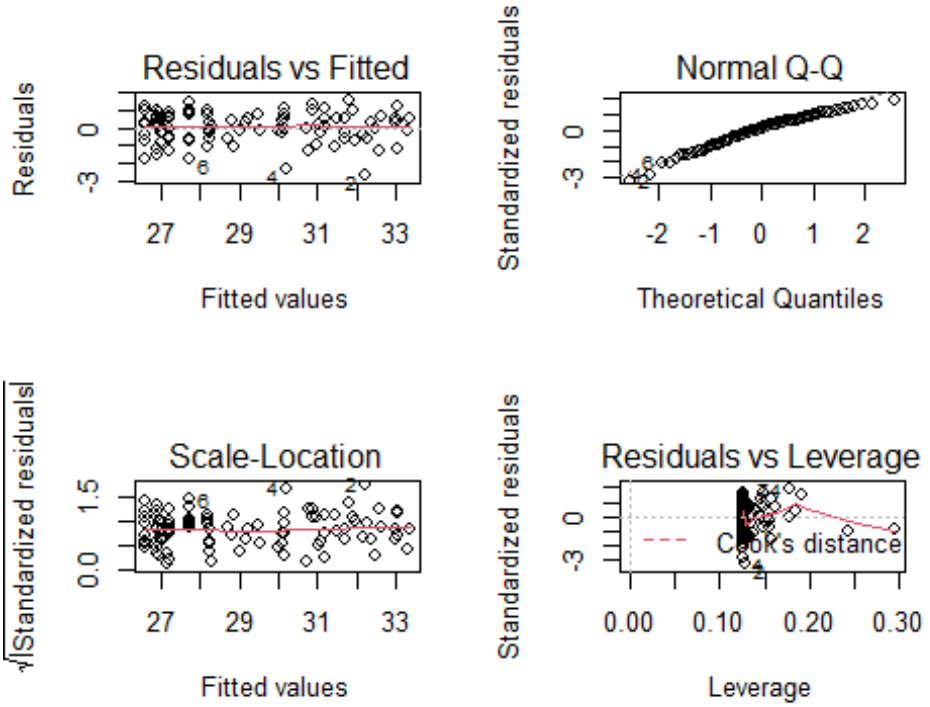
```
[1] "train_data<-zzz[1:96,]\ntest_data<-zzz[97:120,]\ntest_data$HDD<-hdd_avg[97:120]"
```




```
[1] 0.46
```

```
Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Coefficients:
(Intercept)          HDD       month2       month3       month4       month5
  31.387953     0.005474     0.233129    -0.808497    -1.371515    -3.172969
     month6       month7       month8       month9      month10      month11
  -3.631723    -4.482357    -4.775851    -4.175798    -4.423148    -2.758235
    month12
  -0.843951


Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Residuals:
     Min       1Q   Median       3Q      Max
-2.66076 -0.59374  0.08907  0.57219  1.50567

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 31.387953   0.608826  51.555  < 2e-16 ***
HDD          0.005474   0.001946   2.813  0.00612 **
month2       0.233129   0.512438   0.455  0.65034
month3      -0.808497   0.531127  -1.522  0.13175
month4      -1.371515   0.654510  -2.095  0.03918 *
month5      -3.172969   0.678257  -4.678 1.11e-05 ***
month6      -3.631723   0.686479  -5.290 9.75e-07 ***
month7      -4.482357   0.686546  -6.529 4.97e-09 ***
month8      -4.775851   0.686546  -6.956 7.43e-10 ***
month9      -4.175798   0.686465  -6.083 3.48e-08 ***
month10     -4.423148   0.663007  -6.671 2.65e-09 ***
month11     -2.758235   0.568687  -4.850 5.69e-06 ***
month12     -0.843951   0.517891  -1.630  0.10698
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.8974 on 83 degrees of freedom
Multiple R-squared:  0.8724, Adjusted R-squared:  0.854
F-statistic:  47.3 on 12 and 83 DF,  p-value: < 2.2e-16
```

FPUC-Rate 0625513

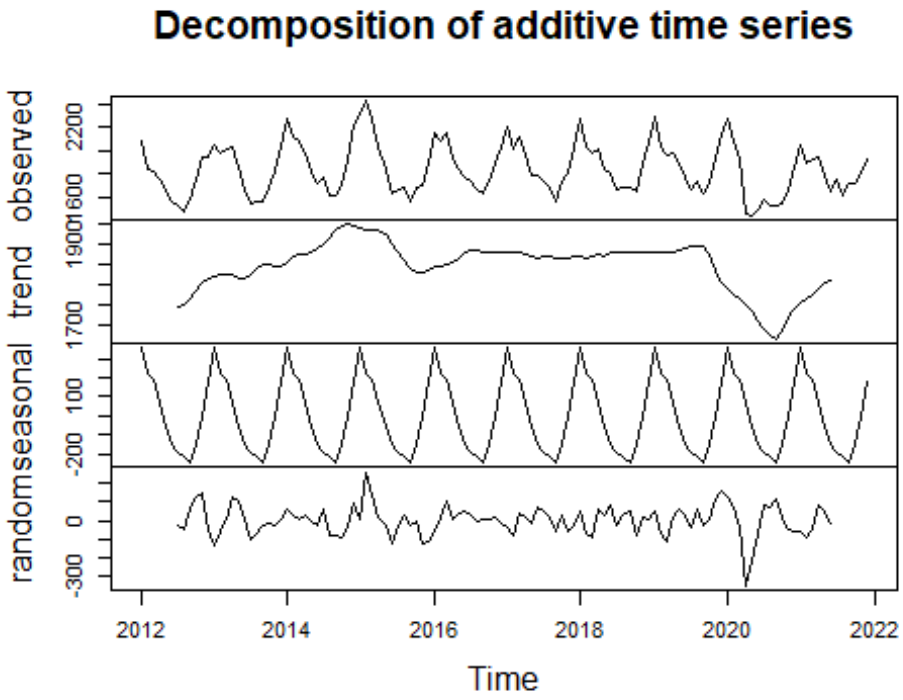


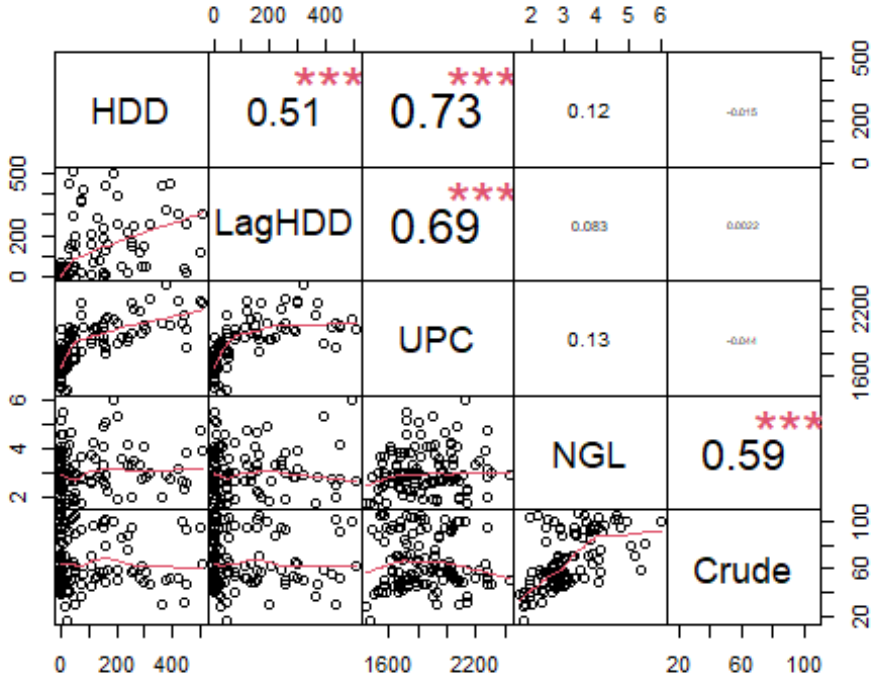

```
[1] "24 Month Mean Absolute Error (MAE): 19.37"

[1] "24 Month Accuracy: 0.93"
```

	Date	Actual.UPC	Predicted.UPC	Absolute.Error	Accuracy
97	Jan 2019	439.06	427.24	11.82	0.97
98	Feb 2019	416.79	415.16	1.62	1.00
99	Mar 2019	375.83	379.14	3.31	0.99
100	Apr 2019	257.58	355.03	97.45	0.62
101	May 2019	246.97	309.80	62.83	0.75
102	Jun 2019	256.19	299.09	42.90	0.83
103	Jul 2019	279.71	280.92	1.21	1.00
104	Aug 2019	265.88	274.79	8.91	0.97
105	Sep 2019	268.34	287.41	19.07	0.93
106	Oct 2019	278.17	284.37	6.20	0.98
107	Nov 2019	318.66	330.03	11.36	0.96
108	Dec 2019	380.66	389.97	9.31	0.98
109	Jan 2020	443.24	427.24	16.00	0.96
110	Feb 2020	386.77	415.16	28.40	0.93
111	Mar 2020	360.22	379.14	18.92	0.95
112	Apr 2020	372.24	355.03	17.21	0.95
113	May 2020	333.54	309.80	23.74	0.93
114	Jun 2020	299.76	299.09	0.66	1.00
115	Jul 2020	310.41	280.92	29.49	0.90
116	Aug 2020	287.25	274.79	12.46	0.96
117	Sep 2020	304.78	287.41	17.37	0.94
118	Oct 2020	302.27	284.37	17.90	0.94
119	Nov 2020	332.73	330.03	2.70	0.99
120	Dec 2020	393.90	389.97	3.93	0.99

FPUC Large Volume Services (LVS, LVTS,LVTS2)

Customer Time-Series Decomposition



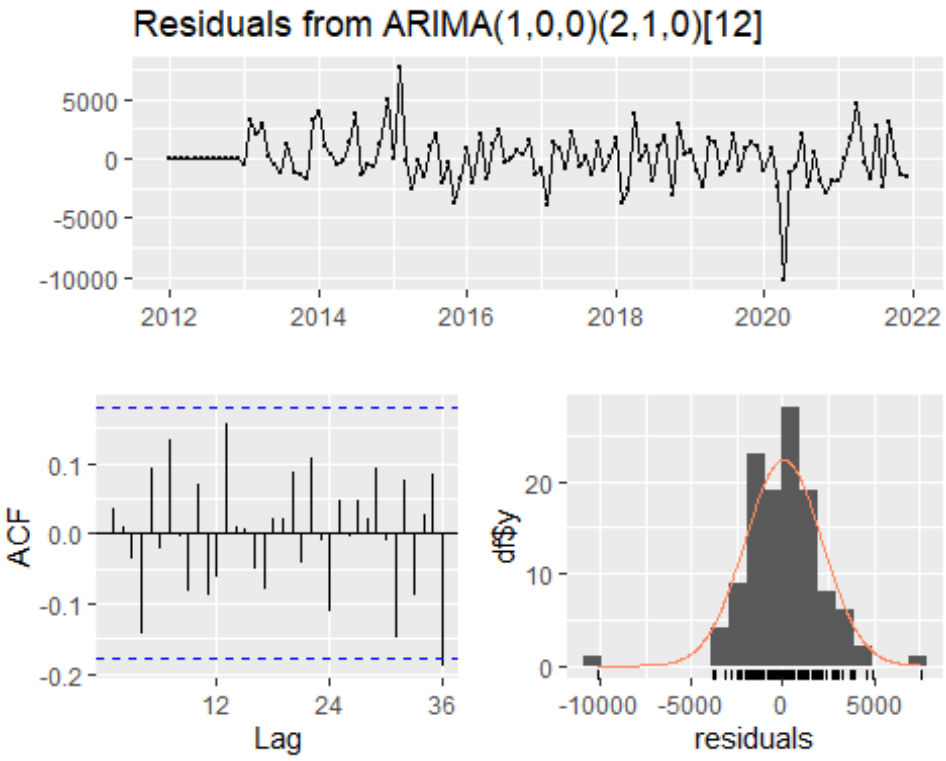


ARIMA Model: Expected Accuracy

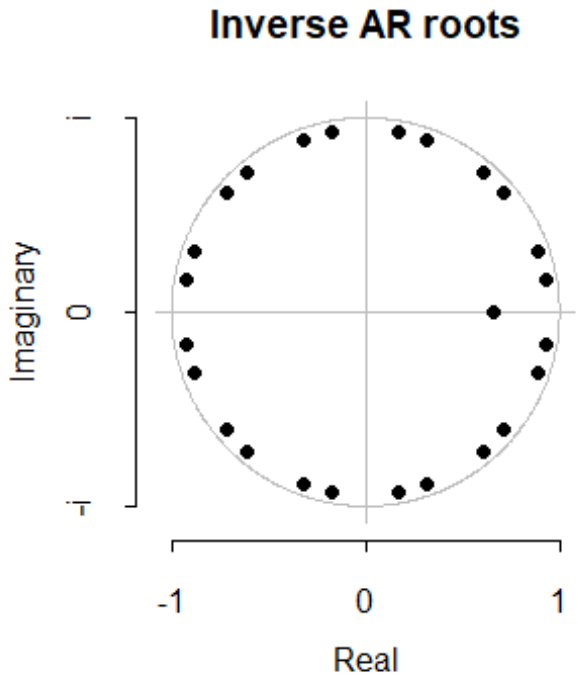
```
                      ME RMSE MAE
Forecast Horizon  1    5   67  51
Forecast Horizon  2    3   79  65
Forecast Horizon  3   10   59  48
Forecast Horizon  4   -1  104  63
Forecast Horizon  5  -13  126  72
Forecast Horizon  6  -19  134  81
Forecast Horizon  7  -37  136  82
Forecast Horizon  8  -33  139  86
Forecast Horizon  9  -38  137  85
Forecast Horizon  10 -43  142  88
Forecast Horizon  11 -43  151 101
Forecast Horizon  12 -54  156 106
Forecast Horizon  13 -56  154 110
Forecast Horizon  14 -63  163 121
Forecast Horizon  15 -57  155 110
Forecast Horizon  16 -53  156 113
Forecast Horizon  17 -59  155 110
Forecast Horizon  18 -62  155 112
Forecast Horizon  19 -72  159 116
Forecast Horizon  20 -68  153 114
Forecast Horizon  21 -68  158 119
Forecast Horizon  22 -71  153 110
Forecast Horizon  23 -68  159 120
Forecast Horizon  24 -77  163 123
```

ARIMA Model: Diagnostics

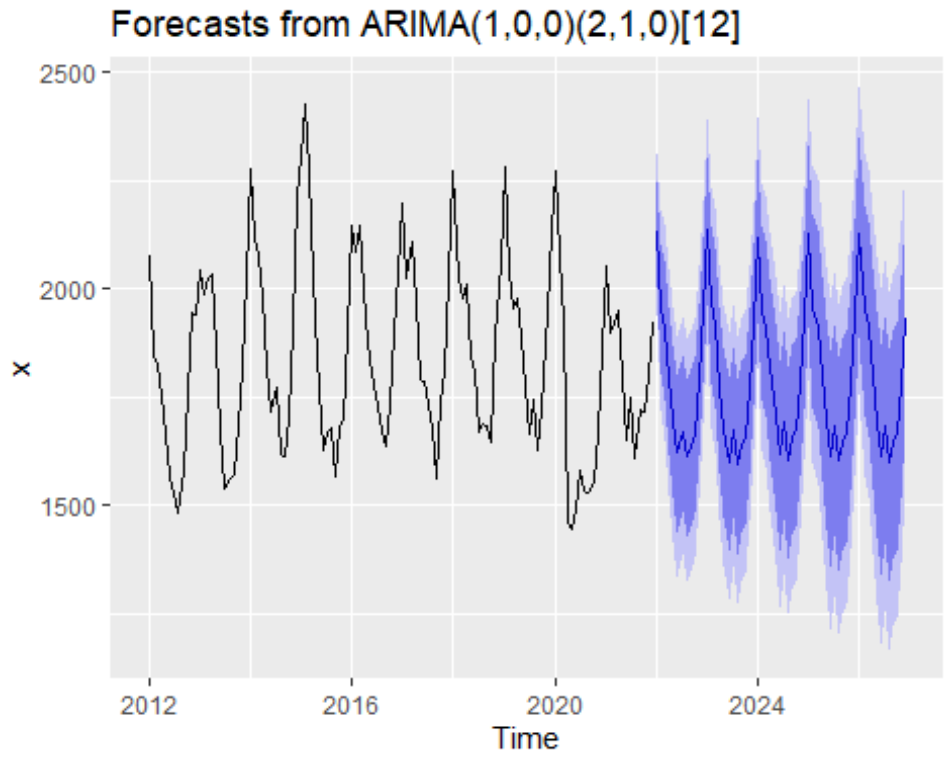
```
Series: x
ARIMA(1,0,0)(2,1,0)[12]
Box Cox transformation: lambda= 1.413314

Coefficients:
         ar1     sar1     sar2
      0.6631  -0.5524  -0.2319
s.e.  0.0716   0.0997   0.1130

sigma^2 estimated as 5053282:  log likelihood=-987.54
AIC=1983.08   AICc=1983.47   BIC=1993.81

Training set error measures:
                    ME     RMSE      MAE         MPE     MAPE     MASE        ACF1
Training set 1.143143 93.47565 66.75757 -0.1331992 3.653763 0.617625 0.03112766
```



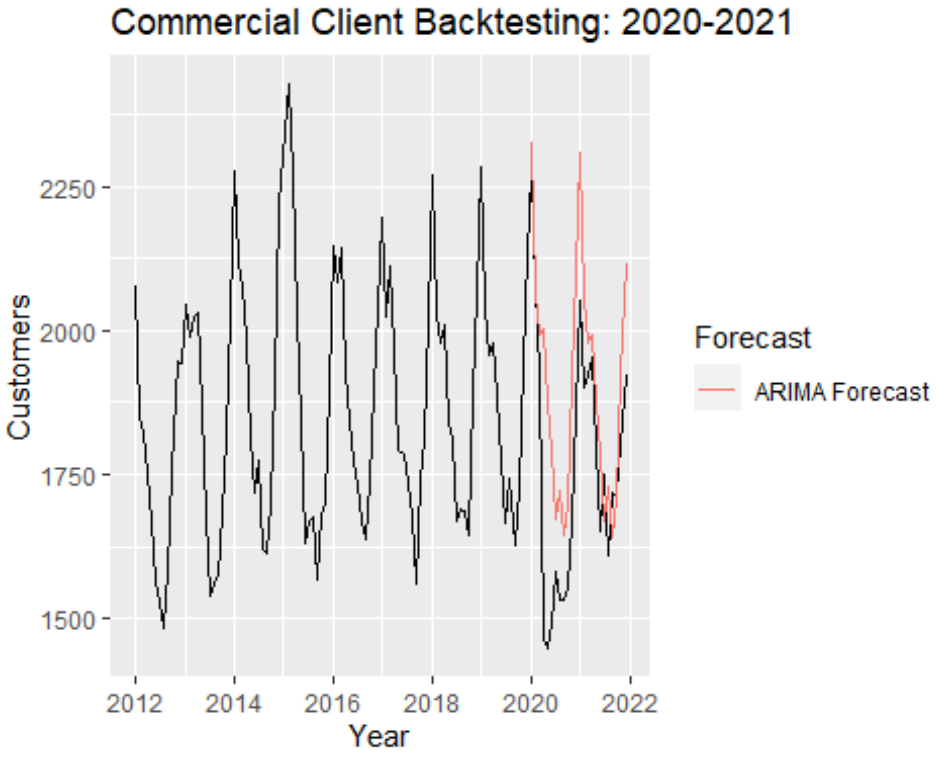

```
 Ljung-Box test

data:  Residuals from ARIMA(1,0,0)(2,1,0)[12]
Q* = 19.354, df = 21, p-value = 0.5624

Model df: 3.   Total lags used: 24
```



ARIMA Model: 5 Year Forecast



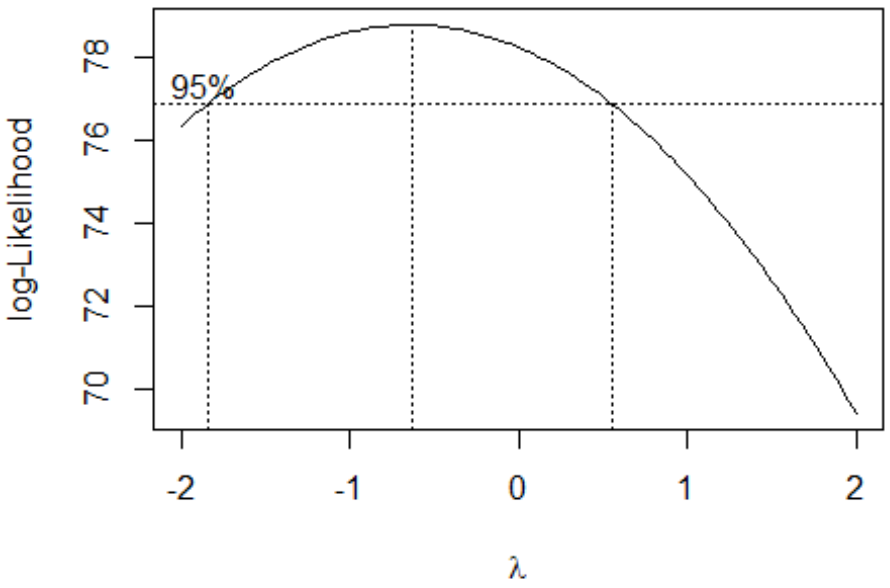
Back-Testing



Test Results

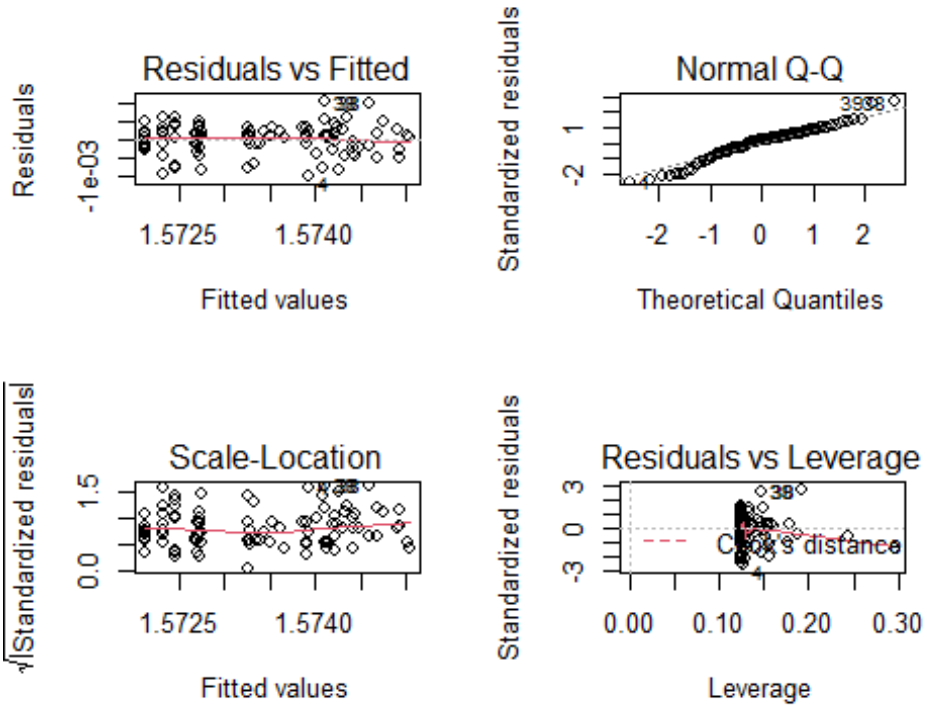
Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021. Although the MLR Model performs slightly better when Back-Testing, we have chose to use the ARIMA forecast in order to reduce Bias in our model.

