

Amtrak Ridership Forecasting

Amtrak, a US railway company, routinely collects data on ridership. This is a subjective exercise built on series of monthly Amtrak ridership between January 1991 and March 2004 in the United States.

Data is in public domain here.

Process

The Forecasting Process that we undertake is noted as follows:

Forecasting Process

Goals

1. Forecast monthly user ridership on its trains for the purpose of Pricing. Using demand data to determine Pricing is called “revenue management” and is a popular practice by airlines and hotel chains. It is a Predictive Goal.
2. Impact Assessment: Evaluating the effect of an event on the timeline such as Airport closure due to inclement weather, or the opening on new large national highway. This goal is retrospective in nature, and is therefore descriptive or even explanatory. Analysis would compare the series before and after the event, with no direct interest in future values of the series. Note that these goals are also geography specific and would therefore require using ridership data at a finer level of geography within United States.
3. Identifying and quantifying Demand during different seasons for planning the number and frequency of trains needed during different seasons. If the model is only aimed at producing monthly indexes of demand, then it is a descriptive goal. In contrast, if the model will be used to forecast seasonal demand for future years then it is a predictive task.
4. Finally, the Amtrak ridership data may be used by national agencies, such as Bureau of Transport Statistics to evaluate trends in transportation modes over the years. Whether it is descriptive or predictive goal depends on what the analysis will be used for. If it is used for the purpose of reporting past trends, then it is descriptive. If the purpose is forecasting future trends, then it is predictive goal.

Forecast Horizon

Forecast Horizon is the k number of periods ahead that we must forecast, and F_{t+k} is a k -step-ahead forecast. In Amtrak ridership example, one month ahead forecast F_{t+1} might be sufficient for Revenue management for creating flexible pricing. Whereas longer term forecasts, such as three month ahead forecast F_{t+3} are more likely to be needed for scheduling and procurement purpose.

Forecast Updating

Timeliness of data collection and transfer directly affect the forecast horizon. Whether improving the timeliness of data collection and transfer is possible or not, its implications on forecasting must be recognized at goal definition stage. Refreshing of forecasts based on new data is called *roll-forward forecasting*.

The Forecasting Process

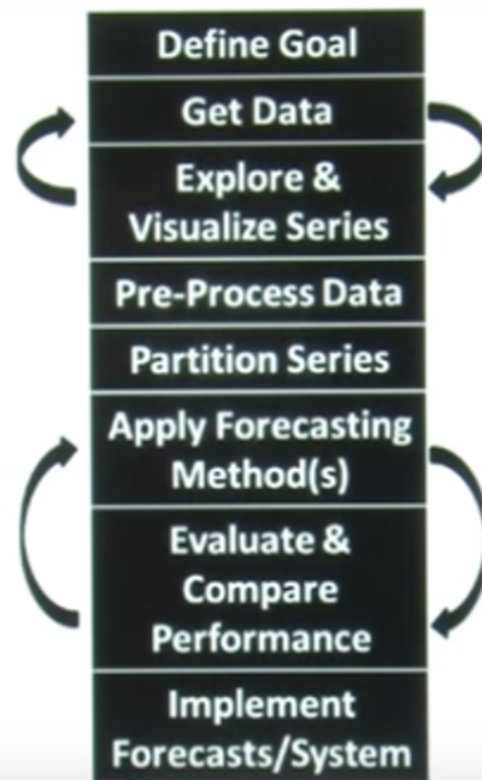


Figure 1: Forecasting Process

Forecast Use

Understanding how the forecast will be used, perhaps by different stakeholders, is critical for generating forecasts of the right type and with a useful accuracy level. Should the forecasts be binary(event/non-event)? Does over-production cost more or less than under-production? Will the forecast be used directly or will they be adjusted in some way before use? Will the forecast be presented to management or to the Technical department? Answers to such questions are necessary to choose appropriate data, methods and evaluation schemes.

Libraries

We will use Rob J Hyndman's forecast package

```
require(tidyverse)
require(forecast)
require(xtable)
require(knitr)
require(zoo)
```