Multiple Linear Regression Model Comparison




```
[1] "Box-Cox Lambda: -0.63"


Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Coefficients:
(Intercept)          HDD       month2       month3       month4       month5
  1.574e+00    1.544e-06   -2.268e-04   -2.628e-04   -3.989e-04   -9.974e-04
     month6       month7       month8       month9      month10      month11
 -1.519e-03   -1.807e-03   -1.942e-03   -2.131e-03   -1.586e-03   -9.711e-04
    month12
 -3.003e-04


Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0009827 -0.0002127  0.0000797  0.0002320  0.0010091

Coefficients:
              Estimate Std. Error  t value Pr(>|t|)
```

```
(Intercept)  1.574e+00  2.843e-04 5537.776  < 2e-16 ***
HDD          1.544e-06  6.310e-07    2.446 0.016542 *
month2      -2.268e-04  2.409e-04   -0.941 0.349283
month3      -2.628e-04  2.492e-04   -1.055 0.294596
month4      -3.989e-04  3.063e-04   -1.302 0.196398
month5      -9.974e-04  3.173e-04   -3.143 0.002316 **
month6      -1.519e-03  3.211e-04   -4.732 9.02e-06 ***
month7      -1.807e-03  3.211e-04   -5.627 2.42e-07 ***
month8      -1.942e-03  3.211e-04   -6.048 4.05e-08 ***
month9      -2.131e-03  3.210e-04   -6.638 3.06e-09 ***
month10     -1.586e-03  3.099e-04   -5.117 1.97e-06 ***
month11     -9.711e-04  2.659e-04   -3.652 0.000454 ***
month12     -3.003e-04  2.428e-04   -1.237 0.219523
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0004223 on 83 degrees of freedom
Multiple R-squared:  0.8368, Adjusted R-squared:  0.8132
F-statistic: 35.46 on 12 and 83 DF,  p-value: < 2.2e-16
```




```
[1] "Regression 24 Month Mean Absolute Error (MAE): 129.76"

[1] "Regression 24 Month Accuracy: 0.92"

        Date Actual.UPC Predicted.UPC Absolute.Error Accuracy
97   Jan 2020    2274.20       2225.62          48.58     0.98
98   Feb 2020    2077.63       2086.08           8.45     1.00
99   Mar 2020    1924.03       2038.25         114.21     0.94
100 Apr 2020    1466.42       1963.50         497.08     0.66
101 May 2020    1448.00       1817.80         369.80     0.74
102 Jun 2020    1490.85       1713.21         222.36     0.85
103 Jul 2020    1582.04       1660.84          78.81     0.95
104 Aug 2020    1532.40       1637.14         104.74     0.93
```

105	Sep 2020	1532.08	1604.94	72.86	0.95
106	Oct 2020	1552.16	1709.00	156.84	0.90
107	Nov 2020	1670.41	1865.08	194.67	0.88
108	Dec 2020	1860.74	2077.88	217.14	0.88
109	Jan 2021	2052.18	2225.62	173.43	0.92
110	Feb 2021	1899.33	2086.08	186.75	0.90
111	Mar 2021	1920.74	2038.25	117.50	0.94
112	Apr 2021	1952.31	1963.50	11.19	0.99
113	May 2021	1795.38	1817.80	22.43	0.99
114	Jun 2021	1650.85	1713.21	62.36	0.96
115	Jul 2021	1748.34	1660.84	87.50	0.95
116	Aug 2021	1609.22	1637.14	27.92	0.98
117	Sep 2021	1719.83	1604.94	114.89	0.93
118	Oct 2021	1716.60	1709.00	7.60	1.00
119	Nov 2021	1802.41	1865.08	62.67	0.97
120	Dec 2021	1923.37	2077.88	154.52	0.92

[1] "ARIMA 24 Month Mean Absolute Error (MAE): 156.5"

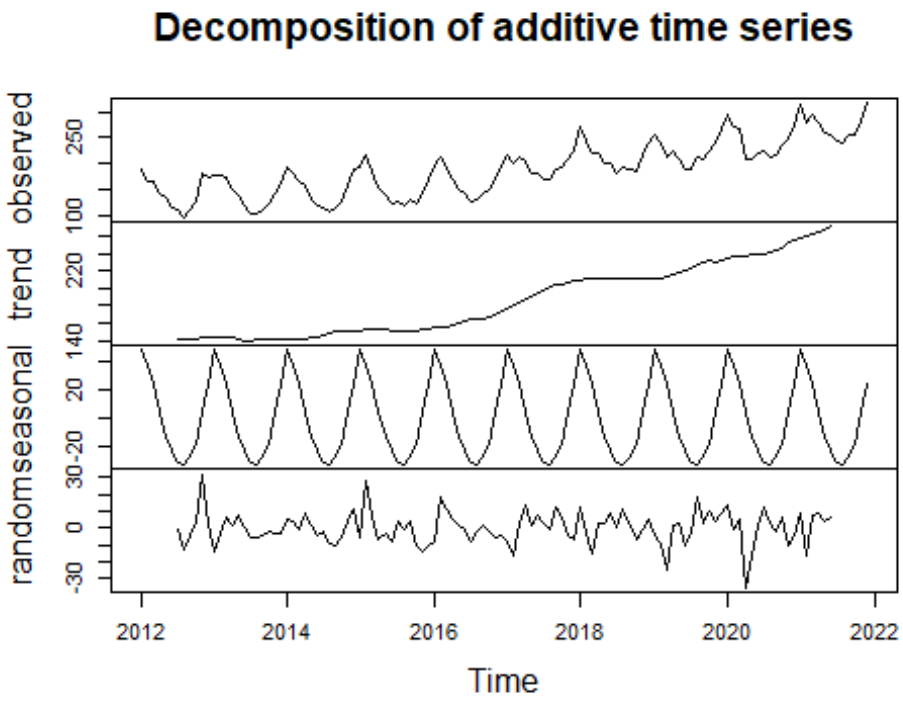
[1] "ARIMA 24 Month Mean Accuracy: 90.5"

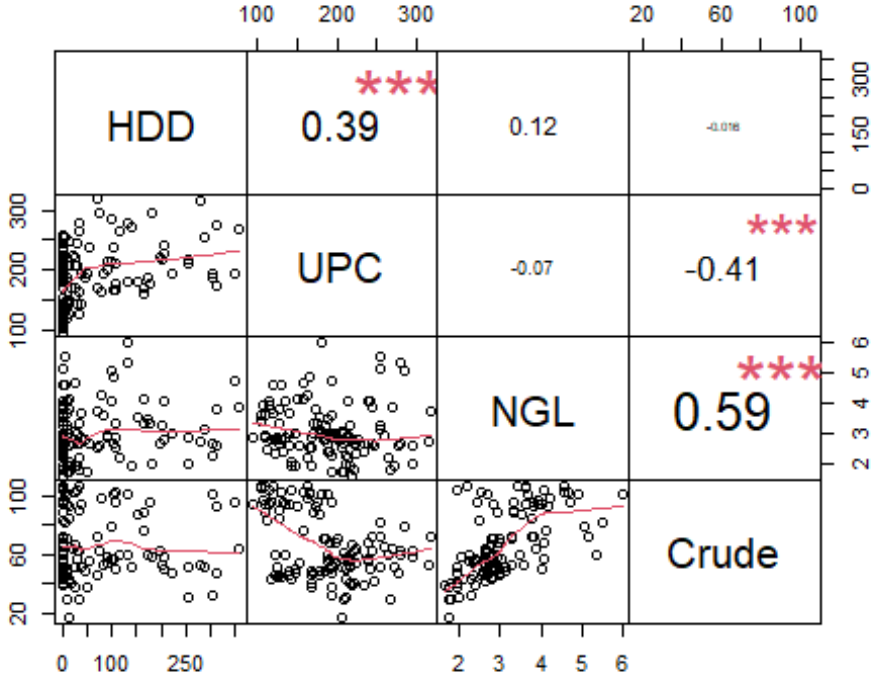
	Actual	Forecast	Absolute_Error	Accuracy
Jan 2020	2274.196	2326	51.40	97.7
Feb 2020	2077.628	2066	11.61	99.4
Mar 2020	1924.035	1991	66.94	96.5
Apr 2020	1466.419	2001	534.90	63.5
May 2020	1448.000	1874	426.04	70.6
Jun 2020	1490.854	1791	300.00	79.9
Jul 2020	1582.035	1673	90.60	94.3
Aug 2020	1532.405	1723	190.95	87.5
Sep 2020	1532.079	1646	114.37	92.5
Oct 2020	1552.163	1698	146.06	90.6
Nov 2020	1670.408	1919	248.68	85.1
Dec 2020	1860.740	2105	244.35	86.9
Jan 2021	2052.183	2308	255.96	87.5
Feb 2021	1899.327	2055	155.50	91.8
Mar 2021	1920.745	1978	57.36	97.0
Apr 2021	1952.308	1994	41.32	97.9
May 2021	1795.376	1878	82.23	95.4
Jun 2021	1650.853	1785	134.29	91.9
Jul 2021	1748.337	1670	78.62	95.5
Aug 2021	1609.223	1730	120.42	92.5
Sep 2021	1719.827	1641	78.75	95.4
Oct 2021	1716.601	1706	10.20	99.4
Nov 2021	1802.407	1927	124.42	93.1
Dec 2021	1923.365	2114	191.12	90.1

FPUC General Services1 (GS-1 & GSTS1)

This section excludes Fort Meade Customers.

Customer Time-Series Decomposition





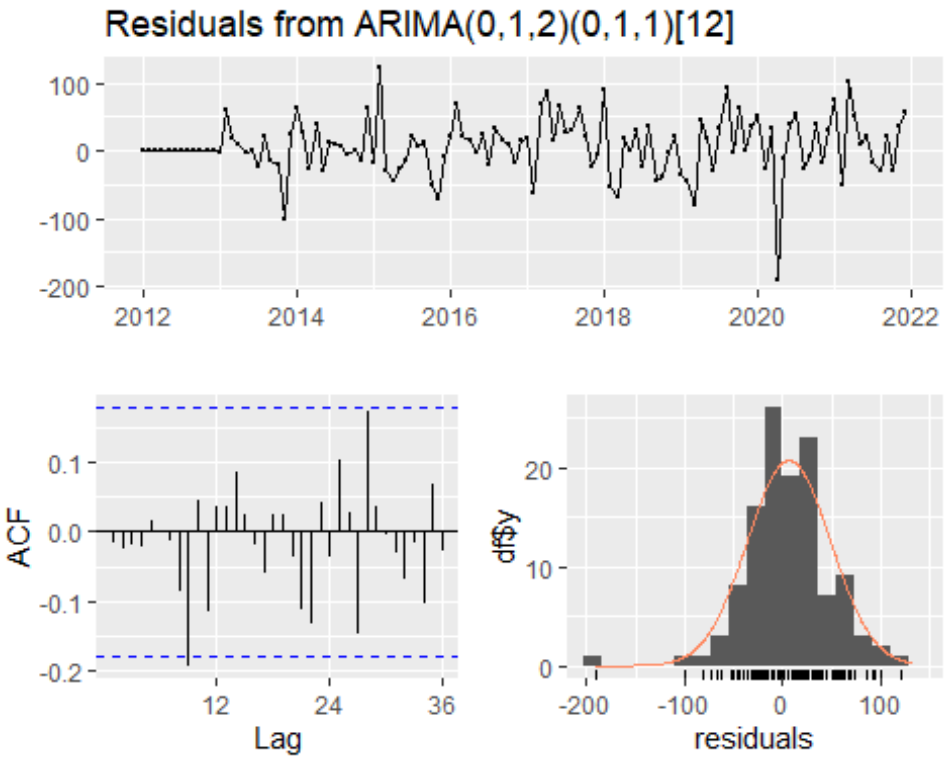
ARIMA Model: Expected Accuracy

	ME	RMSE	MAE
Forecast Horizon	1	3	14	12

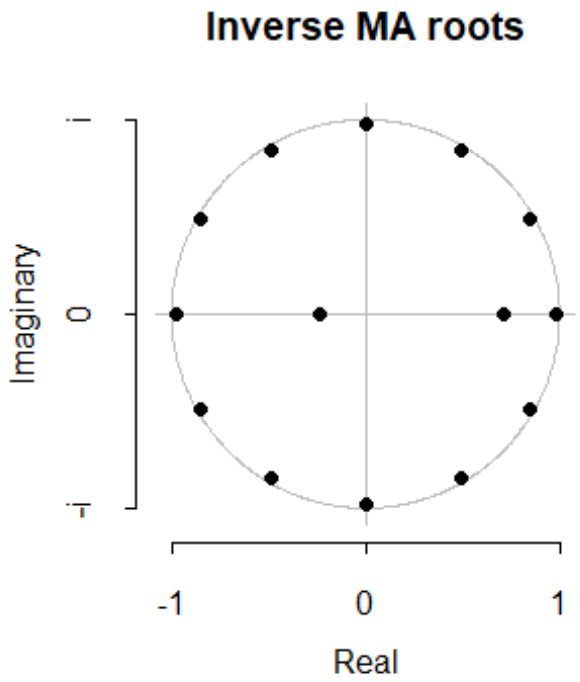
```
Forecast Horizon  2   6   17  14
Forecast Horizon  3   8   19  16
Forecast Horizon  4   7   22  19
Forecast Horizon  5   7   23  19
Forecast Horizon  6   6   24  20
Forecast Horizon  7   5   23  20
Forecast Horizon  8   4   25  20
Forecast Horizon  9   3   25  20
Forecast Horizon  10  3   25  20
Forecast Horizon  11  3   24  20
Forecast Horizon  12  3   23  19
Forecast Horizon  13  5   23  19
Forecast Horizon  14  6   25  19
Forecast Horizon  15  8   28  22
Forecast Horizon  16  9   30  25
Forecast Horizon  17  9   30  25
Forecast Horizon  18  8   30  24
Forecast Horizon  19  7   28  23
Forecast Horizon  20  6   29  24
Forecast Horizon  21  6   28  23
Forecast Horizon  22  6   28  21
Forecast Horizon  23  8   27  21
Forecast Horizon  24  9   27  21
```

ARIMA Model: Diagnostics

```
Series: x
ARIMA(0,1,2)(0,1,1)[12]
Box Cox transformation: lambda= 1.247137

Coefficients:
          ma1      ma2     sma1
      -0.4766  -0.1713  -0.7638
s.e.   0.0988   0.1013   0.1242

sigma^2 estimated as 2105:  log likelihood=-565.17
AIC=1138.34   AICc=1138.73   BIC=1149.03

Training set error measures:
                    ME     RMSE      MAE       MPE     MAPE      MASE
Training set 1.607118 11.43091 8.321258 0.5494051 4.341802 0.4483804
                     ACF1
Training set -0.004598838
```

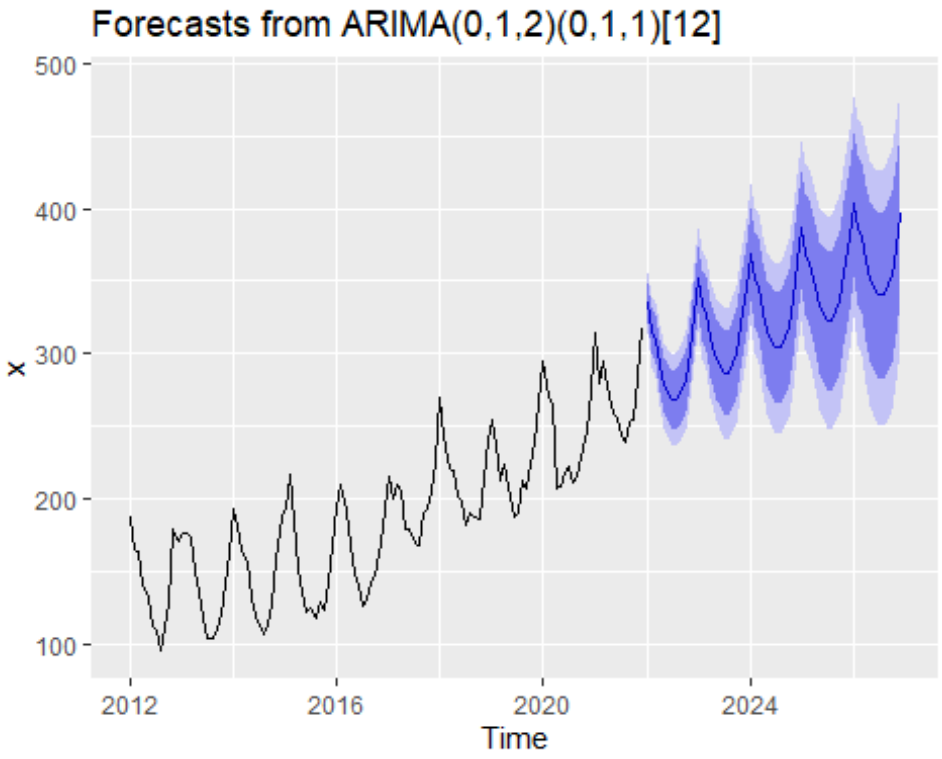



```
 Ljung-Box test

data:  Residuals from ARIMA(0,1,2)(0,1,1)[12]
Q* = 15.609, df = 21, p-value = 0.7912

Model df: 3.   Total lags used: 24
```

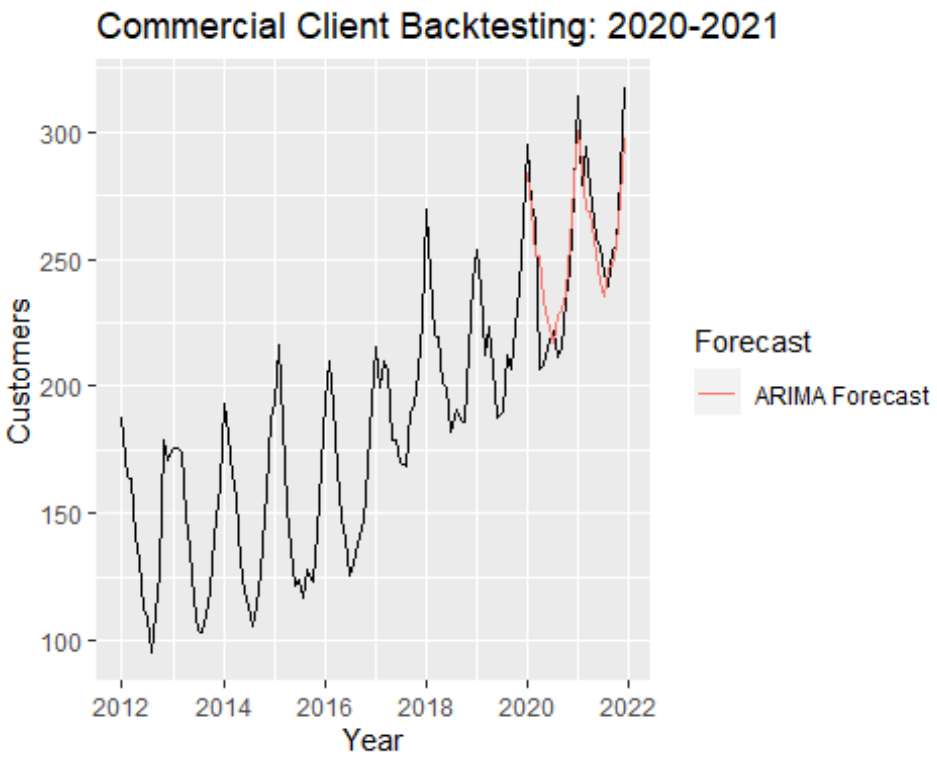


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (0,1,2)(0,1,1) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing



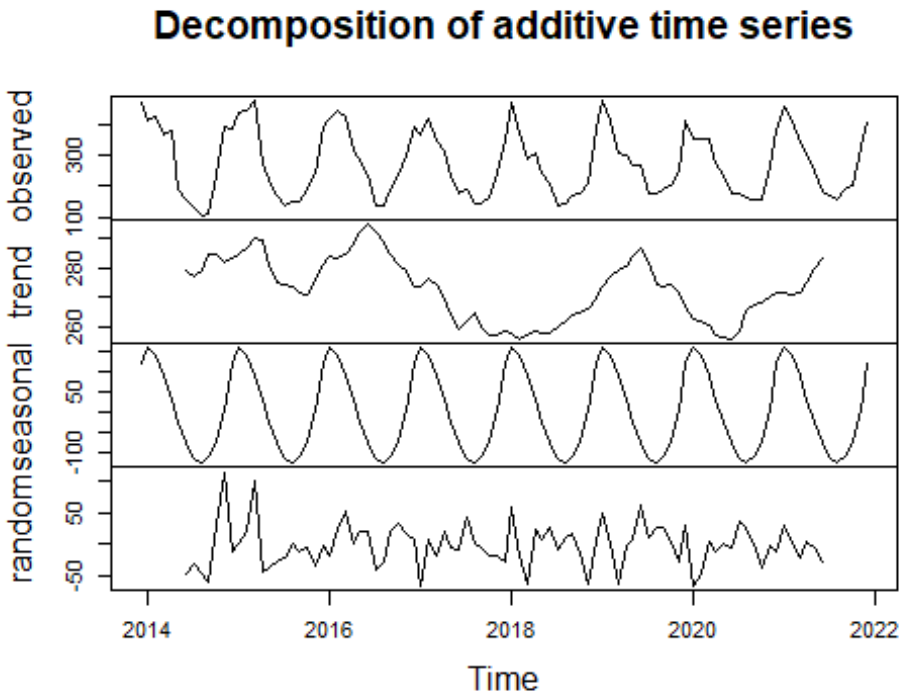
Test Results

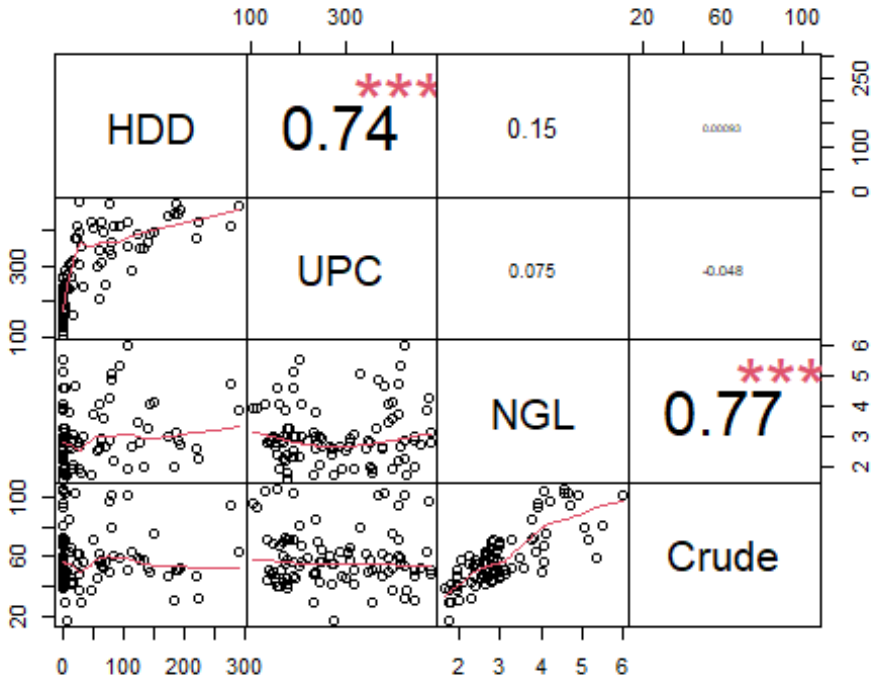
Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021.

```
[1] "24 Month Mean Absolute Error (MAE): 11.81"

[1] "24 Month Mean Accuracy: 95.21"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 295.0728      284          11.06     96.3
Feb 2020 271.3240      270           1.80     99.3
Mar 2020 265.6287      252          14.02     94.7
Apr 2020 206.4639      251          44.57     78.4
May 2020 208.4541      234          25.22     87.9
Jun 2020 218.1702      223           4.65     97.9
Jul 2020 221.8758      217           4.56     97.9
Aug 2020 211.6211      228          16.39     92.3
Sep 2020 215.0513      229          14.40     93.3
Oct 2020 234.3503      237           2.86     98.8
Nov 2020 246.0209      256          10.07     95.9
Dec 2020 275.5689      280           4.35     98.4
Jan 2021 314.1687      300          13.71     95.6
Feb 2021 279.3386      287           7.64     97.3
Mar 2021 294.5708      269          25.22     91.4
Apr 2021 278.6152      269           9.83     96.5
May 2021 258.5211      252           6.79     97.4
Jun 2021 255.2315      241          14.15     94.5
Jul 2021 243.8098      236           8.12     96.7
Aug 2021 239.1119      246           7.06     97.0
Sep 2021 253.5263      248           5.94     97.7
Oct 2021 254.1463      255           1.05     99.6
Nov 2021 283.7844      274          10.03     96.5
Dec 2021 317.2802      297          20.07     93.7
```

Fort Meade General Services1 (GS-1 & GSTS1)

Customer Time-Series Decomposition



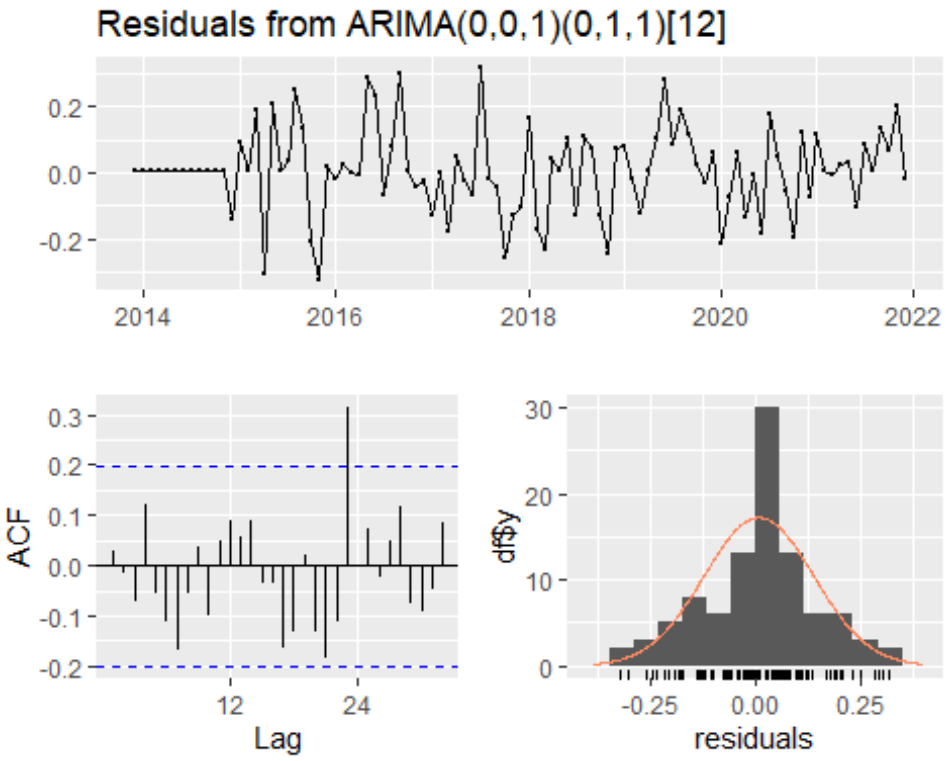


ARIMA Model: Expected Accuracy

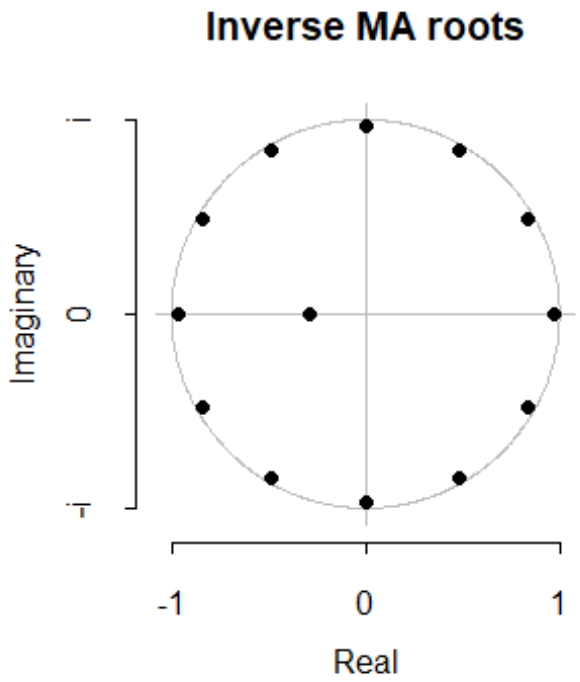
```
                     ME RMSE MAE
Forecast Horizon  1   3   43  36
Forecast Horizon  2   5   46  38
Forecast Horizon  3   2   46  37
Forecast Horizon  4   1   45  36
Forecast Horizon  5   3   45  36
Forecast Horizon  6   3   43  35
Forecast Horizon  7   0   41  33
Forecast Horizon  8  -1   36  30
Forecast Horizon  9   1   41  33
Forecast Horizon  10  0   41  32
Forecast Horizon  11  1   43  34
Forecast Horizon  12  2   43  33
```

ARIMA Model: Diagnostics

```
Series: x
ARIMA(0,0,1)(0,1,1)[12]
Box Cox transformation: lambda= -0.01816321

Coefficients:
         ma1     sma1
      0.2921  -0.6898
s.e.  0.1021   0.1416

sigma^2 estimated as 0.01983:  log likelihood=43.12
AIC=-80.24   AICc=-79.95   BIC=-72.91

Training set error measures:
                     ME     RMSE      MAE        MPE     MAPE      MASE
Training set -0.5133108 38.67201 27.06462 -0.2843901 10.46333 0.6753574
                    ACF1
Training set -0.08786082
```

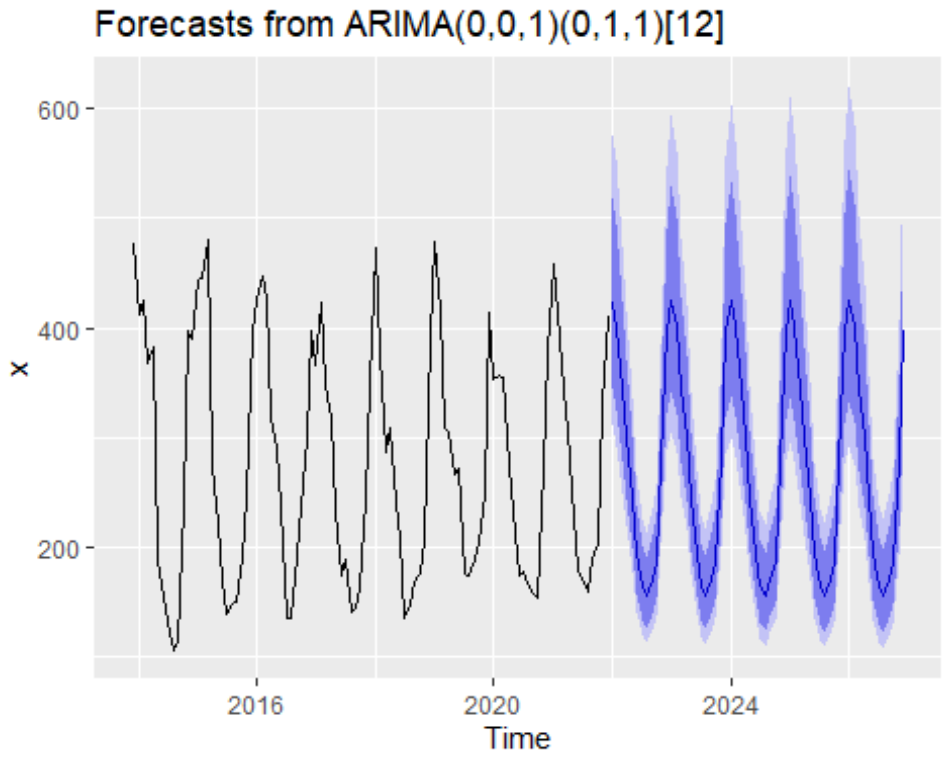



```
 Ljung-Box test

data:  Residuals from ARIMA(0,0,1)(0,1,1)[12]
Q* = 16.55, df = 17, p-value = 0.4853

Model df: 2.   Total lags used: 19
```

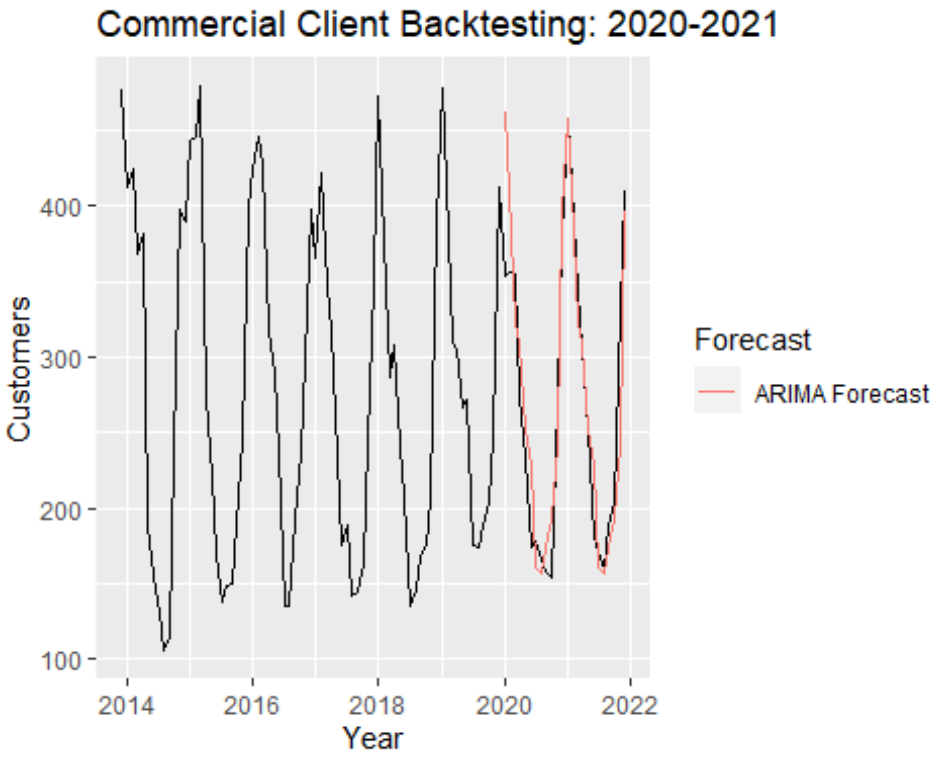


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (0,0,1)(0,1,1) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing



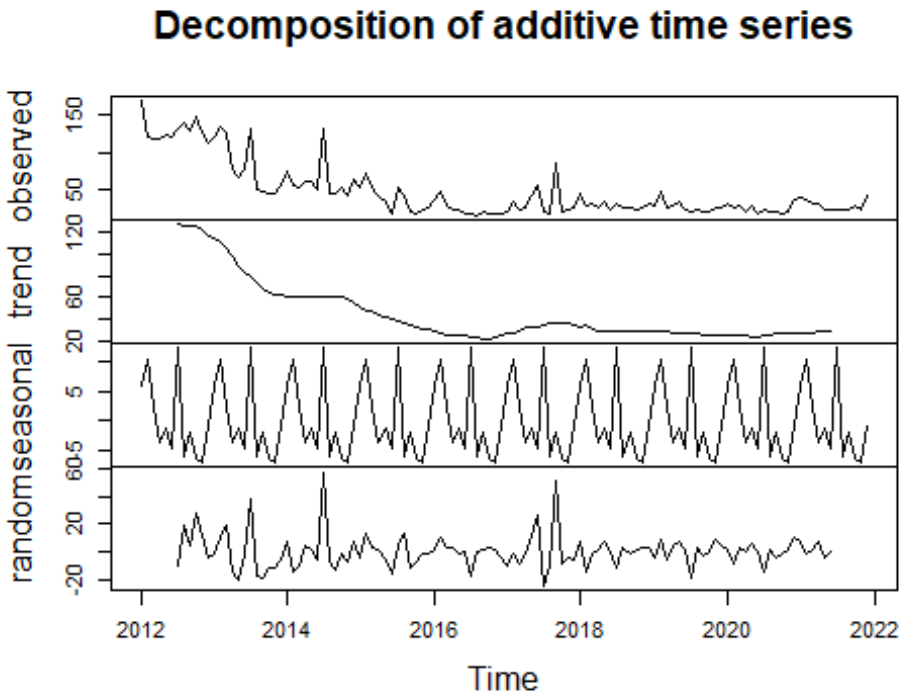
Test Results

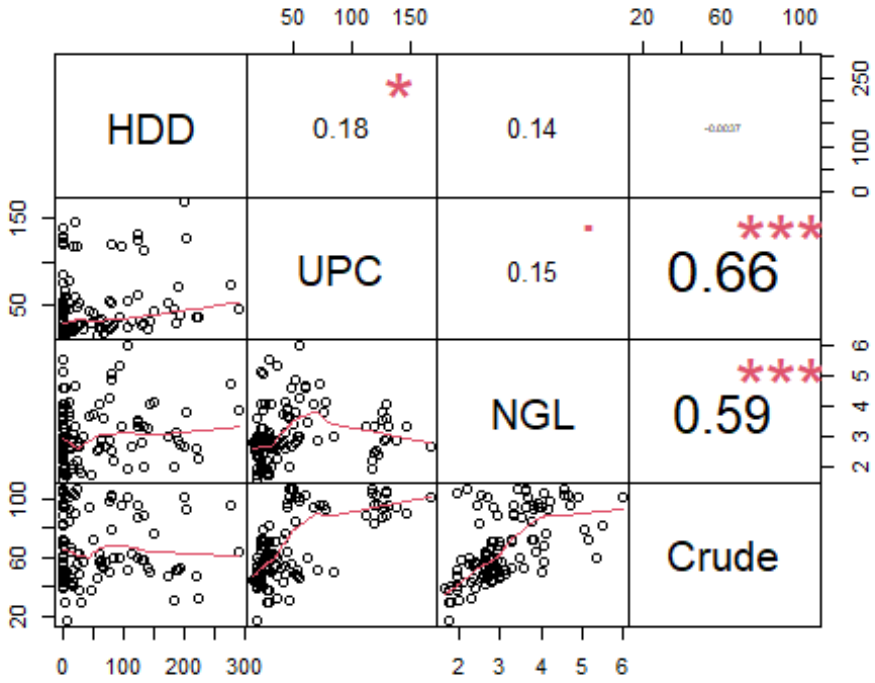
Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021.

```
[1] "24 Month Mean Absolute Error (MAE): 27.19"

[1] "24 Month Mean Accuracy: 89.13"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 353.6036      463         109.11     69.1
Feb 2020 356.8843      410          53.38     85.0
Mar 2020 355.1874      322          32.91     90.7
Apr 2020 273.9174      309          35.21     87.1
May 2020 232.9959      252          19.11     91.8
Jun 2020 174.4376      229          54.43     68.8
Jul 2020 177.3274      160          17.39     90.2
Aug 2020 165.8879      156          10.12     93.9
Sep 2020 158.0450      173          15.21     90.4
Oct 2020 154.3436      193          38.43     75.1
Nov 2020 272.0404      243          29.30     89.2
Dec 2020 378.9267      397          18.32     95.2
Jan 2021 458.8186      458           1.15     99.7
Feb 2021 414.0230      410           3.76     99.1
Mar 2021 343.6100      322          21.33     93.8
Apr 2021 306.1933      309           2.93     99.0
May 2021 251.1692      252           0.94     99.6
Jun 2021 179.9032      229          48.96     72.8
Jul 2021 171.0357      160          11.10     93.5
Aug 2021 158.4264      156           2.66     98.3
Sep 2021 189.1324      173          15.88     91.6
Oct 2021 203.0321      193          10.26     94.9
Nov 2021 330.7724      243          88.03     73.4
Dec 2021 409.8722      397          12.63     96.9
```

CFG Firm Transportation Services (FTS-1)

Customer Time-Series Decomposition





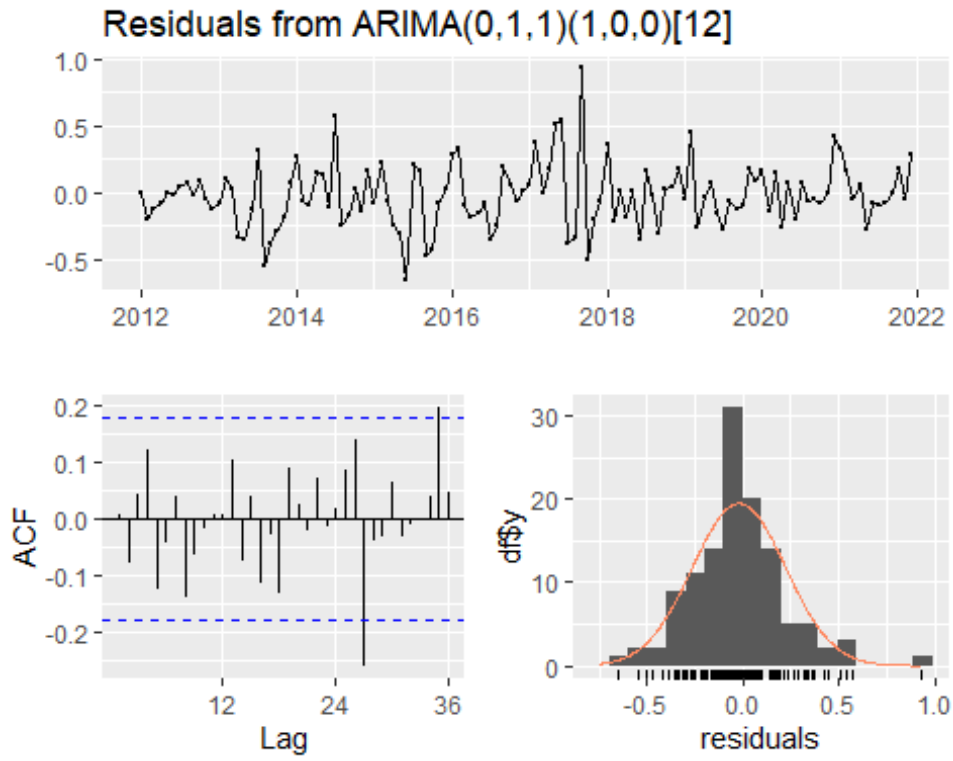
ARIMA Model: Expected Accuracy

In this section we evaluate the expected accuracy of a Seasonal ARIMA Model using cross-validation. ARIMA is an acronym for 'Autoregressive Integrated Moving Average' which is a widely using Time-Series forecasting model that utilizes the recent values to predict outward.

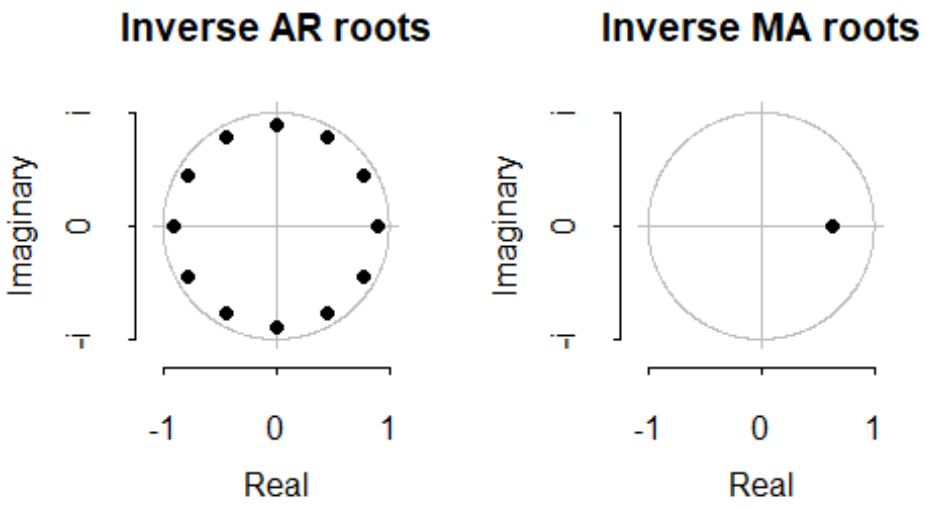
```
                     ME RMSE MAE
Forecast Horizon  1   1   14   9
Forecast Horizon  2   1   14  10
Forecast Horizon  3   1   13   9
Forecast Horizon  4   0   14   9
Forecast Horizon  5   0   17  10
Forecast Horizon  6   0   16  10
Forecast Horizon  7  -2   14   8
Forecast Horizon  8  -2   16   9
Forecast Horizon  9  -2   16   9
Forecast Horizon  10 -4   10   7
Forecast Horizon  11 -4   11   8
Forecast Horizon  12 -4   14   8
Forecast Horizon  13 -3   12   9
Forecast Horizon  14 -4   12  10
Forecast Horizon  15 -4   12  10
Forecast Horizon  16 -4   13  10
Forecast Horizon  17 -4   13  10
Forecast Horizon  18 -4   13  10
Forecast Horizon  19 -5   13   9
Forecast Horizon  20 -5   13   9
Forecast Horizon  21 -5   14  10
Forecast Horizon  22 -5   13  10
Forecast Horizon  23 -5   14  10
Forecast Horizon  24 -5   16  11
```

ARIMA Model: Diagnostics

```
Series: x
ARIMA(0,1,1)(1,0,0)[12]
Box Cox transformation: lambda= -0.05746735

Coefficients:
          ma1    sar1
      -0.6392  0.2709
s.e.   0.0731  0.0863

sigma^2 estimated as 0.06061:  log likelihood=-1.77
AIC=9.53   AICc=9.74   BIC=17.87

Training set error measures:
                     ME     RMSE      MAE       MPE    MAPE      MASE
Training set -0.8996957 15.62633 10.26217 -7.015054 23.3429 0.5810274
                    ACF1
Training set 0.006444286
```

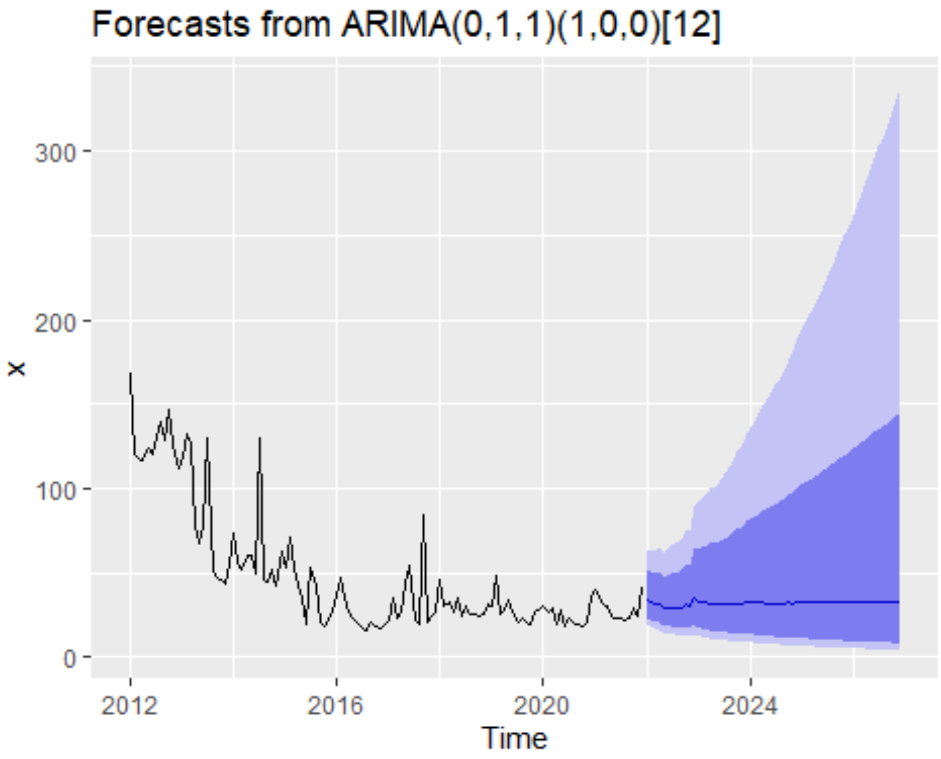



```
 Ljung-Box test

data:  Residuals from ARIMA(0,1,1)(1,0,0)[12]
Q* = 17.295, df = 22, p-value = 0.7469

Model df: 2.   Total lags used: 24
```

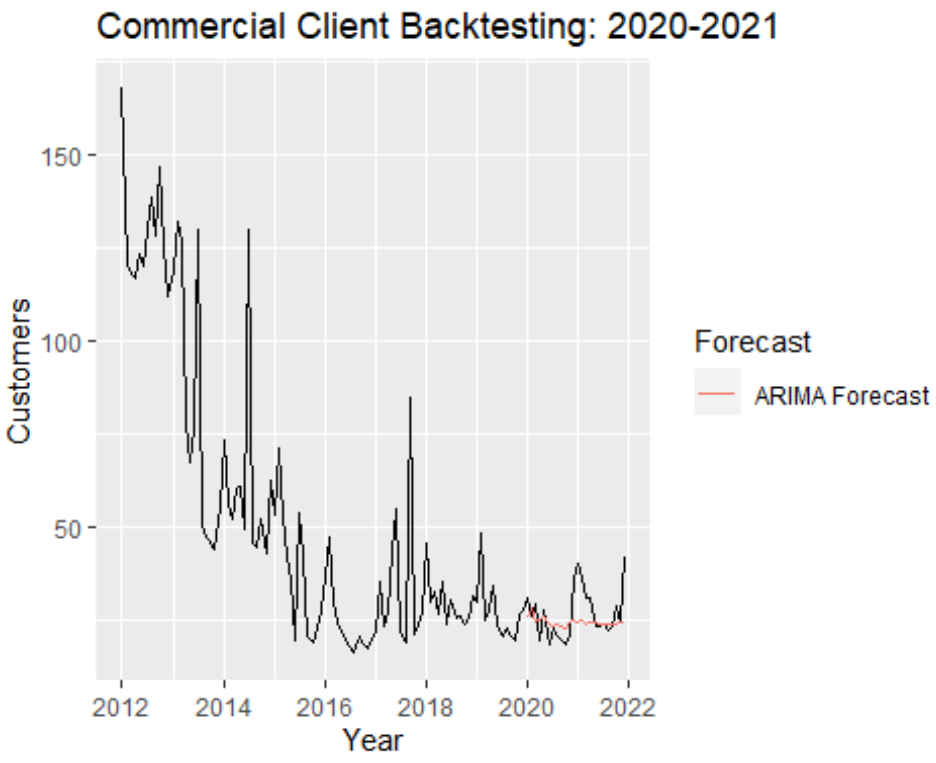


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (0,1,1)(1,0,0) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing