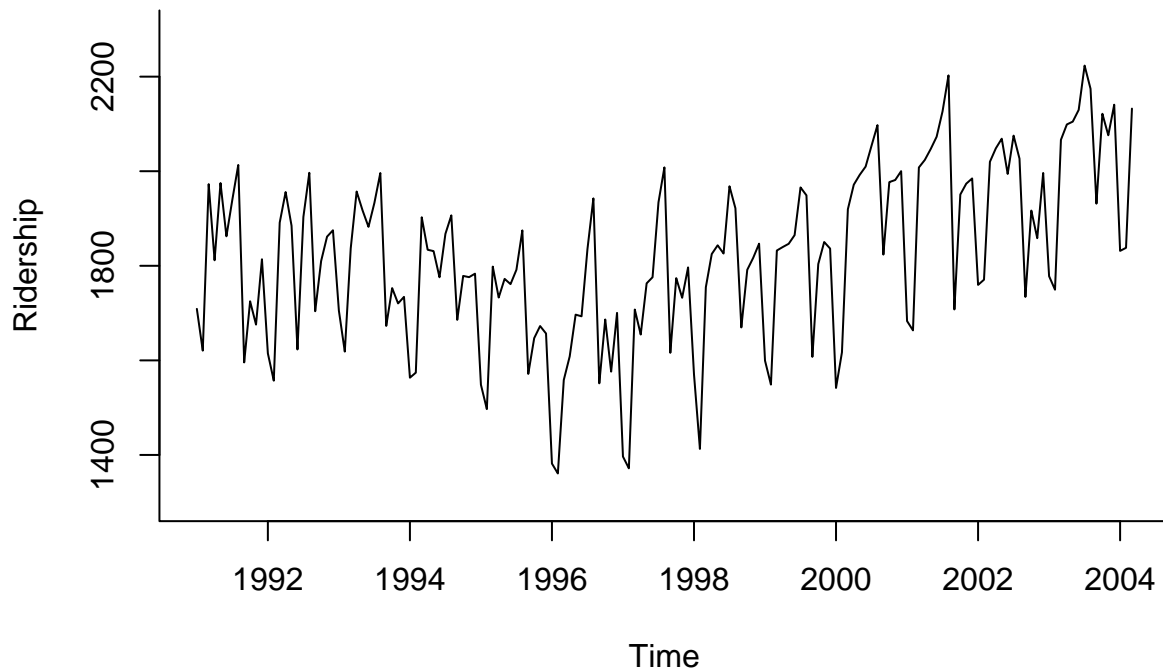
Different kinds of Forecasting

Timeplot

A timeplot of monthly Amtrack ridership is shown in Figure 2.3. Observing the plot reveals nature of time series components.

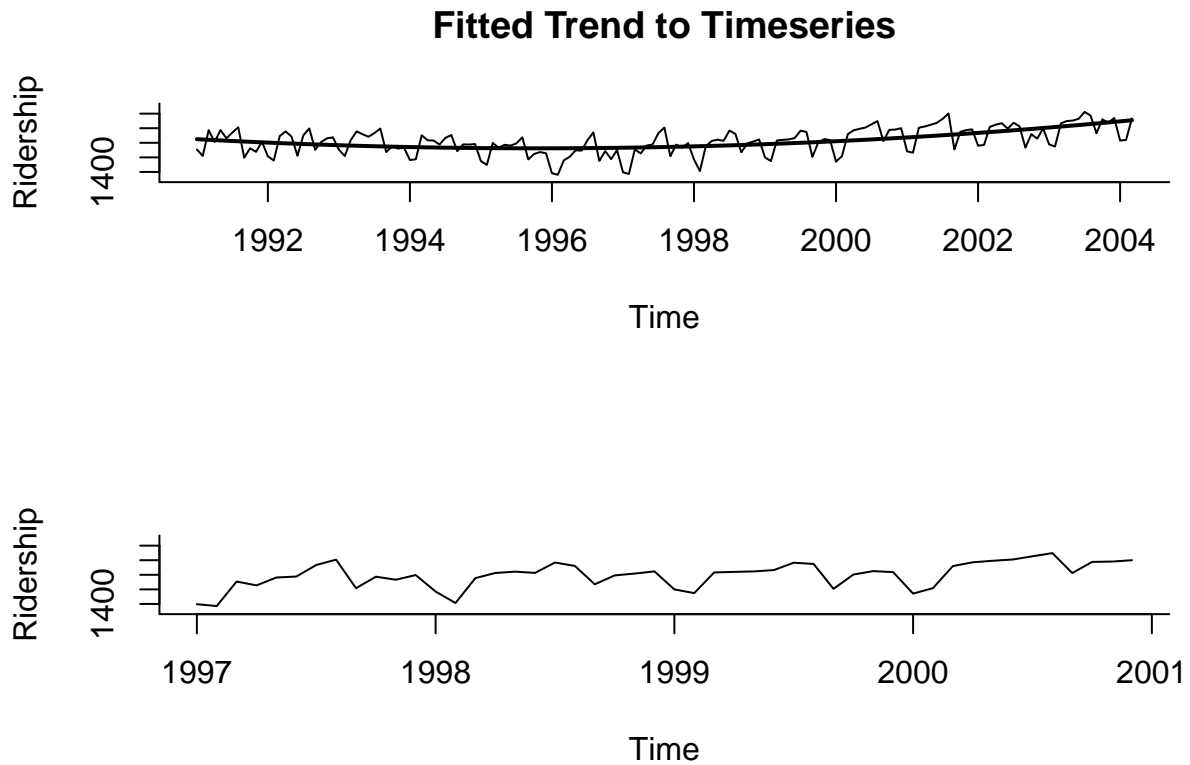
- Values Scale: Thousands of riders
- Overall Level: 1,800,000 riders/month
- Trend: Slight U-shaped
- Seasonality: Pronounced, Annual, Peaks: July, August