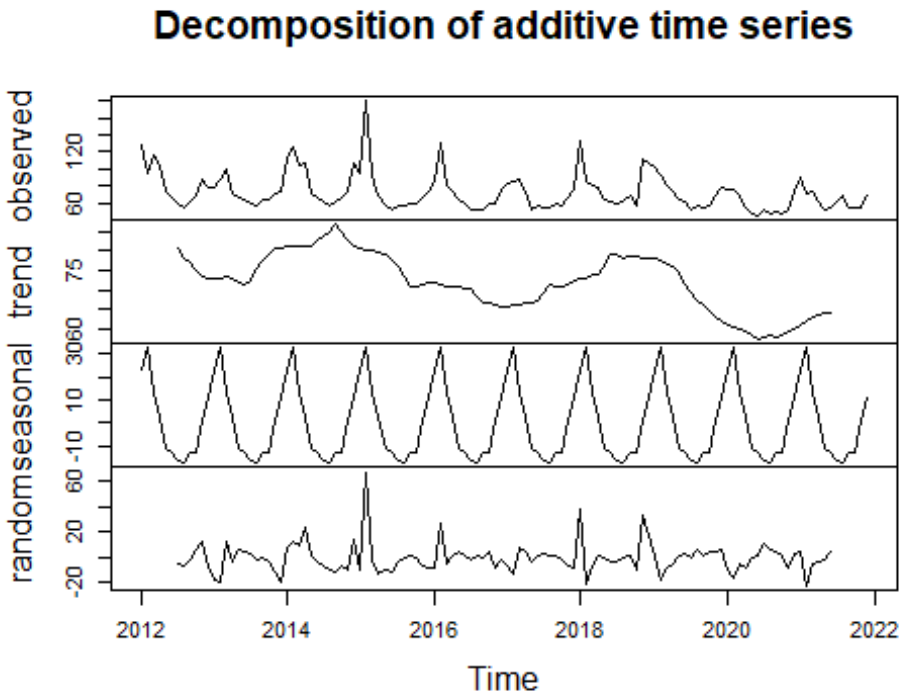
Test Results

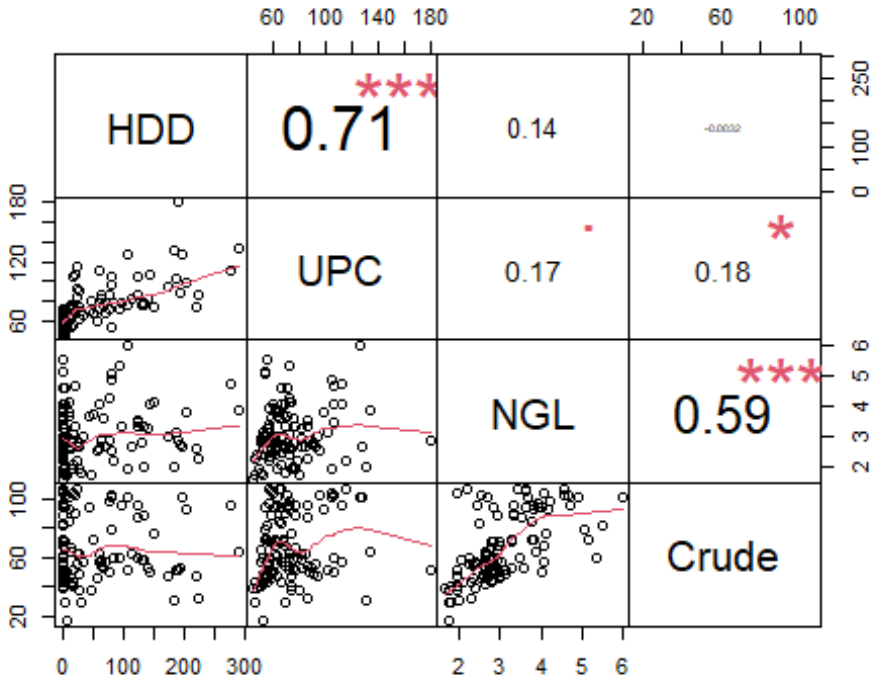
Below we see that the Backtested model does not perform very well. The likely cause for low accuracy is due to the COVID-19 pandemic.

```
[1] "24 Month Mean Absolute Error (MAE): 4.95"

[1] "24 Month Mean Accuracy: 83.22"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 30.94743       25           5.57     82.0
Feb 2020 26.32498       28           2.02     92.3
Mar 2020 29.40401       24           5.06     82.8
Apr 2020 19.80873       25           5.14     74.1
May 2020 27.85945       26           1.71     93.9
Jun 2020 18.68904       24           5.35     71.4
Jul 2020 22.85519       23           0.39     98.3
Aug 2020 20.44514       24           3.30     83.9
Sep 2020 19.76896       23           3.47     82.4
Oct 2020 18.58016       23           4.39     76.4
Nov 2020 21.32995       25           3.38     84.2
Dec 2020 35.98660       25          11.11     69.1
Jan 2021 40.33759       24          15.96     60.4
Feb 2021 36.36868       25          11.34     68.8
Mar 2021 31.13691       24           7.00     77.5
Apr 2021 30.91426       24           6.63     78.6
May 2021 23.38455       25           1.17     95.0
Jun 2021 23.47677       24           0.59     97.5
Jul 2021 23.64849       24           0.22     99.1
Aug 2021 22.47235       24           1.52     93.2
Sep 2021 23.32391       24           0.55     97.6
Oct 2021 28.86276       24           5.06     82.5
Nov 2021 24.63376       24           0.41     98.3
Dec 2021 41.80829       24          17.54     58.0
```

CFG Firm Transportation Services (FTS-2)

Customer Time-Series Decomposition





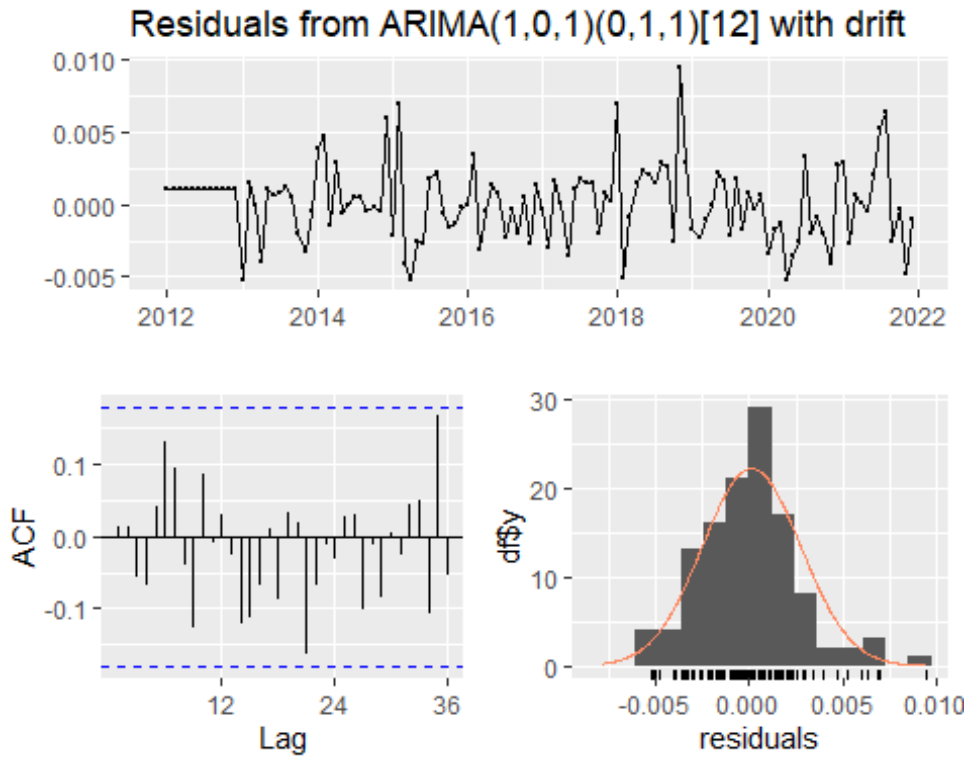
ARIMA Model: Expected Accuracy

In this section we evaluate the expected accuracy of a Seasonal ARIMA Model using cross-validation. ARIMA is an acronym for 'Autoregressive Integrated Moving Average' which is a widely using Time-Series forecasting model that utilizes the recent values to predict outward.

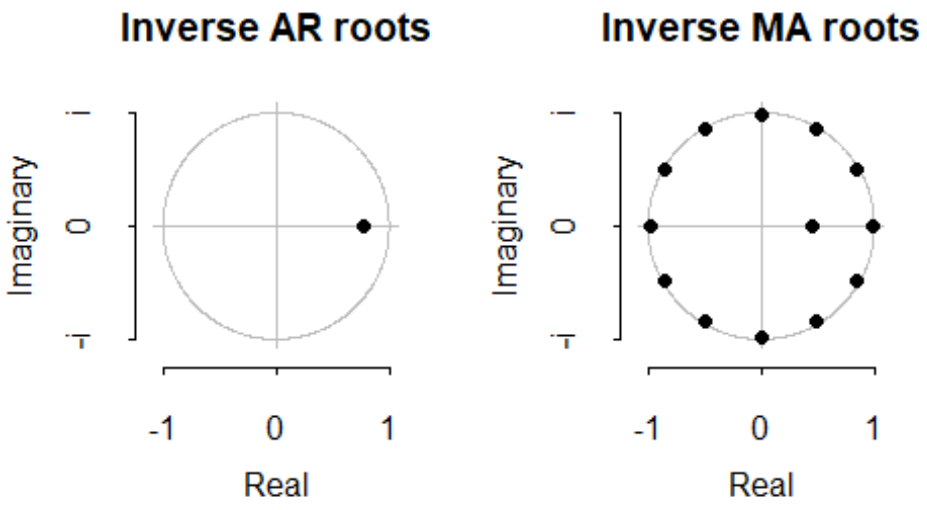
```
                     ME RMSE MAE
Forecast Horizon  1   -2   19  12
Forecast Horizon  2   -3   19  13
Forecast Horizon  3   -1   17  12
Forecast Horizon  4   -1   17  12
Forecast Horizon  5   -2   18  13
Forecast Horizon  6   -2   18  14
Forecast Horizon  7   -1   19  13
Forecast Horizon  8   -2   20  14
Forecast Horizon  9   -2   19  14
Forecast Horizon  10  -2   21  15
Forecast Horizon  11  -3   22  15
Forecast Horizon  12  -4   21  15
Forecast Horizon  13  -6   30  20
Forecast Horizon  14  -8   27  19
Forecast Horizon  15  -6   23  16
Forecast Horizon  16  -6   23  17
Forecast Horizon  17  -6   23  17
Forecast Horizon  18  -7   25  19
Forecast Horizon  19  -7   22  17
Forecast Horizon  20  -6   23  18
Forecast Horizon  21  -7   25  17
Forecast Horizon  22  -7   23  17
Forecast Horizon  23  -8   25  17
Forecast Horizon  24 -10   24  17
```

ARIMA Model: Diagnostics

```
Series: x
ARIMA(1,0,1)(0,1,1)[12] with drift
Box Cox transformation: lambda= -0.8999268

Coefficients:
         ar1      ma1     sma1  drift
      0.7783  -0.4454  -0.7768  0e+00
s.e.  0.1453   0.2108   0.1318  1e-04

sigma^2 estimated as 7.9e-06:  log likelihood=478.54
AIC=-947.09   AICc=-946.5   BIC=-933.68

Training set error measures:
                    ME     RMSE      MAE          MPE     MAPE      MASE
Training set 1.236222 13.48753 7.961932 -0.01207669 9.589661 0.6637106
                    ACF1
Training set -0.1799524
```

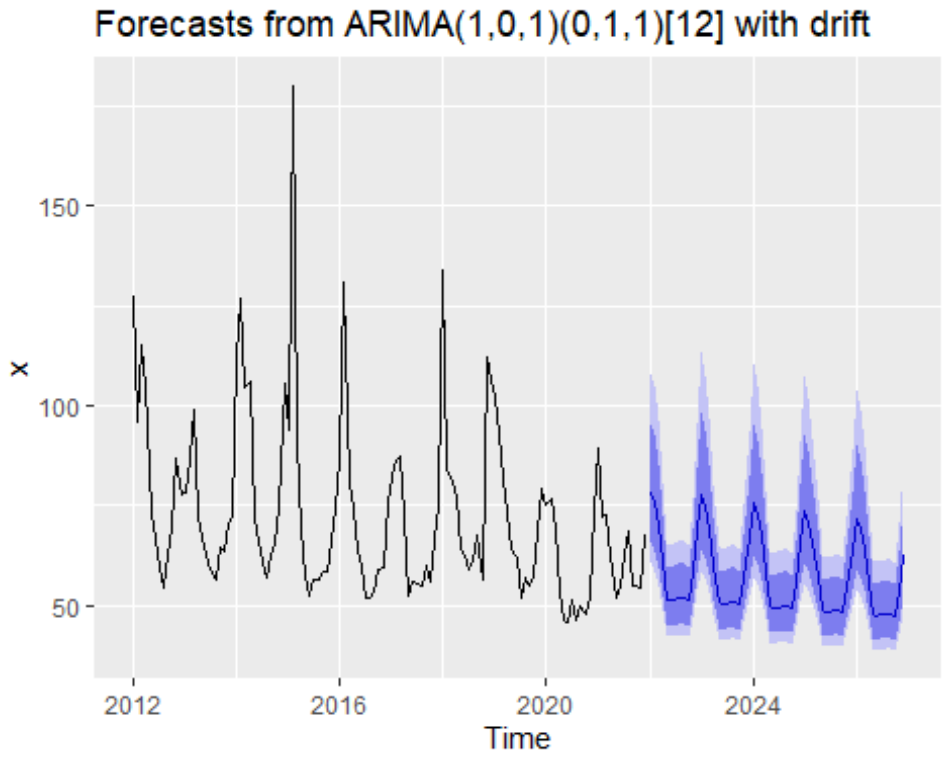



```
 Ljung-Box test

data:  Residuals from ARIMA(1,0,1)(0,1,1)[12] with drift
Q* = 18.749, df = 20, p-value = 0.5382

Model df: 4.   Total lags used: 24
```

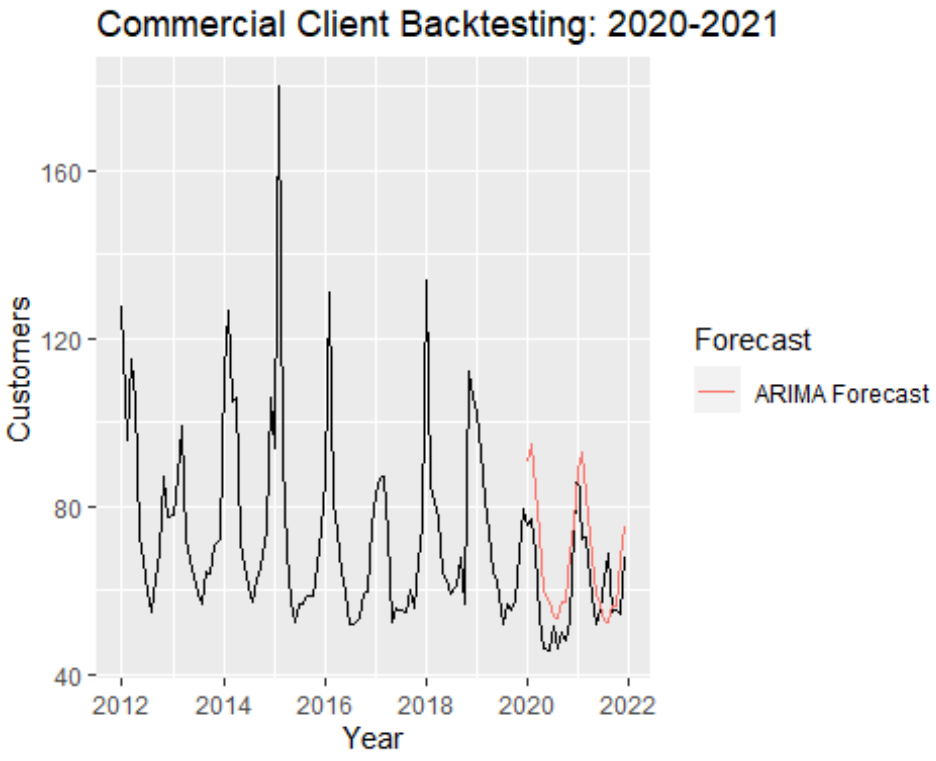


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (1,0,1)(0,1,1) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing



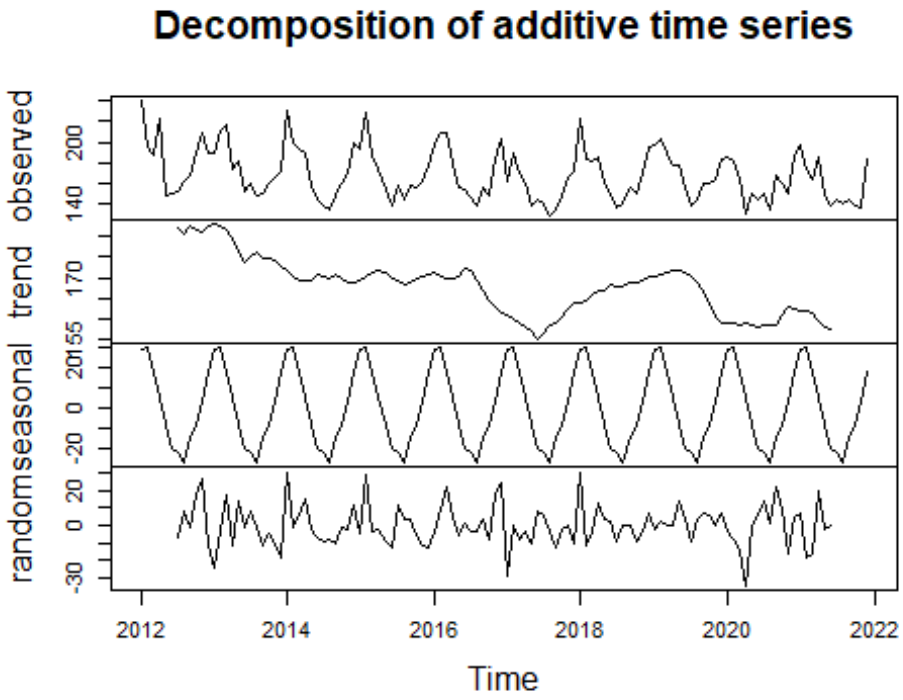
Test Results

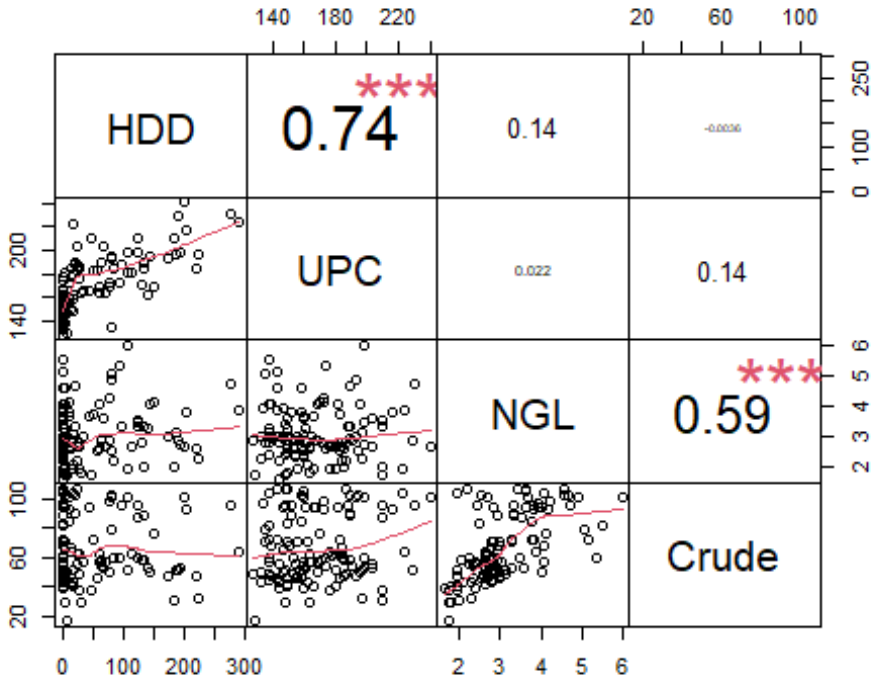
Below we see that the Backtested model does not perform very well. The likely cause for low accuracy is due to the COVID-19 pandemic.

```
[1] "24 Month Mean Absolute Error (MAE): 9.86"

[1] "24 Month Mean Accuracy: 83.35"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 75.21706       91          15.29     79.7
Feb 2020 76.79709       95          18.08     76.5
Mar 2020 69.11833       84          15.05     78.2
Apr 2020 53.36587       74          20.31     61.9
May 2020 46.18851       60          13.76     70.2
Jun 2020 45.55479       57          11.77     74.2
Jul 2020 51.40258       54           2.16     95.8
Aug 2020 46.27479       53           6.92     85.0
Sep 2020 49.88989       57           7.05     85.9
Oct 2020 47.75895       57           9.37     80.4
Nov 2020 52.58031       68          15.90     69.8
Dec 2020 73.75763       76           2.23     97.0
Jan 2021 89.28133       89           0.70     99.2
Feb 2021 72.06951       93          20.74     71.2
Mar 2021 72.62871       83           9.91     86.4
Apr 2021 62.48610       72           9.94     84.1
May 2021 51.87561       59           7.24     86.0
Jun 2021 55.05091       57           1.51     97.3
Jul 2021 62.27089       53           9.37     85.0
Aug 2021 68.79875       53          16.26     76.4
Sep 2021 54.84691       56           1.36     97.5
Oct 2021 55.03719       56           1.36     97.5
Nov 2021 54.23723       67          13.21     75.6
Dec 2021 67.64344       75           7.09     89.5
```

CFG Firm Transportation Services 2.1 (FTS-2.1)

Customer Time-Series Decomposition





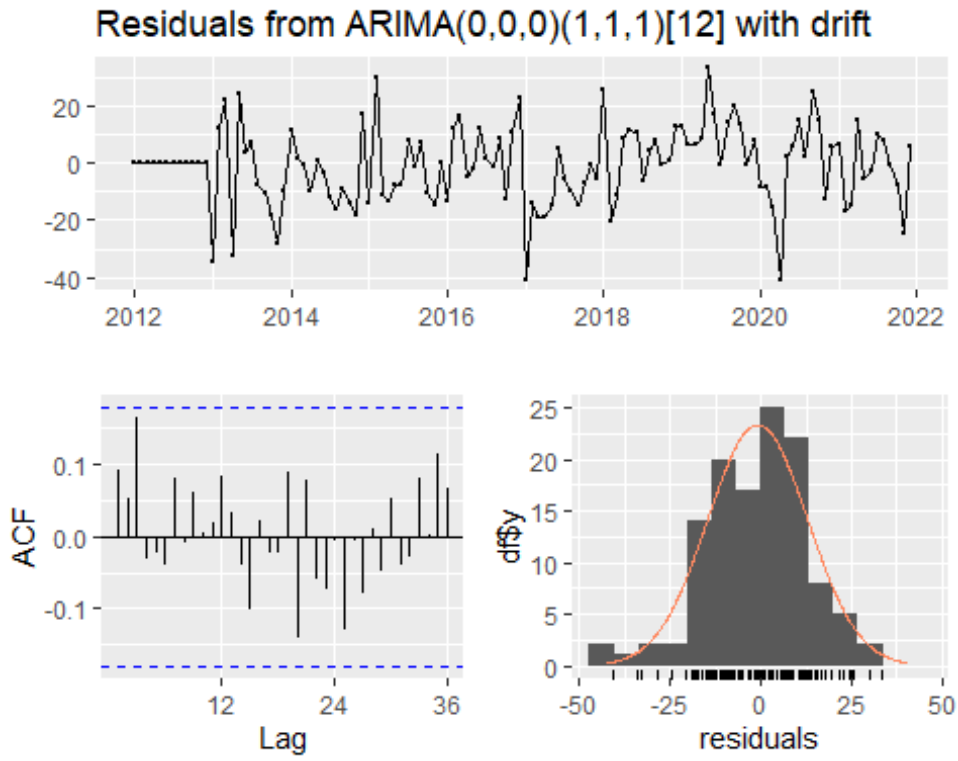
ARIMA Model: Expected Accuracy

		ME	RMSE	MAE
Forecast Horizon	1	0	18	13
Forecast Horizon	2	2	16	12
Forecast Horizon	3	2	16	13