Figure 2.3: Monthly ridership on AMtrack Trains (in thousands) from Jan 1991 to March 2004



Trend and Zooming/Window

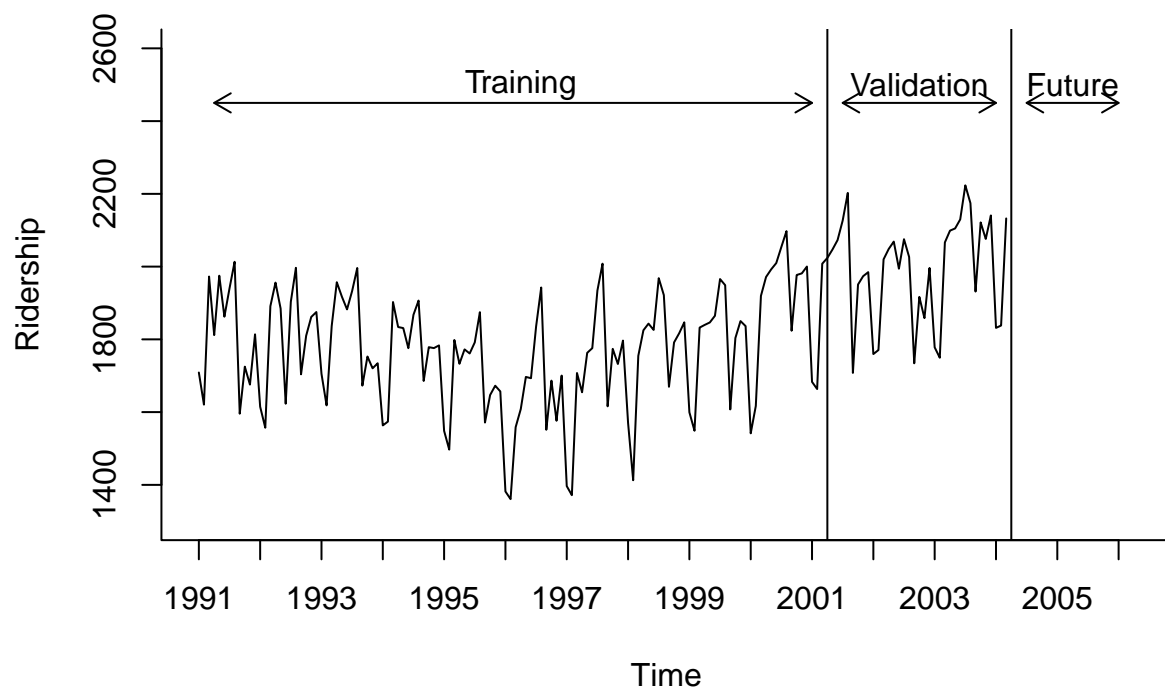
To fit a quadratic trend, run the forecast package's linear regression model for time series, called `tslm`. The `y` value is ridership and two `x` values are trend and square of trend. The function `I` treats square of trend as-is. Plot time series and its fitted regression line in the top panel of figure 2.4 The bottom panel shows a zoomed-in view of timeseries from January 1997 to December 2000. Use the `window` function to identify a subset of time series.