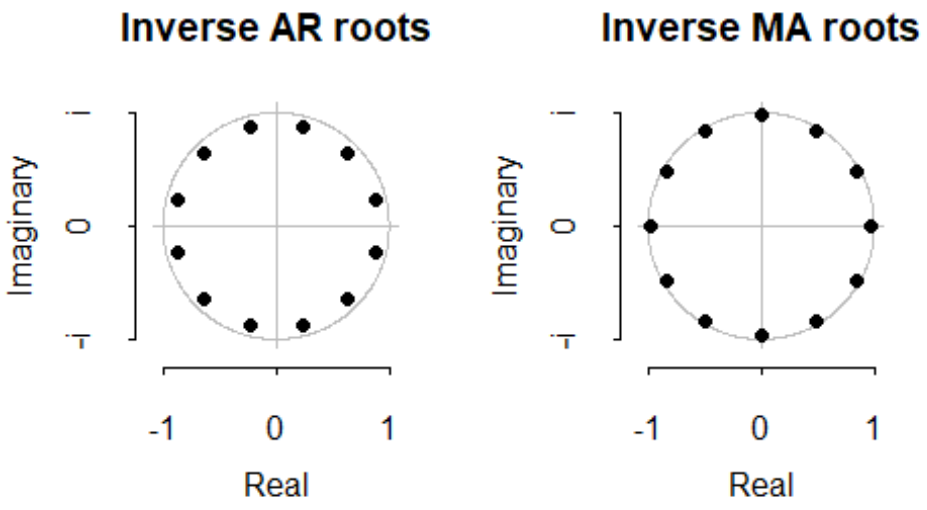
```
Forecast Horizon  4   1   19  15
Forecast Horizon  5   2   18  13
Forecast Horizon  6   1   18  14
Forecast Horizon  7   2   19  15
Forecast Horizon  8   2   19  15
Forecast Horizon  9   3   18  14
Forecast Horizon  10  5   18  13
Forecast Horizon  11  4   19  15
Forecast Horizon  12  4   19  16
Forecast Horizon  13  5   20  16
Forecast Horizon  14  4   19  15
Forecast Horizon  15  3   19  16
Forecast Horizon  16  4   19  15
Forecast Horizon  17  4   19  15
Forecast Horizon  18  2   18  14
Forecast Horizon  19  3   19  15
Forecast Horizon  20  3   19  15
Forecast Horizon  21  3   18  15
Forecast Horizon  22  3   19  15
Forecast Horizon  23  1   20  16
Forecast Horizon  24  2   20  16
```

ARIMA Model: Diagnostics

```
Series: x
ARIMA(0,0,0)(1,1,1)[12] with drift

Coefficients:
         sar1     sma1    drift
      -0.2980  -0.7156  -0.1839
s.e.   0.1315   0.1406   0.0386

sigma^2 estimated as 216.9:  log likelihood=-449.38
AIC=906.76   AICc=907.14   BIC=917.48

Training set error measures:
                     ME     RMSE      MAE        MPE     MAPE      MASE
Training set -0.8984894 13.77529 10.54294 -0.8951662 6.323403 0.6523965
                  ACF1
Training set 0.091708
```

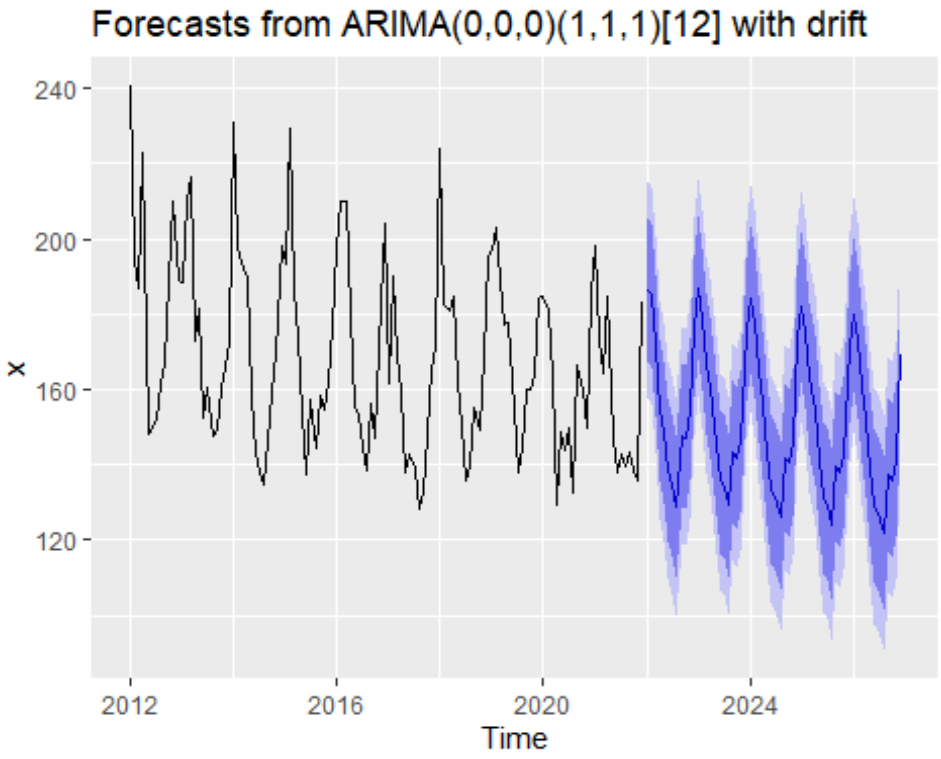



```
 Ljung-Box test

data:  Residuals from ARIMA(0,0,0)(1,1,1)[12] with drift
Q* = 15.931, df = 21, p-value = 0.7735

Model df: 3.   Total lags used: 24
```

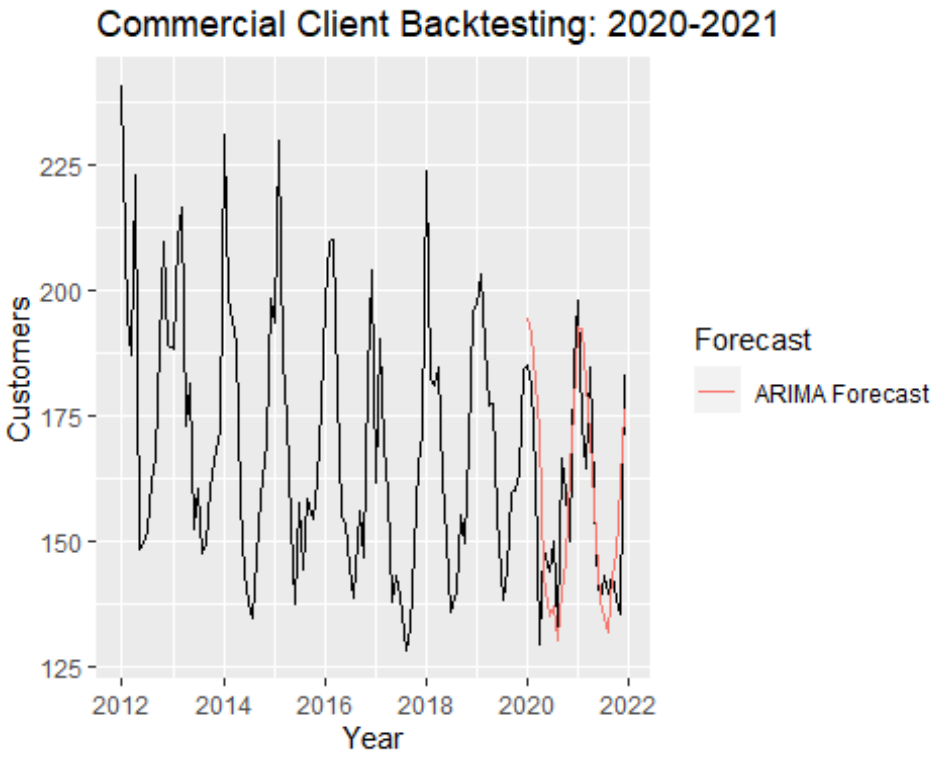


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (0,0,0)(1,1,1) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing



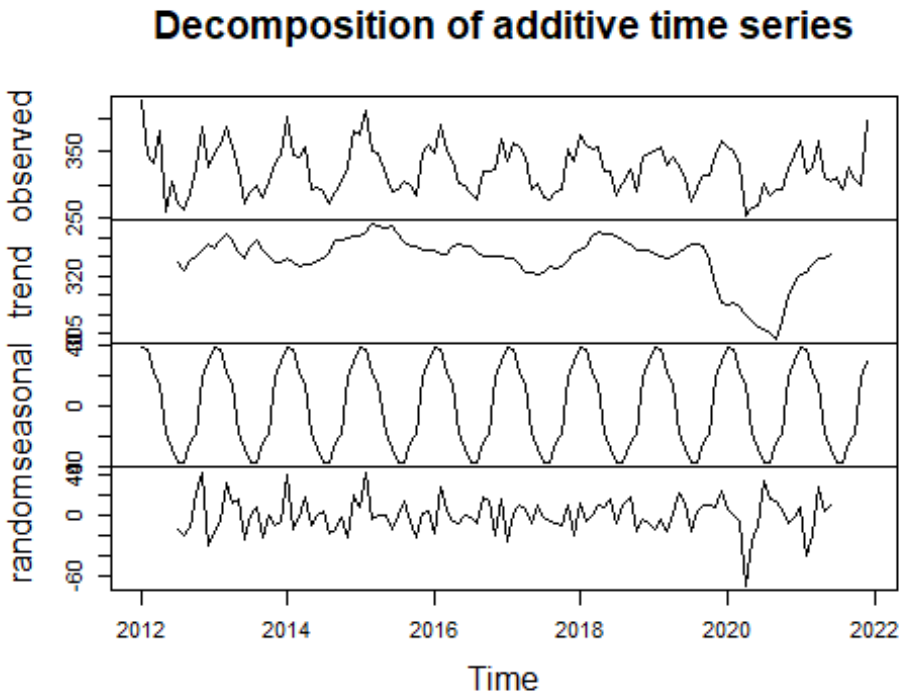
Test Results

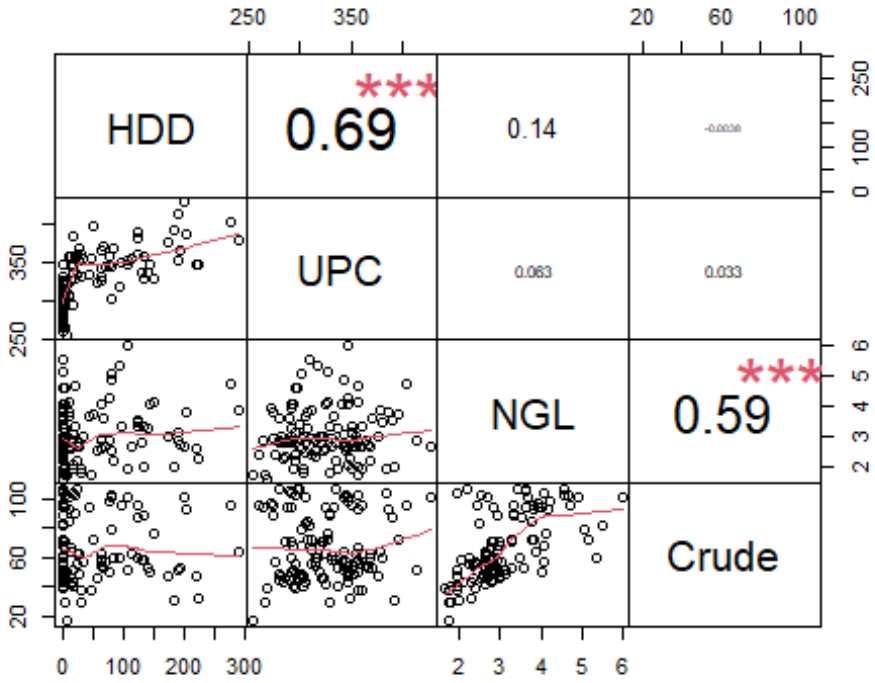
Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021.

```
[1] "24 Month Mean Absolute Error (MAE): 12.15"

[1] "24 Month Mean Accuracy: 92.1"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 184.9354      194           9.36     94.9
Feb 2020 180.8702      191          10.58     94.2
Mar 2020 163.6365      182          18.12     88.9
Apr 2020 129.3101      172          42.69     67.0
May 2020 148.6370      143           5.53     96.3
Jun 2020 144.0005      135           8.92     93.8
Jul 2020 150.0385      137          12.85     91.4
Aug 2020 132.6847      130           2.44     98.2
Sep 2020 166.5175      140          26.71     84.0
Oct 2020 159.7967      146          13.76     91.4
Nov 2020 149.8273      164          14.66     90.2
Dec 2020 185.0275      176           8.75     95.3
Jan 2021 197.9600      193           5.40     97.3
Feb 2021 173.4320      192          18.85     89.1
Mar 2021 164.2545      181          17.11     89.6
Apr 2021 184.5933      171          13.69     92.6
May 2021 147.0528      150           3.33     97.7
Jun 2021 137.8588      138           0.44     99.7
Jul 2021 143.0358      135           8.11     94.3
Aug 2021 139.4640      132           7.70     94.5
Sep 2021 143.4607      143           0.47     99.7
Oct 2021 138.5777      147           8.88     93.6
Nov 2021 135.6381      162          26.14     80.7
Dec 2021 183.0659      176           7.10     96.1
```

CFG Firm Transportation Services 3 (FTS-3)

Customer Time-Series Decomposition





ARIMA Model: Expected Accuracy

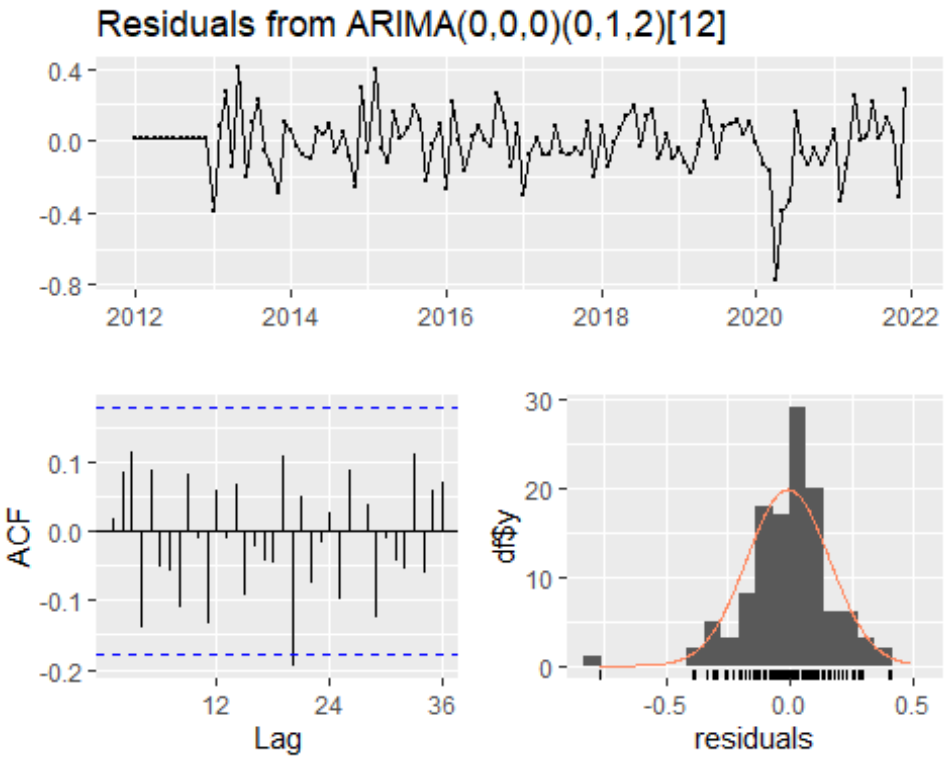
In this section we evaluate the expected accuracy of a Seasonal ARIMA Model using cross-validation. ARIMA is an acronym for 'Autoregressive Integrated Moving Average' which is a widely using Time-Series forecasting model that utilizes the recent values to predict outward.

```
                     ME RMSE MAE
Forecast Horizon  1  -1   20  16
Forecast Horizon  2   1   18  14
Forecast Horizon  3   2   16  12
Forecast Horizon  4  -1   22  15
Forecast Horizon  5  -4   24  16
Forecast Horizon  6  -4   25  18
Forecast Horizon  7  -4   25  18
Forecast Horizon  8  -4   26  20
Forecast Horizon  9  -4   25  18
Forecast Horizon  10 -3   25  18
Forecast Horizon  11 -3   25  18
Forecast Horizon  12 -5   25  19
Forecast Horizon  13 -4   27  20
Forecast Horizon  14 -5   28  20
Forecast Horizon  15 -4   27  19
Forecast Horizon  16 -4   27  20
Forecast Horizon  17 -5   28  21
Forecast Horizon  18 -6   27  20
Forecast Horizon  19 -6   28  21
Forecast Horizon  20 -6   28  20
Forecast Horizon  21 -7   28  20
Forecast Horizon  22 -6   27  20
Forecast Horizon  23 -6   28  20
Forecast Horizon  24 -6   28  21
```

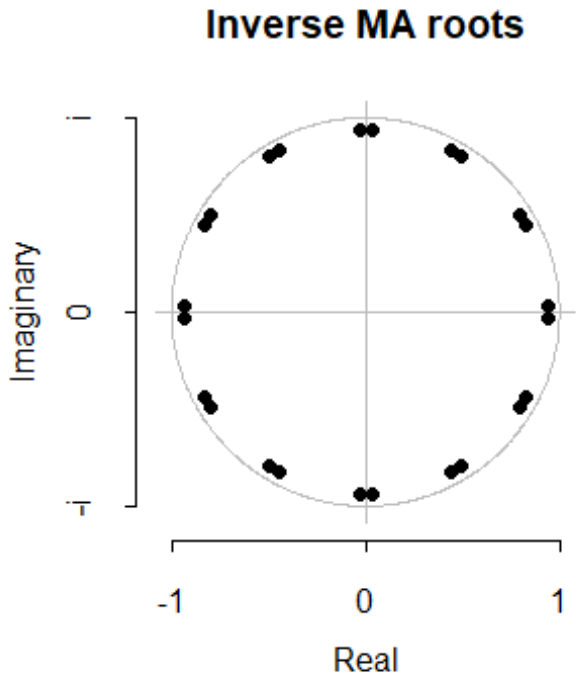
ARIMA Model: Diagnostics

In this section we evaluate the diagnostics of the ARIMA Model. Below we see that the model fails the Ljung-Box Test and therefore we can determine the data is independently distributed. In addition, we see from the graphs that the lagged values are not auto-correlated with one another, and the residuals are normally distributed.

```
Series: x
ARIMA(0,0,0)(0,1,2)[12]
Box Cox transformation: lambda= 0.1579887

Coefficients:
         sma1    sma2
      -0.8660  0.2177
s.e.   0.1138  0.1146

sigma^2 estimated as 0.03131:  log likelihood=30.02
AIC=-54.04   AICc=-53.81   BIC=-45.99

Training set error measures:
                     ME     RMSE      MAE         MPE     MAPE      MASE
Training set -1.125332 21.80423 15.74203 -0.5553668 4.875923 0.7166238
                    ACF1
Training set -0.0205863
```

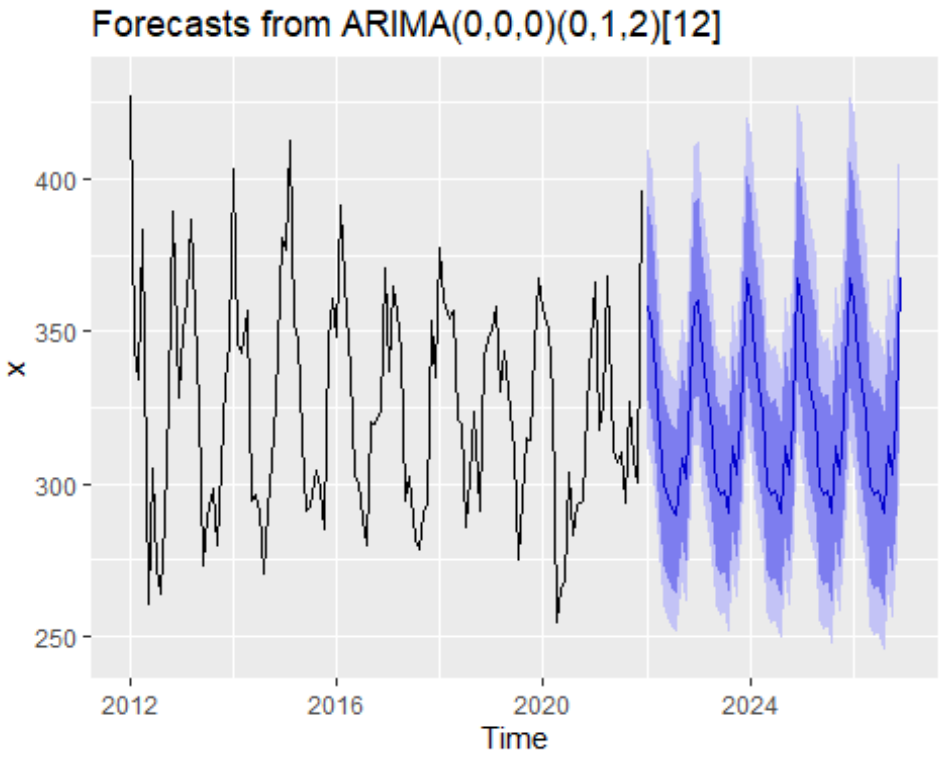



```
 Ljung-Box test

data:  Residuals from ARIMA(0,0,0)(0,1,2)[12]
Q* = 23.317, df = 22, p-value = 0.384

Model df: 2.   Total lags used: 24
```

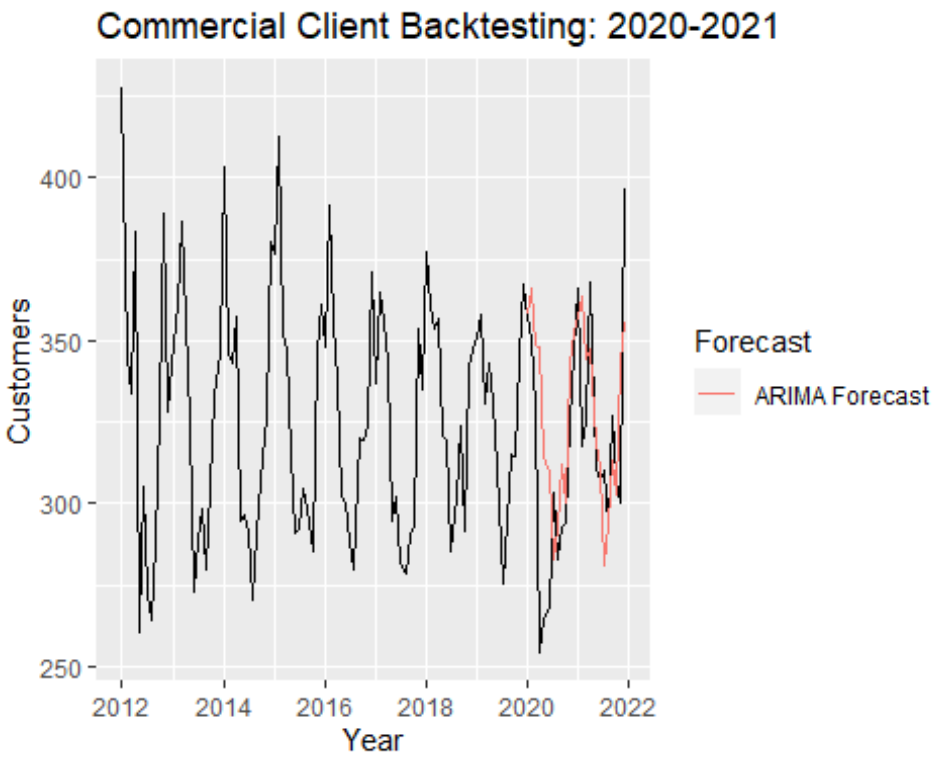


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (0,0,0)(0,1,2) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing

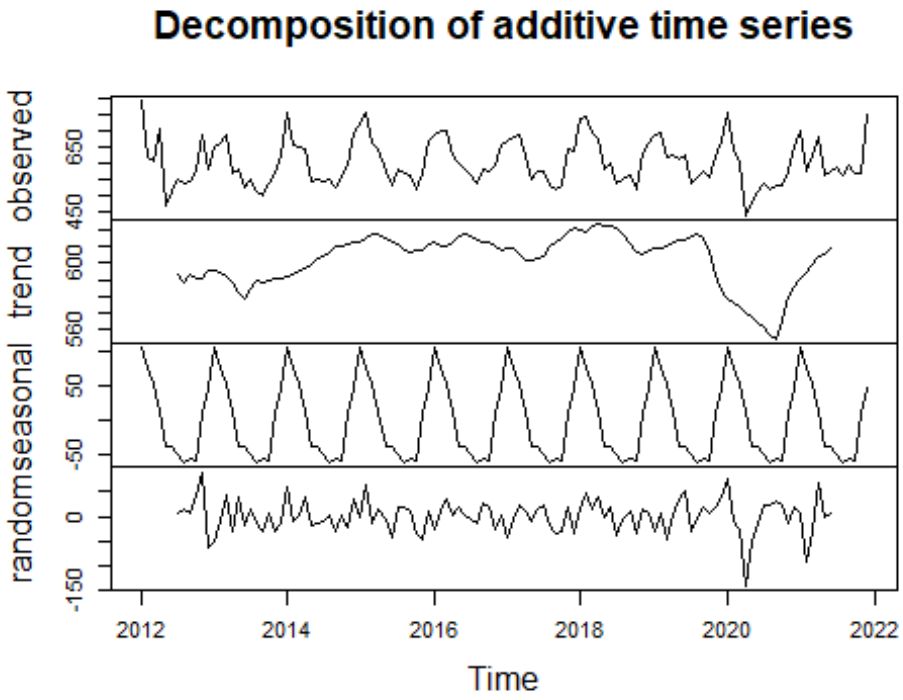


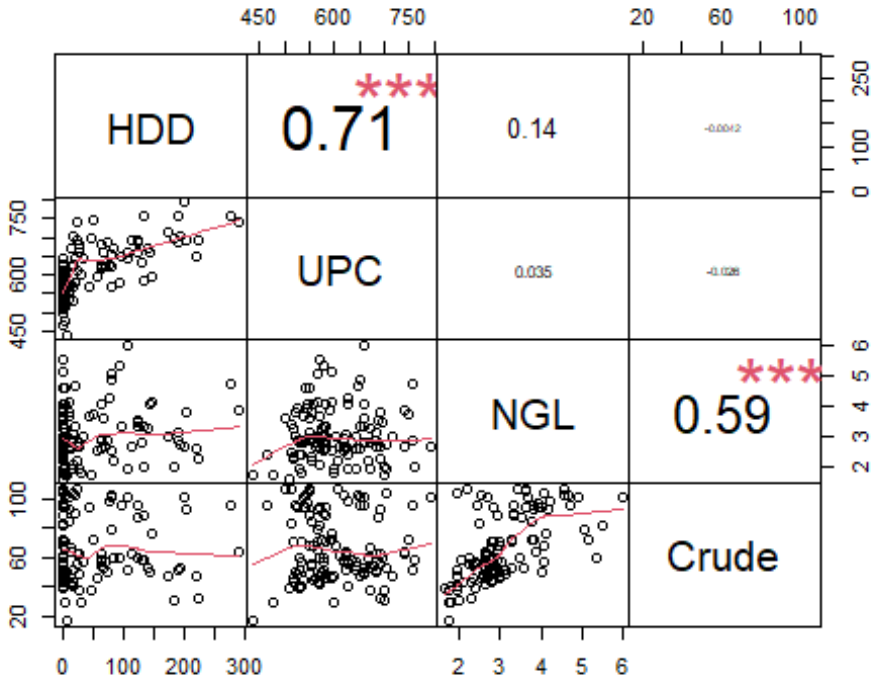
Test Results

```
[1] "24 Month Mean Absolute Error (MAE): 22.35"

[1] "24 Month Mean Accuracy: 92.54"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 357.2387      358           0.80     99.8
Feb 2020 350.5933      366          15.64     95.5
Mar 2020 329.5892      349          19.13     94.2
Apr 2020 254.3217      348          93.44     63.3
May 2020 265.1815      314          49.26     81.4
Jun 2020 268.1213      310          41.44     84.5
Jul 2020 303.5993      283          20.73     93.2
Aug 2020 282.8235      292           9.19     96.8
Sep 2020 293.0900      312          18.74     93.6
Oct 2020 294.2695      300           5.69     98.1
Nov 2020 325.1166      343          17.91     94.5
Dec 2020 346.0596      353           6.48     98.1
Jan 2021 366.1266      357           8.98     97.5
Feb 2021 317.5337      363          45.79     85.6
Mar 2021 325.6924      344          18.56     94.3
Apr 2021 368.1631      347          20.93     94.3
May 2021 310.9012      319           8.26     97.3
Jun 2021 306.9670      311           3.85     98.7
Jul 2021 310.3999      281          29.50     90.5
Aug 2021 293.4862      293           0.02    100.0
Sep 2021 326.7397      314          13.20     96.0
Oct 2021 307.9847      303           5.09     98.3
Nov 2021 300.3937      344          43.27     85.6
Dec 2021 396.1482      356          40.60     89.8
```

CFG Firm Transportation Services 3.1 (FTS-3.1)

Customer Time-Series Decomposition





ARIMA Model: Expected Accuracy

In this section we evaluate the expected accuracy of a Seasonal ARIMA Model using cross-validation. ARIMA is an acronym for 'Autoregressive Integrated Moving Average' which is a widely using Time-Series forecasting model that utilizes the recent values to predict outward.

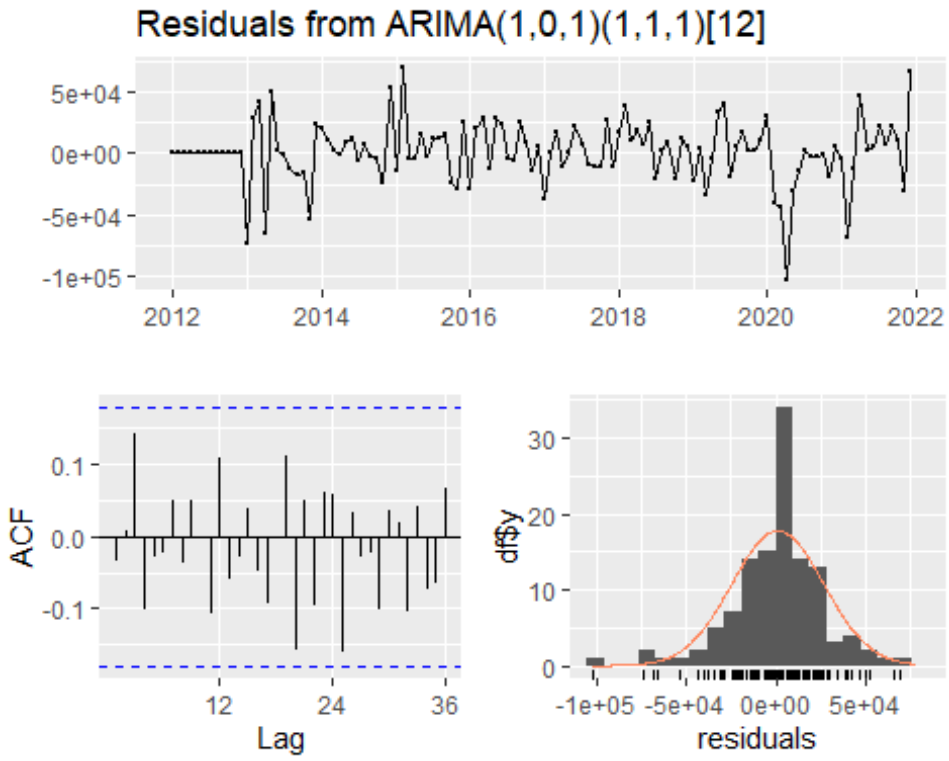
Here we evaluate model accuracy by using cross-validation and rolling forecasts throughout the time-series to determine our expected accuracy over a 24 Month period.

```
                      ME RMSE MAE
Forecast Horizon  1    2   35  29
Forecast Horizon  2    2   35  29
Forecast Horizon  3    1   34  28
Forecast Horizon  4   -5   49  35
Forecast Horizon  5   -7   51  37
Forecast Horizon  6  -10   52  39
Forecast Horizon  7  -12   52  38
Forecast Horizon  8  -12   54  42
Forecast Horizon  9  -13   53  39
Forecast Horizon  10 -11   53  39
Forecast Horizon  11 -11   53  40
Forecast Horizon  12 -13   52  38
Forecast Horizon  13 -11   51  35
Forecast Horizon  14 -16   54  37
Forecast Horizon  15 -19   55  38
Forecast Horizon  16 -18   56  39
Forecast Horizon  17 -21   58  40
Forecast Horizon  18 -22   59  41
Forecast Horizon  19 -22   58  39
Forecast Horizon  20 -20   60  42
Forecast Horizon  21 -21   61  42
Forecast Horizon  22 -20   62  44
Forecast Horizon  23 -19   62  43
Forecast Horizon  24 -18   63  46
```

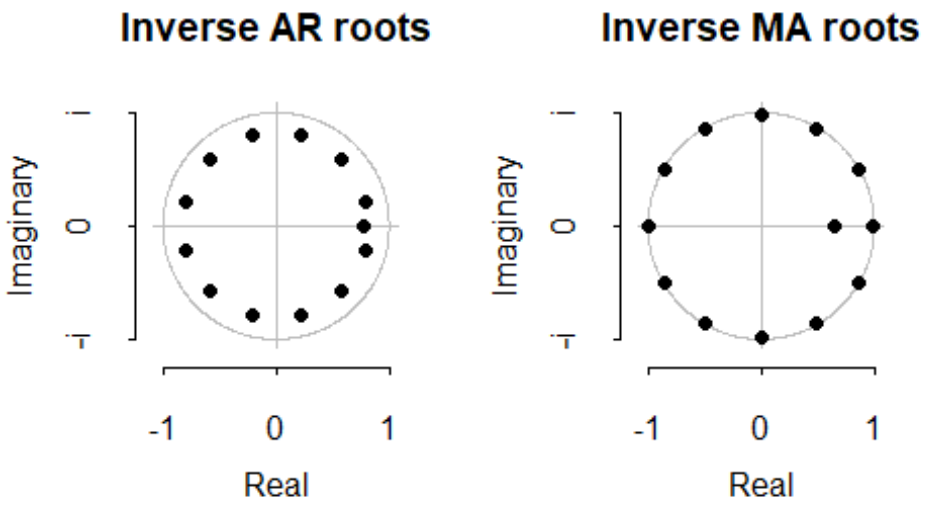
ARIMA Model: Diagnostics

In this section we evaluate the diagnostics of the ARIMA Model. Below we see that the model fails the Ljung-Box Test and therefore we can determine the data is independently distributed. In addition, we see from the graphs that the lagged values are not auto-correlated with one another, and the residuals are normally distributed.

```
Series: x
ARIMA(1,0,1)(1,1,1)[12]
Box Cox transformation: lambda= 1.999927

Coefficients:
         ar1      ma1     sar1     sma1
      0.7658  -0.6503  -0.0942  -0.8469
s.e.  0.2645   0.3064   0.1649   0.2497

sigma^2 estimated as 752712066:  log likelihood=-1263.24
AIC=2536.48   AICc=2537.07   BIC=2549.89

Training set error measures:
                    ME     RMSE      MAE         MPE     MAPE      MASE
Training set 1.079514 41.55689 28.77267 -0.1508344 4.817785 0.6611755
                     ACF1
Training set 0.004183769
```

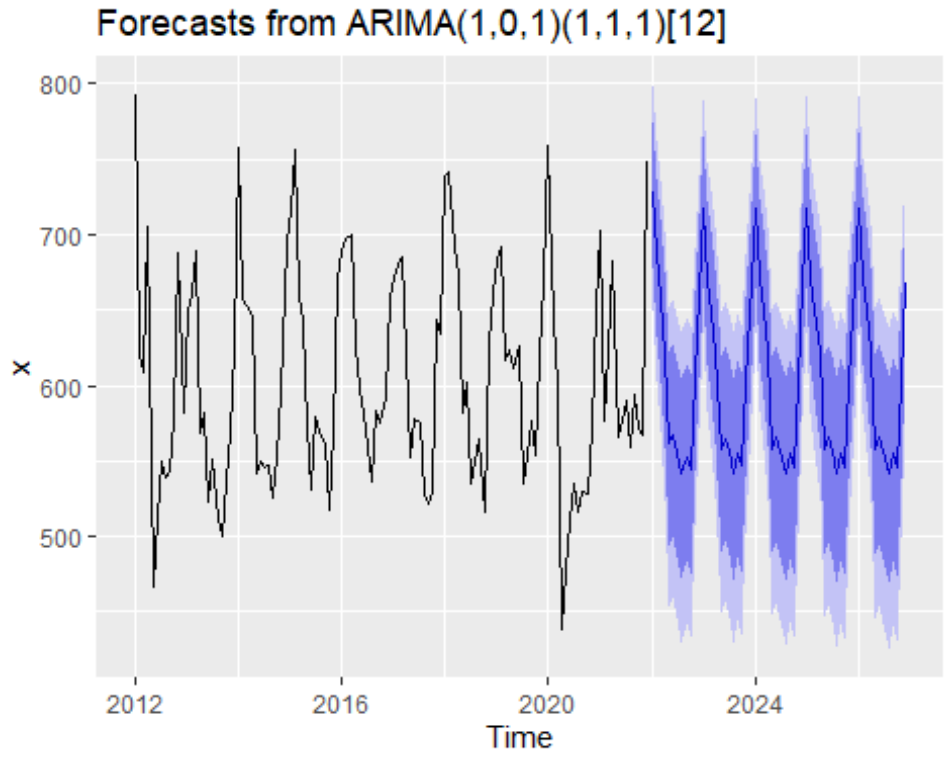



```
 Ljung-Box test

data:  Residuals from ARIMA(1,0,1)(1,1,1)[12]
Q* = 18.786, df = 20, p-value = 0.5358

Model df: 4.   Total lags used: 24
```

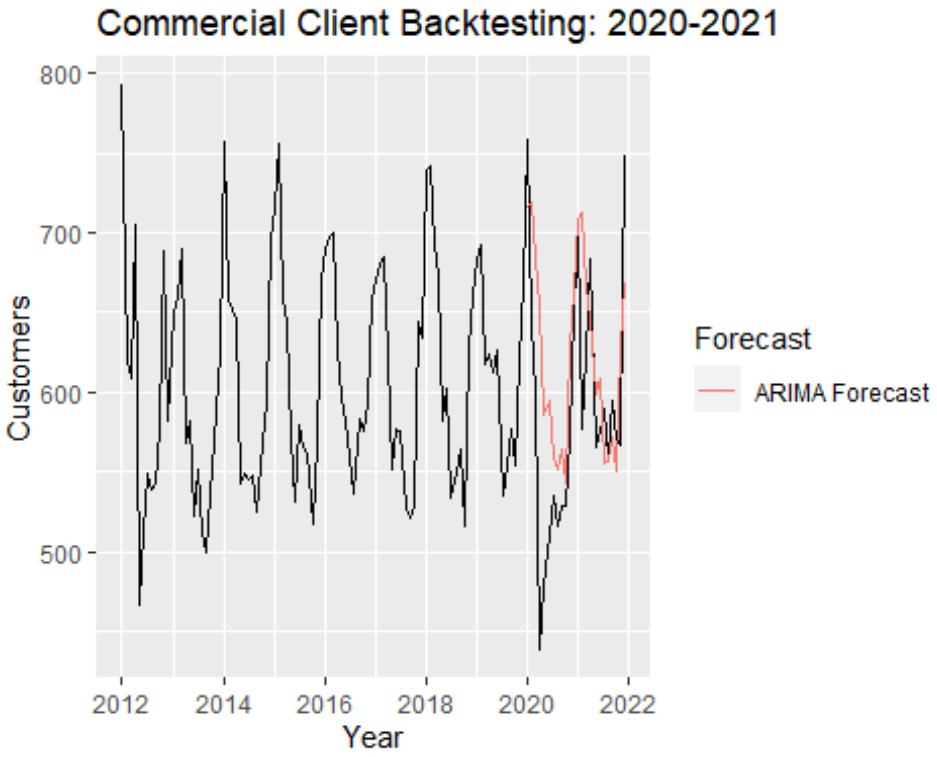


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (1,0,1)(1,1,1) model. This model only uses 1 difference,1 Seasonal Moving Average, 1 Seasonal Difference, and is expected to be extremely accurate as previously shown. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



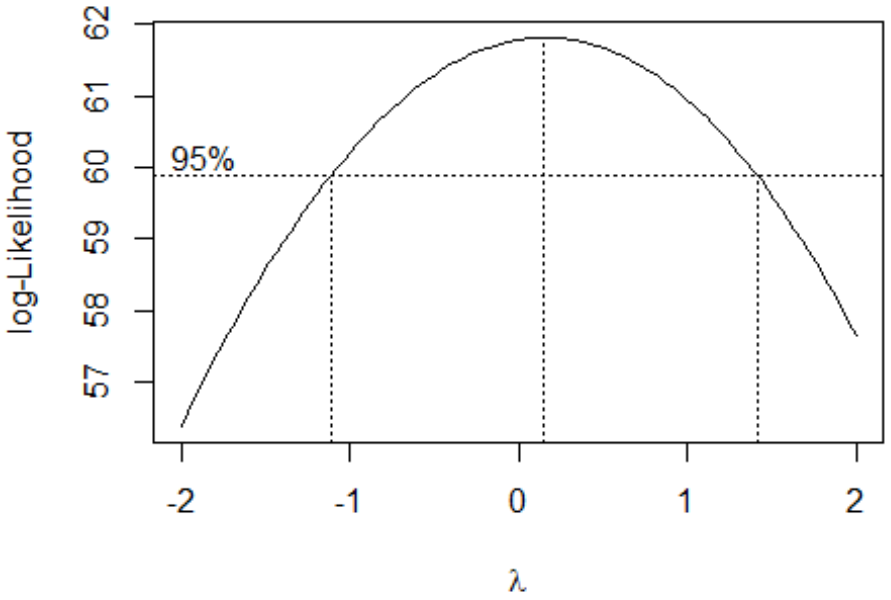
Back-Testing



Test Results

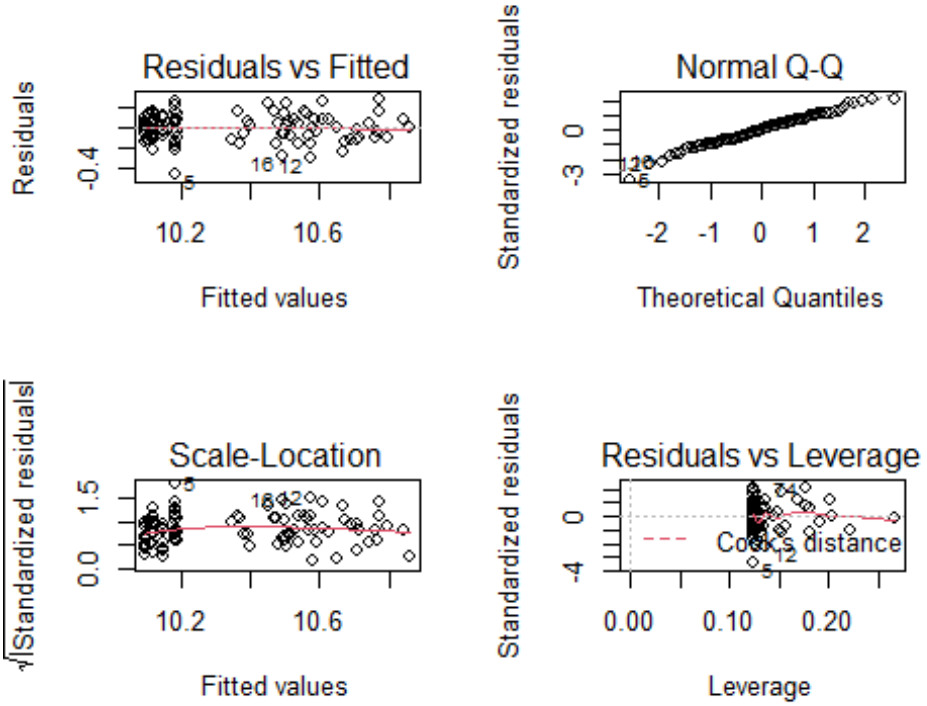
Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021. Below we see that the MLR Model slightly outperforms our ARIMA model. However, we have chosen the ARIMA Model to forecast in order to reduce bias.

```
[1] "24 Month Mean Absolute Error (MAE): 53.99"

[1] "24 Month Mean Accuracy: 90.2"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 758.7760      717          41.77     94.5
Feb 2020 643.3735      718          75.05     88.3
Mar 2020 600.2289      685          84.92     85.9
Apr 2020 438.8201      653         214.21     51.2
May 2020 477.5222      586         108.07     77.4
Jun 2020 510.9879      595          84.27     83.5
Jul 2020 534.7259      559          24.54     95.4
Aug 2020 516.4768      552          35.79     93.1
Sep 2020 529.1251      564          34.91     93.4
Oct 2020 528.6099      543          13.90     97.4
Nov 2020 572.2167      628          56.26     90.2
Dec 2020 651.6680      663          11.00     98.3
Jan 2021 702.4959      709           6.61     99.1
Feb 2021 576.7601      713         136.03     76.4
Mar 2021 622.7690      666          43.62     93.0
Apr 2021 683.0183      647          36.46     94.7
May 2021 565.2633      598          32.72     94.2
Jun 2021 576.1918      609          32.90     94.3
Jul 2021 589.3725      555          34.50     94.1
Aug 2021 559.3486      557           2.84     99.5
Sep 2021 594.4582      572          22.38     96.2
Oct 2021 570.9517      550          20.75     96.4
Nov 2021 567.2088      629          61.65     89.1
Dec 2021 748.3889      668          80.61     89.2

[1] "train_data<-zzz[1:96,]\ntest_data<-zzz[85:120,]\ntest_data$HDD<-hdd_avg[97:120]\n"
```




```
[1] 0.14


Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Coefficients:
(Intercept)          HDD       month2       month3       month4       month5
 10.5779207    0.0009675    0.0099685   -0.0629082   -0.0942243   -0.3921382
     month6       month7       month8       month9      month10      month11
 -0.3901263   -0.4259153   -0.4795503   -0.4570130   -0.4742162   -0.2467709
    month12
 -0.1333771


Call:
lm(formula = ((UPC^lambda - 1)/lambda) ~ HDD + month, data = train_data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.44435 -0.08733  0.00439  0.08801  0.27156

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 10.5779207  0.0991352 106.702  < 2e-16 ***
HDD          0.0009675  0.0004313   2.243 0.027560 *
month2       0.0099685  0.0824942   0.121 0.904111
month3      -0.0629082  0.0872712  -0.721 0.473036
month4      -0.0942243  0.1064947  -0.885 0.378832
month5      -0.3921382  0.1101593  -3.560 0.000617 ***
month6      -0.3901263  0.1110074  -3.514 0.000717 ***
month7      -0.4259153  0.1110074  -3.837 0.000242 ***
```

```
month8      -0.4795503  0.1110074  -4.320 4.30e-05 ***
month9      -0.4570130  0.1110074  -4.117 9.02e-05 ***
month10     -0.4742162  0.1080396  -4.389 3.32e-05 ***
month11     -0.2467709  0.0898915  -2.745 0.007411 **
month12     -0.1333771  0.0827996  -1.611 0.111011
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1413 on 83 degrees of freedom
Multiple R-squared:  0.767,  Adjusted R-squared:  0.7333
F-statistic: 22.77 on 12 and 83 DF,  p-value: < 2.2e-16
```



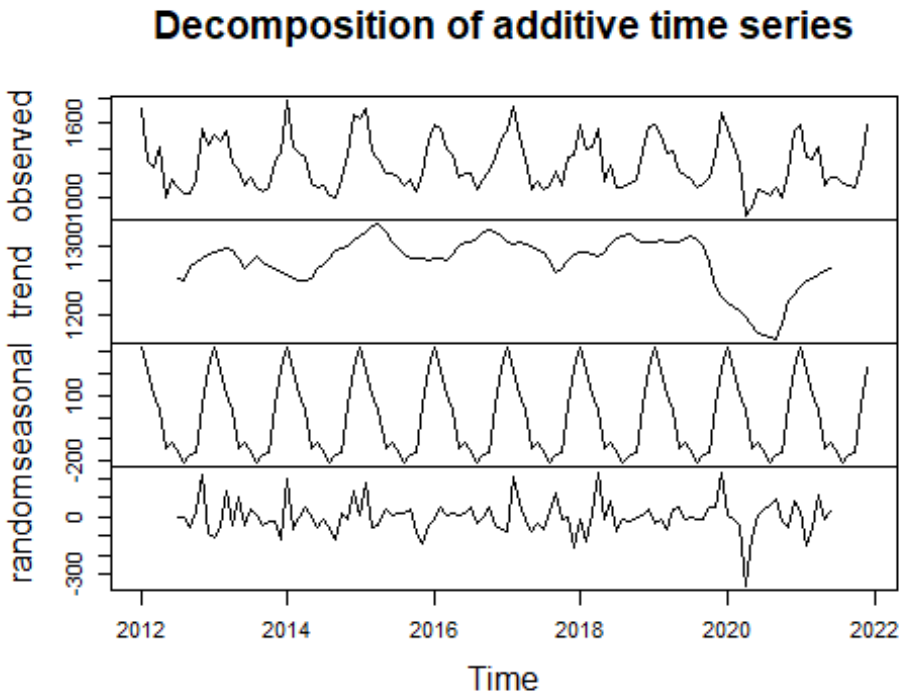

```
[1] "24 Month Mean Absolute Error (MAE): 45.34"

[1] "24 Month Accuracy: 0.92"
```