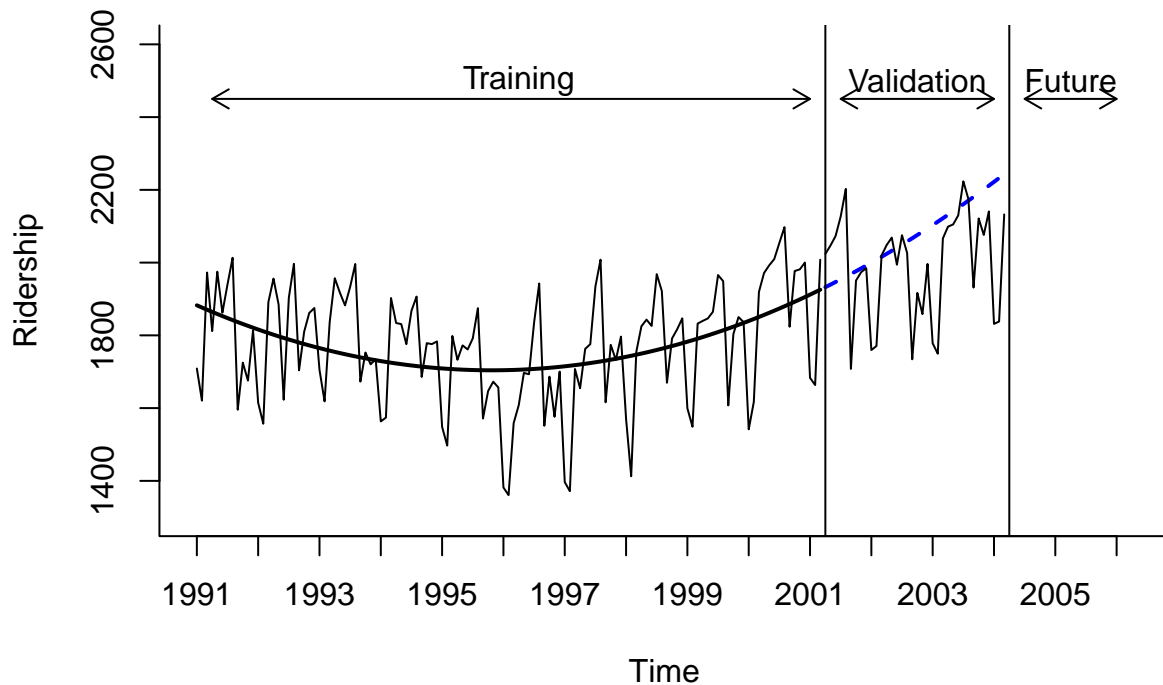


Partitioning the Data

Temporal partitioning: Partitioning the data in Training and Validation period is a linear process unlike that used in Cross sectional data which must be randomly selected. A random selection on a timeline will cause a “hole”. In the same vein, a third partition - “test”- is not advised as the impact of recency on forecasting is much higher. The latest partition, if made, will affect the forecasting detrimentally. Finally, the last difference is that in Time series, Training and Validation dataset are recombined before attempting to forecast future values.

Define the number of months of training and validation datasets, `nValid` and `nTrain`, respectively. Use the `time` and `window` function to create the training and validation sets. Fit a model (here, a linear regression model) to the training set. Use the `forecast` function to make predictions of time series in the validation period. Plot the predictions.





Computing Predictive Measures

- Forecast Error/ Residual
- MAE/MAD
- Average Error
- MAPE
- RMSE
- Zero Counts affecting MAPE
- MASE
- Forecast accuracy vs Profitability: Balancing the cost and perspective of Type One and Type Two Errors

```
##           ME      RMSE      MAE      MPE      MAPE      ACF1  Theil's U
## Test set -83.96208 179.8494 133.7383 -4.725374 7.07573 0.4170651 1.062068
```

Residuals

Use the `names` function to find out which elements are included with the `forecast` object called `ridership.lm.pred`. The model's residuals are forecast error in training period. Subtracting the model's `mean` (or forecasts) from `valid.ts` (or actuals) in the validation period gives the forecast error in the validation period.