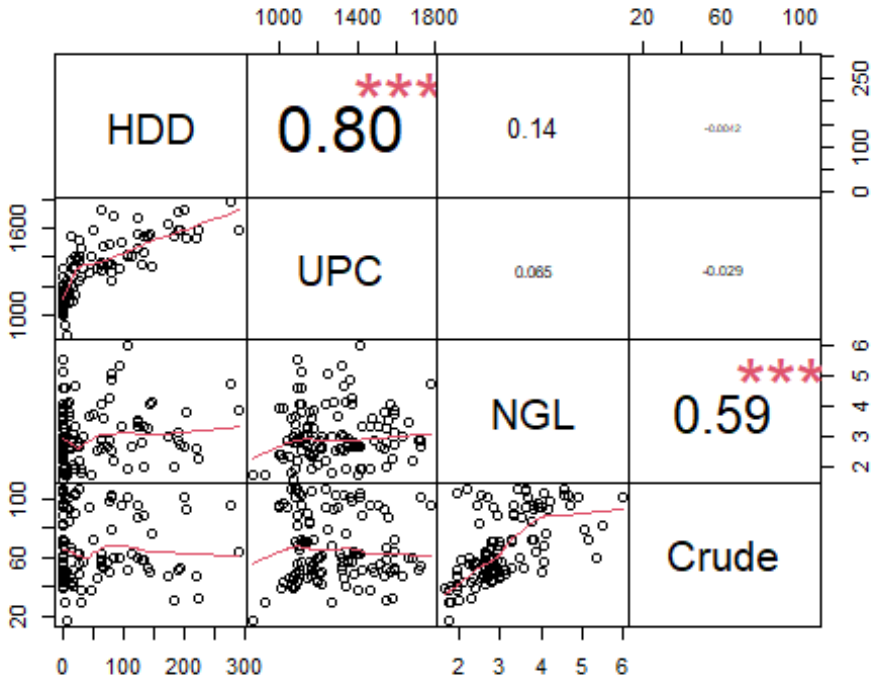
	Date	Actual.UPC	Predicted.UPC	Absolute.Error	Accuracy
97	Aug 2019	758.78	701.71	57.07	0.92
98	Sep 2019	643.37	688.58	45.21	0.93
99	Oct 2019	600.23	658.80	58.57	0.90
100	Nov 2019	438.82	638.23	199.41	0.55
101	Dec 2019	477.52	561.80	84.28	0.82
102	Jan 2020	510.99	561.81	50.83	0.90
103	Feb 2020	534.73	553.58	18.85	0.96
104	Mar 2020	516.48	541.43	24.96	0.95
105	Apr 2020	529.13	546.51	17.38	0.97
106	May 2020	528.61	544.61	16.00	0.97
107	Jun 2020	572.22	609.53	37.31	0.93
108	Jul 2020	651.67	651.74	0.07	1.00
109	Aug 2020	702.50	701.71	0.79	1.00
110	Sep 2020	576.76	688.58	111.82	0.81
111	Oct 2020	622.77	658.80	36.03	0.94
112	Nov 2020	683.02	638.23	44.79	0.93

113	Dec 2020	565.26	561.80	3.46	0.99
114	Jan 2021	576.19	561.81	14.38	0.98
115	Feb 2021	589.37	553.58	35.79	0.94
116	Mar 2021	559.35	541.43	17.92	0.97
117	Apr 2021	594.46	546.51	47.95	0.92
118	May 2021	570.95	544.61	26.34	0.95
119	Jun 2021	567.21	609.53	42.32	0.93
120	Jul 2021	748.39	651.74	96.65	0.87

CFG Firm Transportation Services 4 (FTS-4)

Customer Time-Series Decomposition





ARIMA Model: Expected Accuracy

In this section we evaluate the expected accuracy of a Seasonal ARIMA Model using cross-validation. ARIMA is an acronym for 'Autoregressive Integrated Moving Average' which is a widely using Time-Series forecasting model that utilizes the recent values to predict outward.

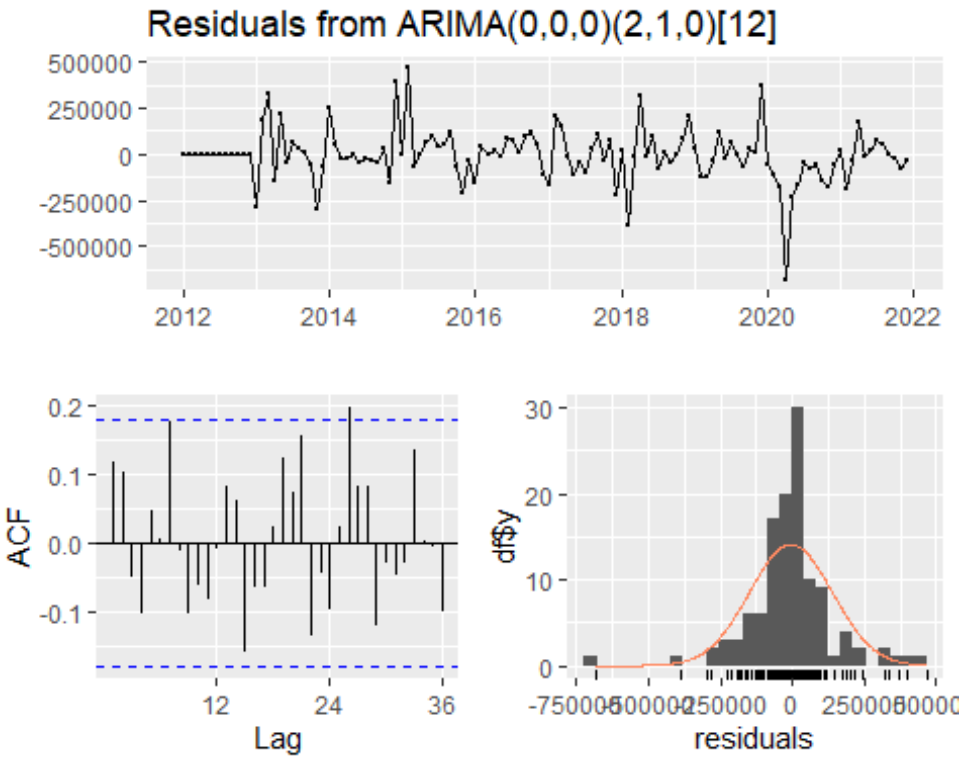
Here we evaluate model accuracy by using cross-validation and rolling forecasts throughout the time-series to determine our expected accuracy over a 24 Month period.

```
                      ME RMSE MAE
Forecast Horizon  1    1   94  72
Forecast Horizon  2    0   94  72
Forecast Horizon  3    0   93  70
Forecast Horizon  4  -18  128  83
Forecast Horizon  5  -25  143  91
Forecast Horizon  6  -26  143  91
Forecast Horizon  7  -26  145  93
Forecast Horizon  8  -26  144  91
Forecast Horizon  9  -27  144  92
Forecast Horizon  10 -30  145  92
Forecast Horizon  11 -33  148  98
Forecast Horizon  12 -37  148  97
Forecast Horizon  13 -34  149  96
Forecast Horizon  14 -41  153 102
Forecast Horizon  15 -32  147  95
Forecast Horizon  16 -34  148  96
Forecast Horizon  17 -43  145  93
Forecast Horizon  18 -45  144  92
Forecast Horizon  19 -44  145  93
Forecast Horizon  20 -41  143  89
Forecast Horizon  21 -41  144  91
Forecast Horizon  22 -40  143  89
Forecast Horizon  23 -44  144  92
Forecast Horizon  24 -45  145  93
```

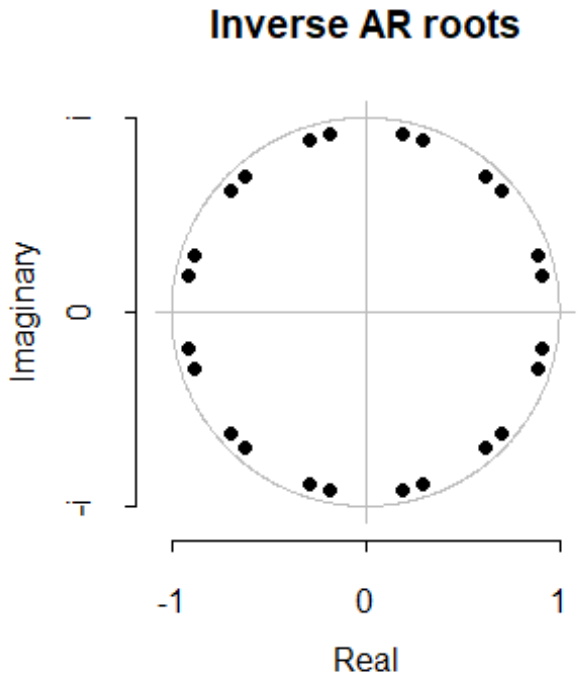
ARIMA Model: Diagnostics

In this section we evaluate the diagnostics of the ARIMA Model. Below we see that the model fails the Ljung-Box Test and therefore we can determine the data is independently distributed. In addition, we see from the graphs that the lagged values are not auto-correlated with one another, and the residuals are normally distributed.

```
Series: x
ARIMA(0,0,0)(2,1,0)[12]
Box Cox transformation: lambda= 1.999927

Coefficients:
         sar1     sar2
      -0.6737  -0.1896
s.e.   0.0977   0.1101

sigma^2 estimated as 2.333e+10:  log likelihood=-1444.14
AIC=2894.28   AICc=2894.51   BIC=2902.33

Training set error measures:
                     ME    RMSE      MAE         MPE     MAPE      MASE      ACF1
Training set -6.167554 107.182 70.08685 -0.9842833 5.573475 0.6835392 0.1803864
```

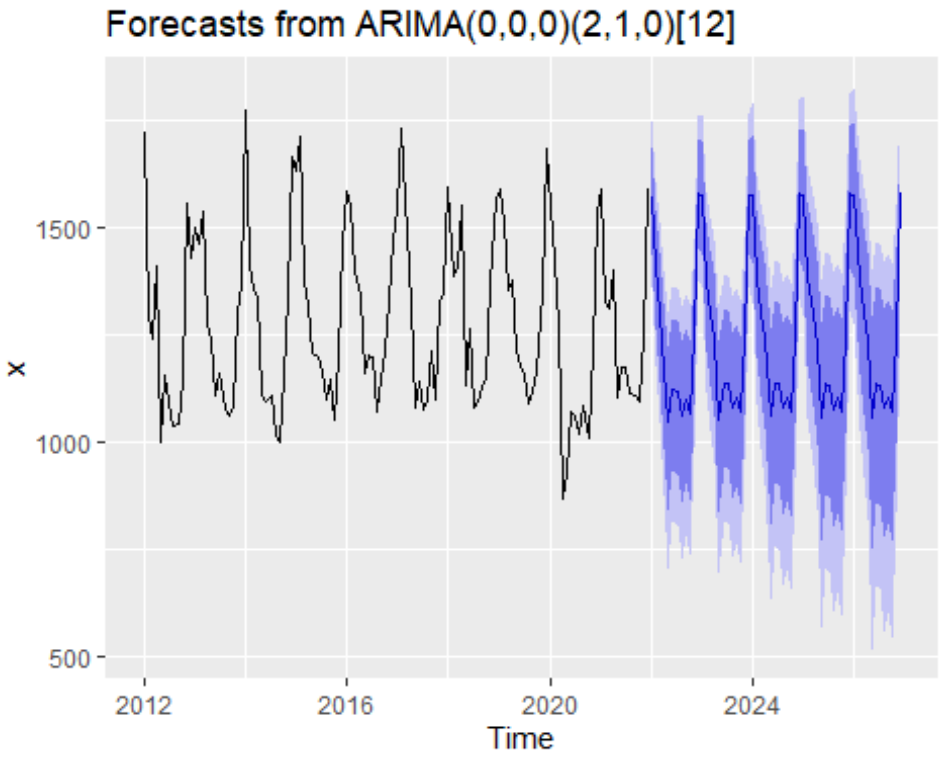



```
 Ljung-Box test

data:  Residuals from ARIMA(0,0,0)(2,1,0)[12]
Q* = 28.927, df = 22, p-value = 0.1469

Model df: 2.   Total lags used: 24
```

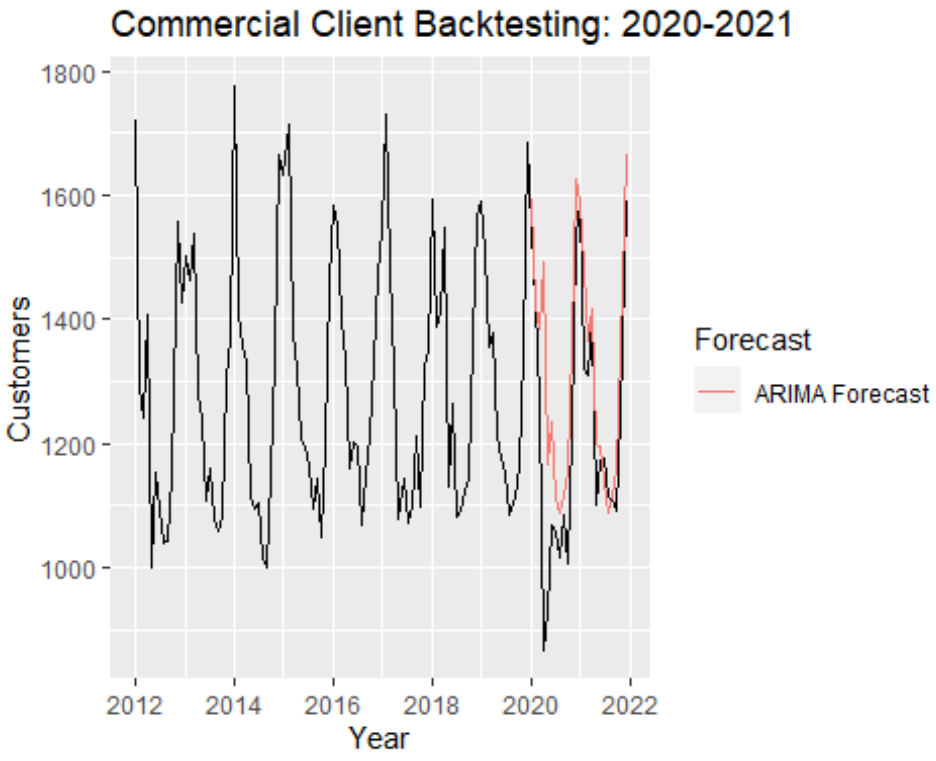


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (0,0,0)(2,1,0) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing



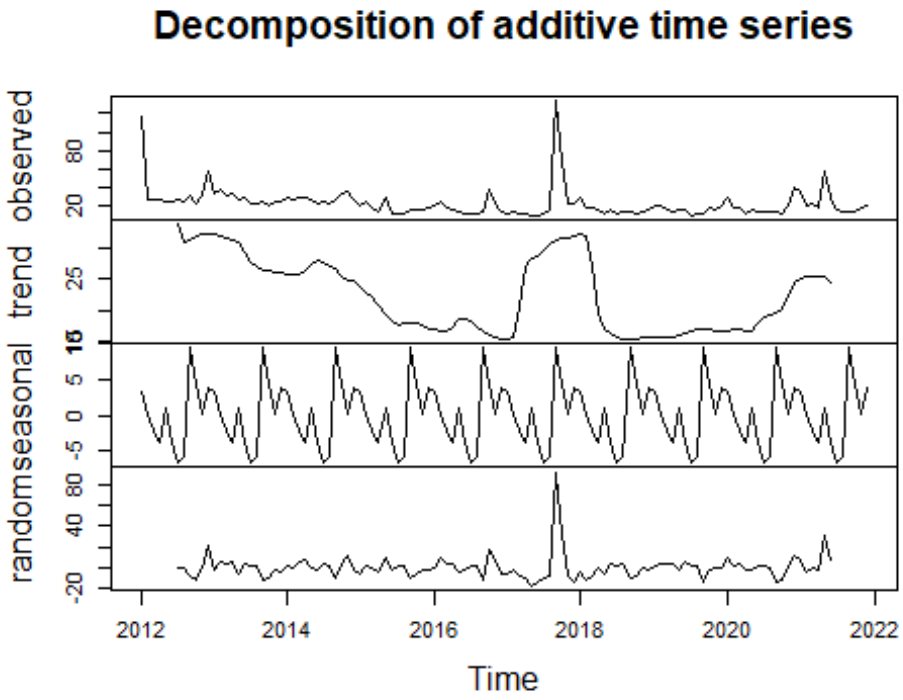
Test Results

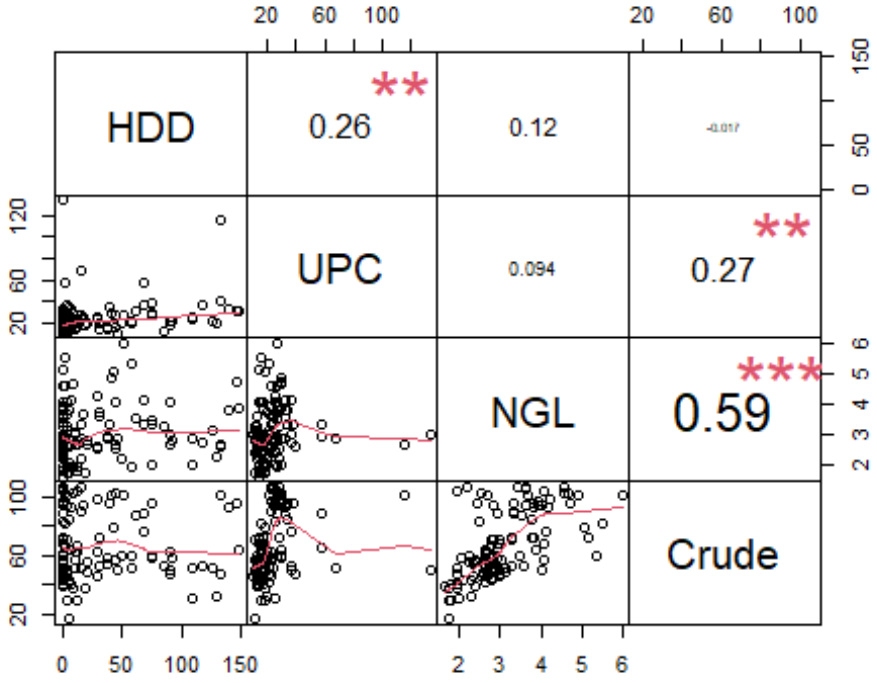
Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021.

```
[1] "24 Month Mean Absolute Error (MAE): 100.16"

[1] "24 Month Mean Accuracy: 90.57"

            Actual Forecast Absolute_Error Accuracy
Jan 2020 1545.2199     1594          48.54     96.9
Feb 2020 1424.4107     1422           2.39     99.8
Mar 2020 1272.1744     1384         112.28     91.2
Apr 2020  866.9262     1492         625.04     27.9
May 2020  930.2424     1168         237.70     74.4
Jun 2020 1067.9327     1234         166.40     84.4
Jul 2020 1060.5911     1112          51.43     95.2
Aug 2020 1016.2394     1090          73.49     92.8
Sep 2020 1084.8909     1116          31.16     97.1
Oct 2020 1008.0936     1155         146.66     85.5
Nov 2020 1216.0861     1362         145.86     88.0
Dec 2020 1533.2362     1626          92.87     93.9
Jan 2021 1590.8676     1591           0.42    100.0
Feb 2021 1324.2394     1482         157.43     88.1
Mar 2021 1310.0760     1364          54.25     95.9
Apr 2021 1401.9377     1418          16.01     98.9
May 2021 1101.3030     1199          97.64     91.1
Jun 2021 1172.5551     1197          24.03     98.0
Jul 2021 1175.2190     1140          35.28     97.0
Aug 2021 1113.5756     1088          25.90     97.7
Sep 2021 1109.8959     1115           4.85     99.6
Oct 2021 1091.1894     1161          70.08     93.6
Nov 2021 1244.6461     1352         107.12     91.4
Dec 2021 1589.4880     1666          76.93     95.2
```

Commercial Standby Generator Service (CS-GS)

Customer Time-Series Decomposition





ARIMA Model: Expected Accuracy

In this section we evaluate the expected accuracy of a Seasonal ARIMA Model using cross-validation. ARIMA is an acronym for 'Autoregressive Integrated Moving Average' which is a widely using Time-Series forecasting model that utilizes the recent values to predict outward.

Here we evaluate model accuracy by using cross-validation and rolling forecasts throughout the time-series to determine our expected accuracy over a 24 Month period.

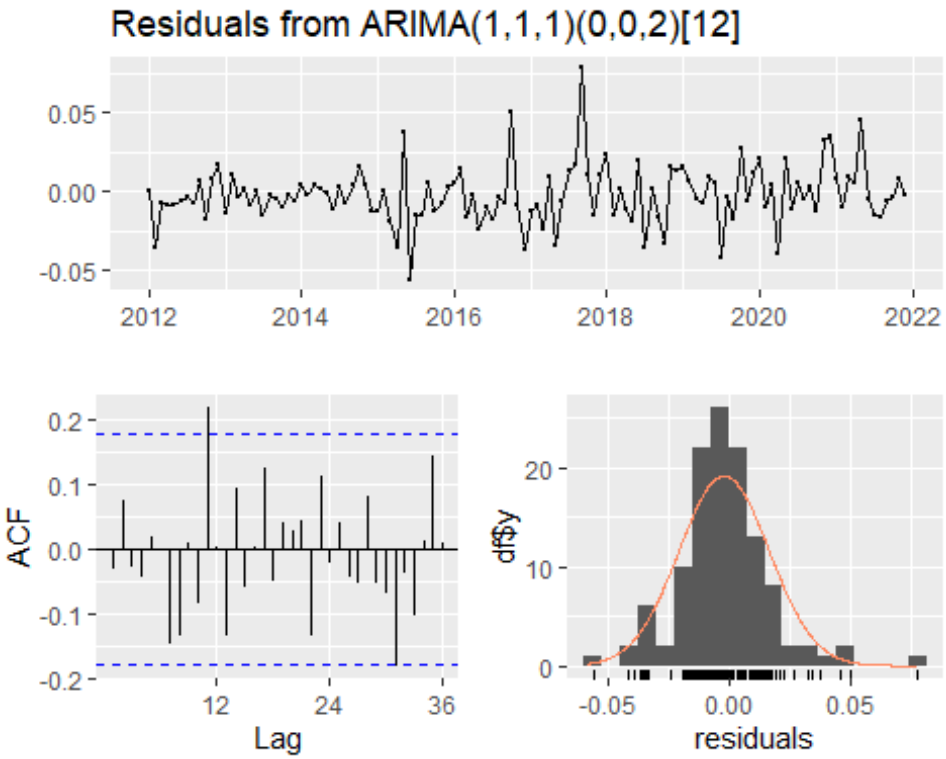
```
                     ME RMSE MAE
Forecast Horizon  1   0   20   8
Forecast Horizon  2   0   23  11
Forecast Horizon  3   0   23  10
Forecast Horizon  4   0   23  10
Forecast Horizon  5   1   23  11
Forecast Horizon  6   1   22  11
Forecast Horizon  7   1   22  11
Forecast Horizon  8   1   22  11
Forecast Horizon  9   1   23  11
Forecast Horizon  10 -3   12   8
Forecast Horizon  11 -4    7   6
Forecast Horizon  12 -3    8   6
Forecast Horizon  13 -3    8   7
Forecast Horizon  14 -3    7   6
Forecast Horizon  15 -3    7   6
Forecast Horizon  16 -3    7   6
Forecast Horizon  17 -2   10   7
Forecast Horizon  18 -1   10   7
Forecast Horizon  19 -1   10   7
Forecast Horizon  20 -1   10   7
Forecast Horizon  21 -1   10   7
Forecast Horizon  22 -1   10   7
Forecast Horizon  23 -1    9   7
Forecast Horizon  24 -1    9   6
```

ARIMA Model: Diagnostics

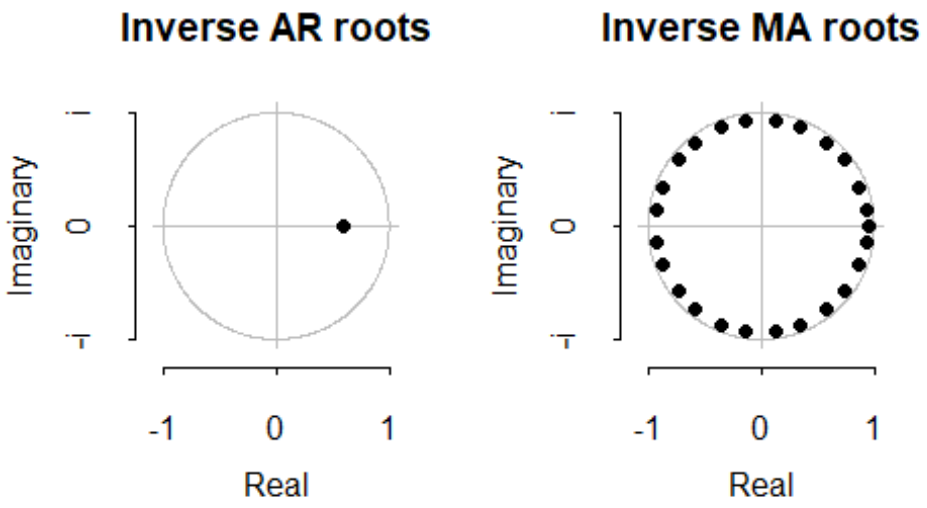
In this section we evaluate the diagnostics of the ARIMA Model. Below we see that the model fails the Ljung-Box Test and therefore we can determine the data is independently distributed. In addition, we see from the graphs that the lagged values are not auto-correlated with one another, and the residuals are normally distributed.

```
Series: x
ARIMA(1,1,1)(0,0,2)[12]
Box Cox transformation: lambda= -0.8999268

Coefficients:
         ar1      ma1    sma1    sma2
      0.5858  -0.9464  0.1748  0.2033
s.e.  0.0896   0.0355  0.0870  0.1272

sigma^2 estimated as 0.0003605:  log likelihood=303.87
AIC=-597.74   AICc=-597.21   BIC=-583.85

Training set error measures:
```

```
                     ME      RMSE       MAE        MPE      MAPE      MASE
Training set 0.7554106 13.82694 5.825997 -5.770132 21.32155 0.6131921
                    ACF1
Training set 0.08335257
```

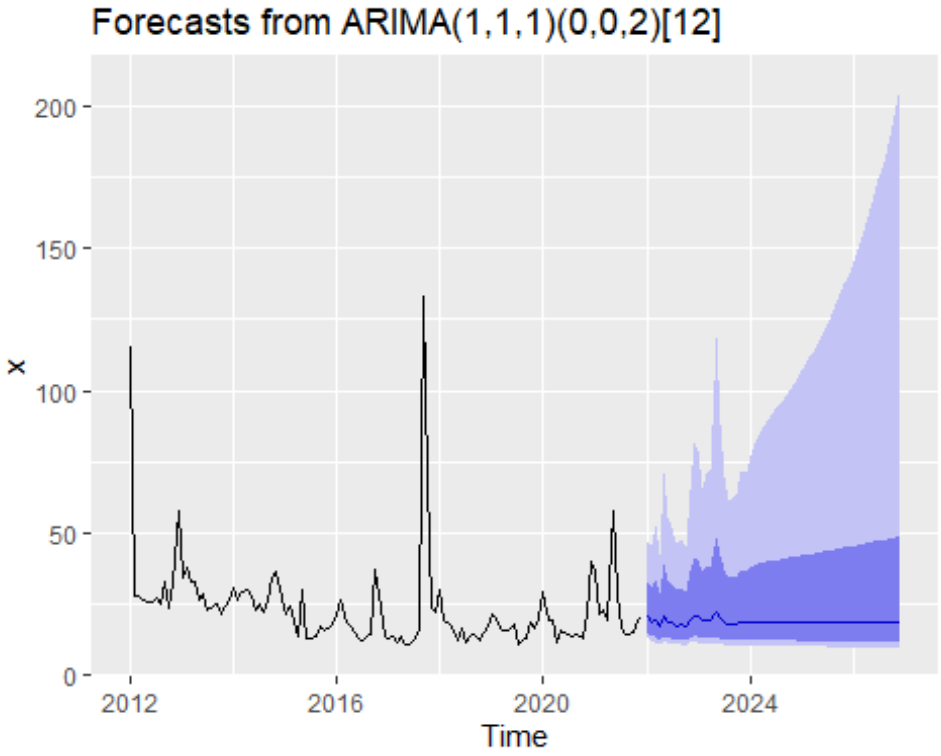



```
 Ljung-Box test

data:  Residuals from ARIMA(1,1,1)(0,0,2)[12]
Q* = 25.822, df = 20, p-value = 0.1718

Model df: 4.   Total lags used: 24
```

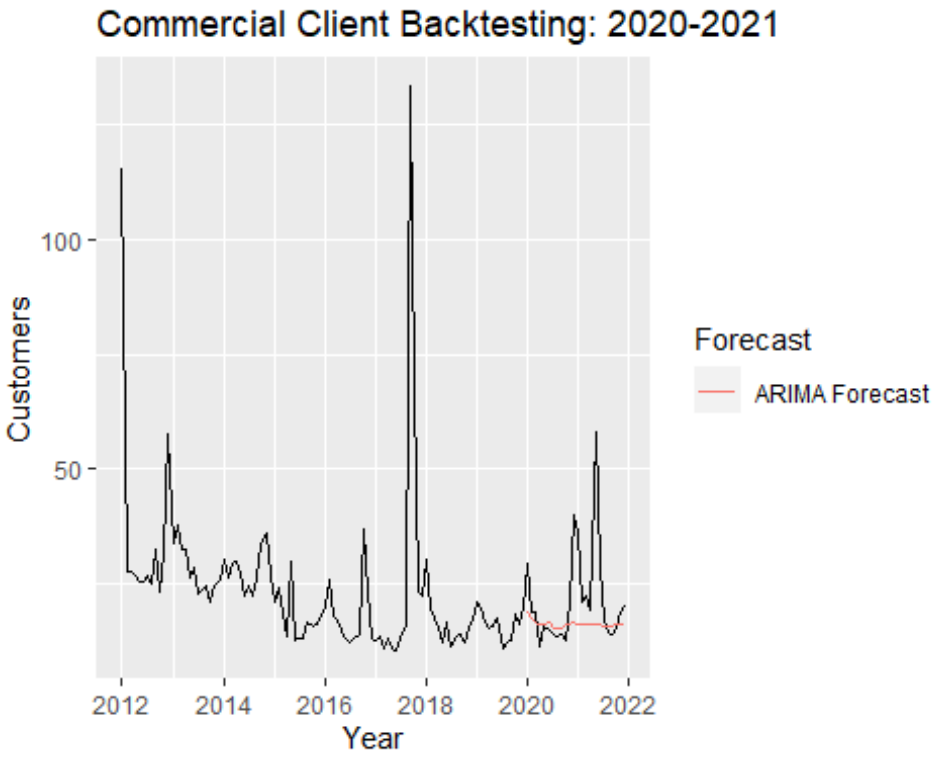


ARIMA Model: 5 Year Forecast

Below we fit & forecast 60 months into the future using an ARIMA (1,1,1)(0,0,2) model. In the graph below we see the 80% and 95% Prediction Intervals bounding our forecast.



Back-Testing

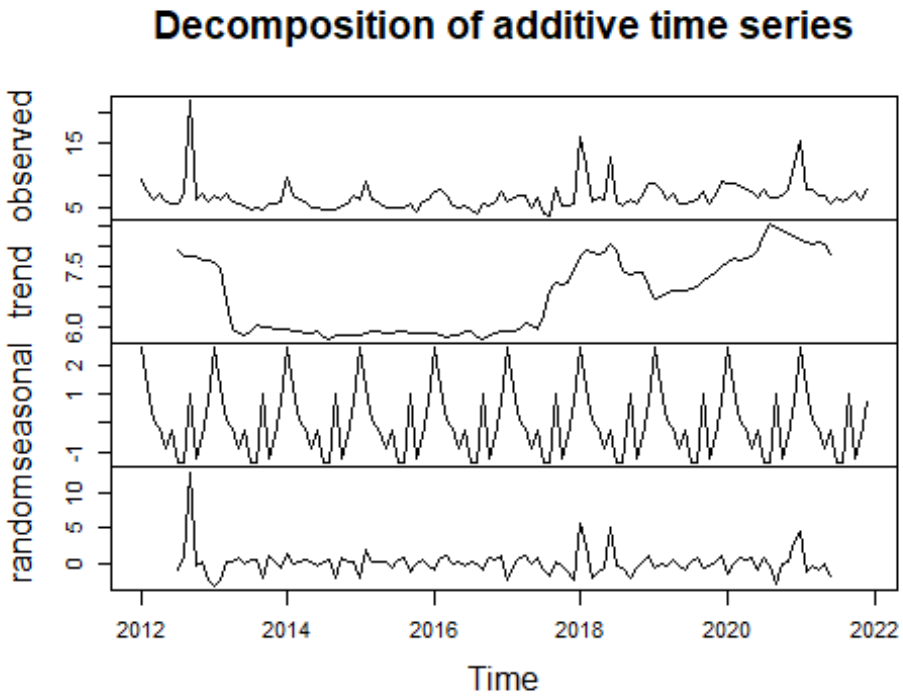


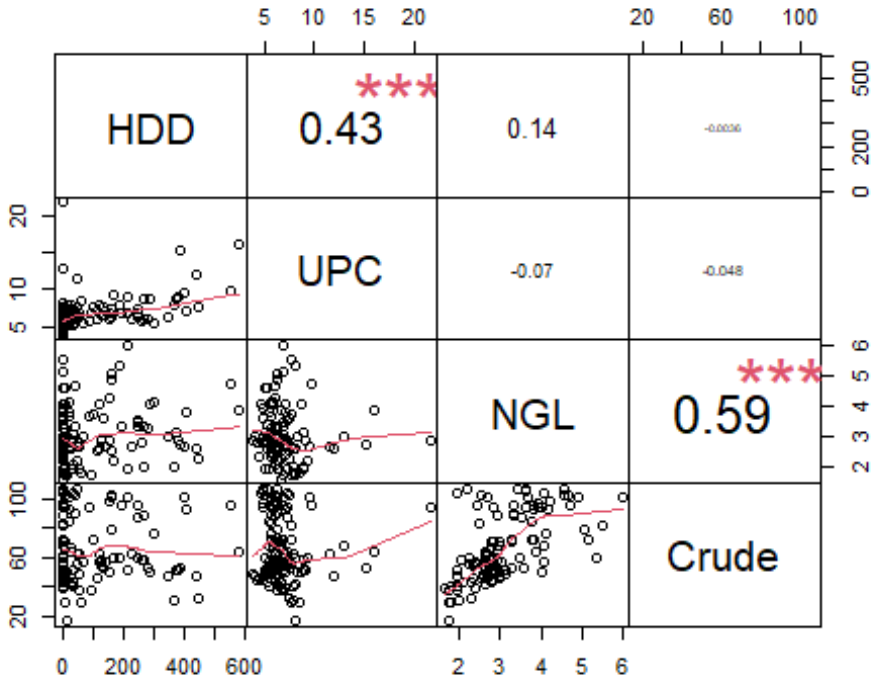
Test Results

```
[1] "24 Month Mean Absolute Error (MAE): 6.61"

[1] "24 Month Mean Accuracy: 76.36"

           Actual Forecast Absolute_Error Accuracy
Jan 2020 29.33957       19          10.54     64.1
Feb 2020 18.85025       18           1.22     93.5
Mar 2020 18.94512       17           2.15     88.7
Apr 2020 11.30448       16           5.00     55.8
May 2020 15.68618       16           0.44     97.2
Jun 2020 14.80522       16           1.60     89.2
Jul 2020 13.78952       15           1.30     90.6
Aug 2020 13.75153       15           1.70     87.6
Sep 2020 14.00443       15           1.43     89.8
Oct 2020 12.62525       16           3.46     72.6
Nov 2020 21.19530       16           5.20     75.5
Dec 2020 40.04194       16          23.60     41.1
Jan 2021 36.02817       16          19.64     45.5
Feb 2021 21.10220       16           4.81     77.2
Mar 2021 22.45417       16           6.31     71.9
Apr 2021 19.40448       16           3.34     82.8
May 2021 57.91730       16          41.83     27.8
Jun 2021 28.41638       16          12.29     56.8
Jul 2021 17.04888       16           1.25     92.7
Aug 2021 14.20446       16           1.68     88.2
Sep 2021 13.93481       16           1.96     85.9
Oct 2021 15.14433       16           1.00     93.4
Nov 2021 19.03706       16           2.98     84.3
Dec 2021 20.11432       16           3.95     80.4
```

Firm Transporation Service (FTS-A & FTS-B)

Customer Time-Series Decomposition





ARIMA Model: Expected Accuracy

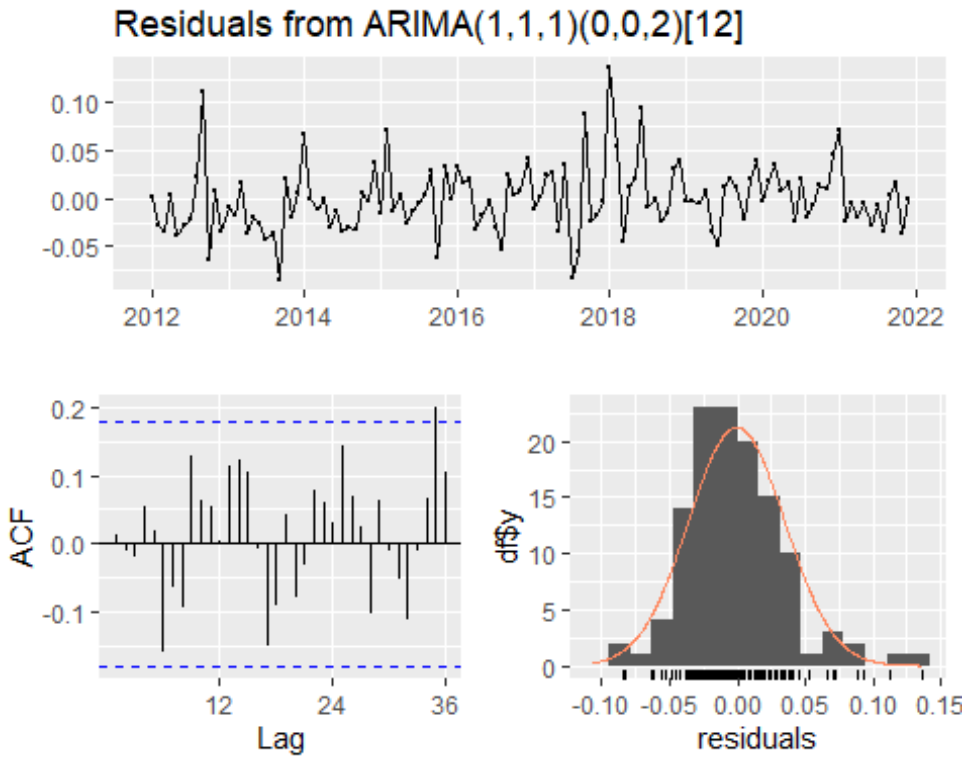
		ME	RMSE	MAE
Forecast Horizon	1	1	2	2
Forecast Horizon	2	1	2	2
Forecast Horizon	3	1	2	2

```
Forecast Horizon  4   1    2   2
Forecast Horizon  5   1    3   2
Forecast Horizon  6   1    3   2
Forecast Horizon  7   1    3   2
Forecast Horizon  8   1    3   2
Forecast Horizon  9   1    3   2
Forecast Horizon  10  1    2   2
Forecast Horizon  11  1    3   2
Forecast Horizon  12  1    3   2
Forecast Horizon  13  2    3   2
Forecast Horizon  14  1    3   2
Forecast Horizon  15  1    2   1
Forecast Horizon  16  1    2   2
Forecast Horizon  17  1    2   2
Forecast Horizon  18  1    2   2
Forecast Horizon  19  1    2   1
Forecast Horizon  20  1    2   1
Forecast Horizon  21  1    2   1
Forecast Horizon  22  1    2   1
Forecast Horizon  23  1    2   1
Forecast Horizon  24  1    2   1
```

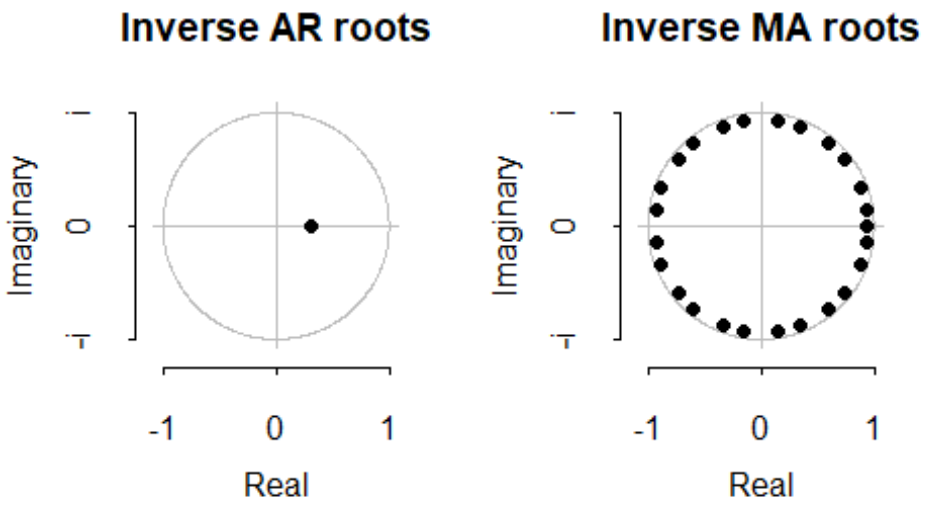
ARIMA Model: Diagnostics

In this section we evaluate the diagnostics of the ARIMA Model. Below we see that the model fails the Ljung-Box Test and therefore we can determine the data is independently distributed. In addition, we see from the graphs that the lagged values are not auto-correlated with one another, and the residuals are normally distributed.

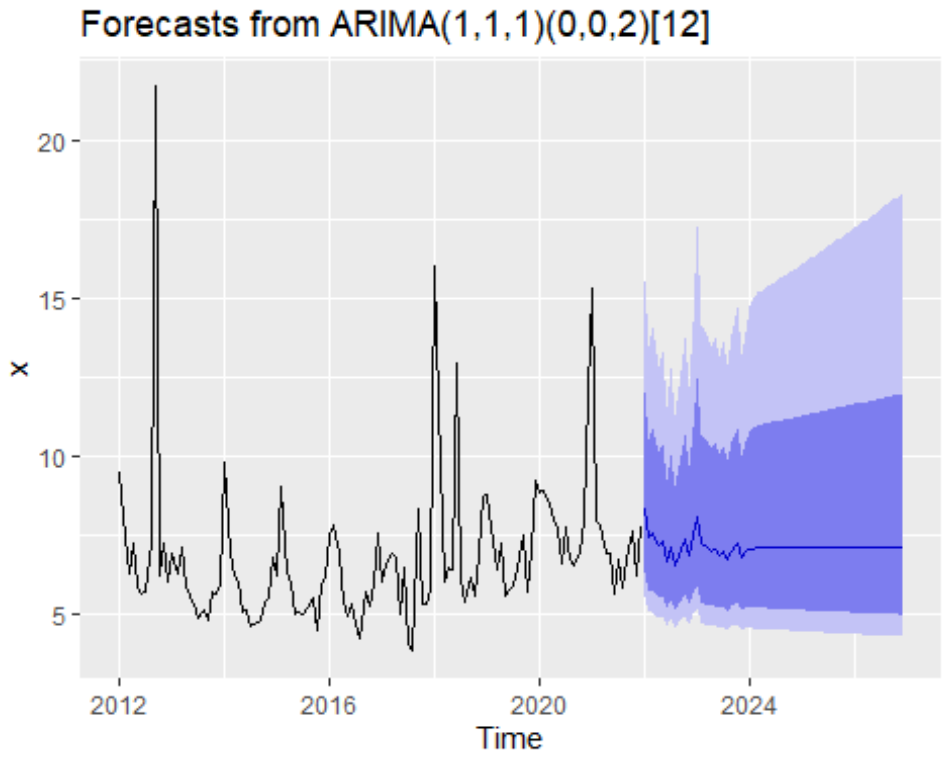
```
Series: x
ARIMA(1,1,1)(0,0,2)[12]
Box Cox transformation: lambda= -0.8999268

Coefficients:
         ar1      ma1    sma1    sma2
      0.3155  -0.9399  0.3005  0.2441
s.e.  0.1007   0.0404  0.1028  0.0929

sigma^2 estimated as 0.001302:  log likelihood=226.81
AIC=-443.62   AICc=-443.09   BIC=-429.72

Training set error measures:
                    ME     RMSE      MAE        MPE     MAPE      MASE
Training set 0.286797 2.132018 1.114148 -0.7710812 14.04426 0.7644121
                    ACF1
Training set 0.01822849
```



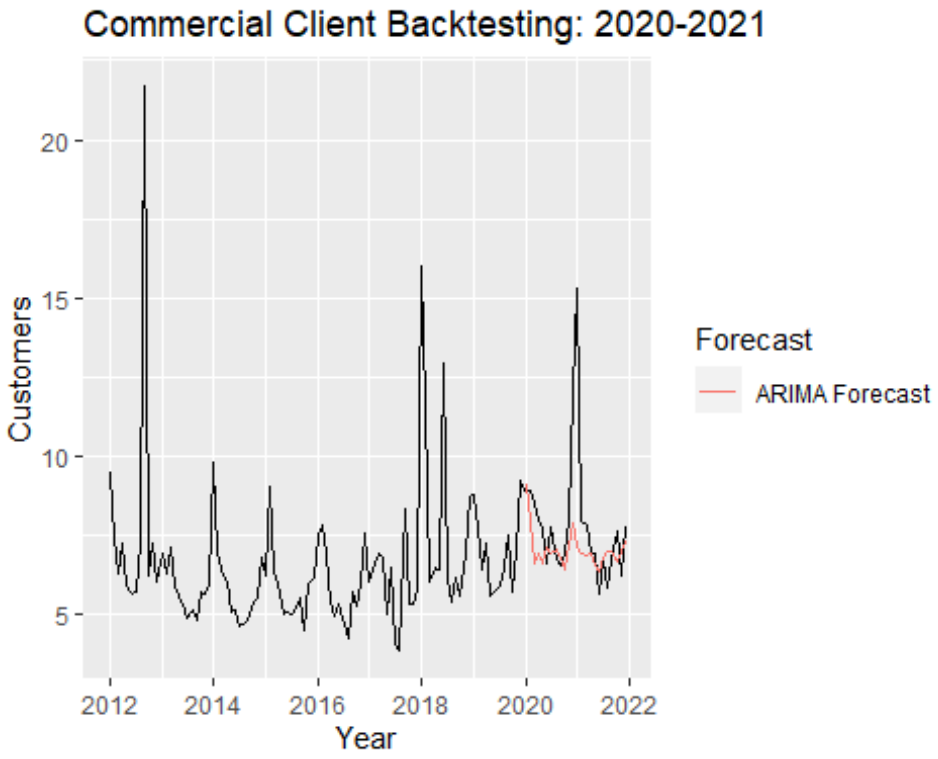

```
 Ljung-Box test

data:  Residuals from ARIMA(1,1,1)(0,0,2)[12]
Q* = 21.245, df = 20, p-value = 0.3828

Model df: 4.   Total lags used: 24
```



ARIMA Model: 5 Year Forecast



Back-Testing



Test Results

Below we see that the model performs roughly as expected for a “normal” year of 2019, and continues to have a high degree of accuracy in 2020 and 2021.

```
[1] "24 Month Mean Absolute Error (MAE): 1.15"

[1] "24 Month Mean Accuracy: 87.75"

            Actual Forecast Absolute_Error Accuracy
Jan 2020  8.843333        9           0.28     96.8
Feb 2020  8.936923        8           0.95     89.4
Mar 2020  8.505000        7           1.90     77.7
Apr 2020  7.994545        7           1.08     86.5
May 2020  7.716000        7           1.08     86.0
Jun 2020  6.625455        7           0.52     92.2
Jul 2020  7.780000        7           0.84     89.2
Aug 2020  6.736364        7           0.34     95.0
Sep 2020  6.523333        7           0.25     96.2
Oct 2020  6.951667        6           0.55     92.1
Nov 2020  7.996364        7           0.80     90.0
Dec 2020 11.984667        8           4.10     65.8
Jan 2021 15.289231        7           8.12     46.9
Feb 2021  7.974375        7           1.01     87.3
Mar 2021  7.839000        7           0.99     87.4
Apr 2021  6.914615        7           0.04     99.4
May 2021  6.911818        7           0.34     95.1
Jun 2021  5.654167        6           0.68     88.0
Jul 2021  6.720000        7           0.06     99.1
Aug 2021  5.836667        7           1.19     79.6
Sep 2021  6.774167        7           0.24     96.5
Oct 2021  7.634444        7           0.96     87.4
Nov 2021  6.235833        7           0.76     87.8
Dec 2021  7.757500        7           0.42     94.6
```