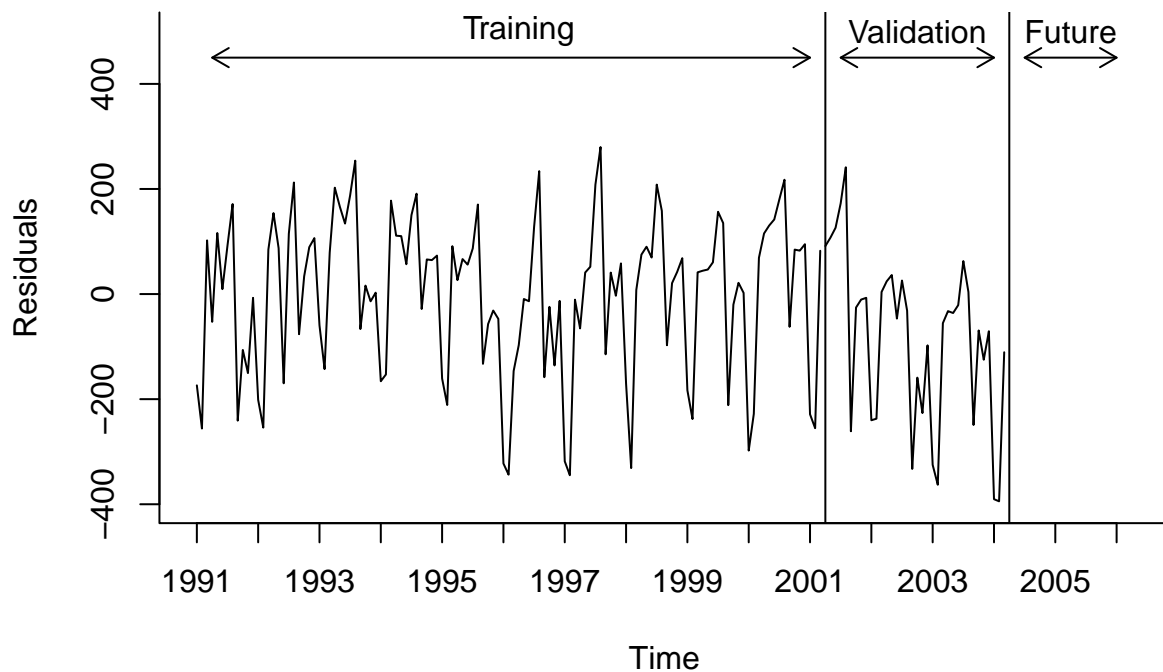


Figure 3.3: Timeplot of forecast errors (residuals) from a quadratic trend model applied to the Amtrack ridership data.

Put the model's residuals into the `hist` function to plot the histogram of, or frequency of forecast errors in each of seven (automatically and equally sized) bins.

```
## [1] "model"      "mean"      "lower"     "upper"     "level"
## [6] "x"          "series"    "method"    "newdata"    "residuals"
## [11] "fitted"
```

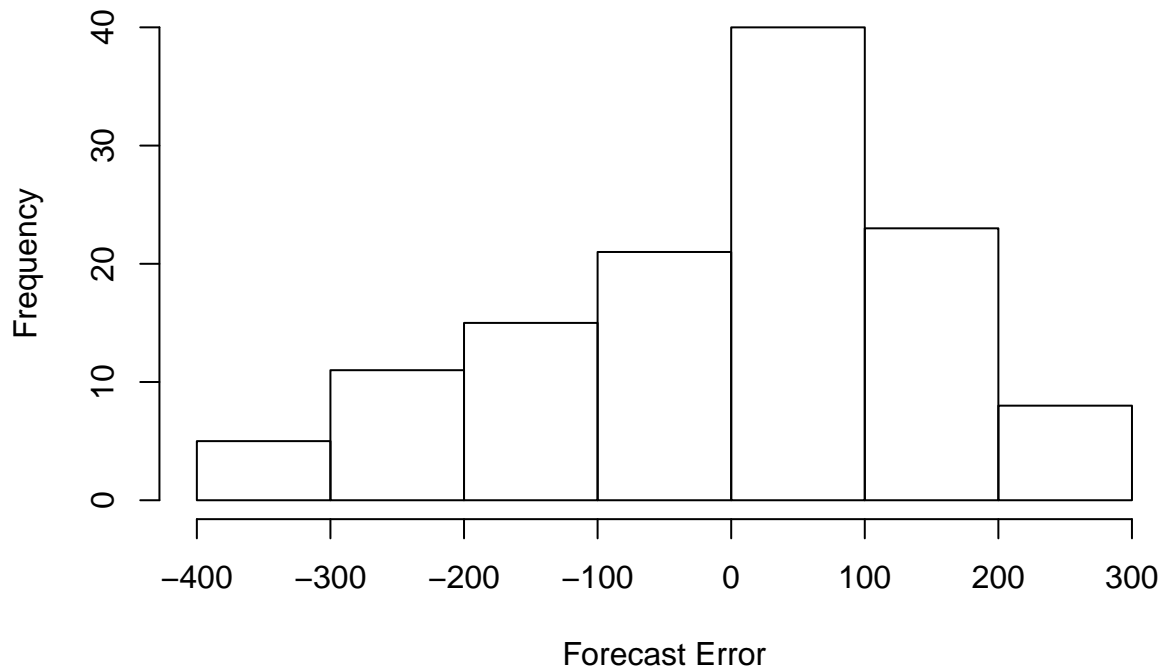



Figure 3.4: Histogram of forecast errors in the Training period from a quadratic trend model applied to the Amtrak ridership data.

Prediction Intervals: When errors are not normally distributed, forecast errors can be obtained from the training period to construct a prediction interval in the validation period and future. For example, a 95% prediction interval can be constructed by using the 5th and 95th percentiles from the sample of forecast errors.

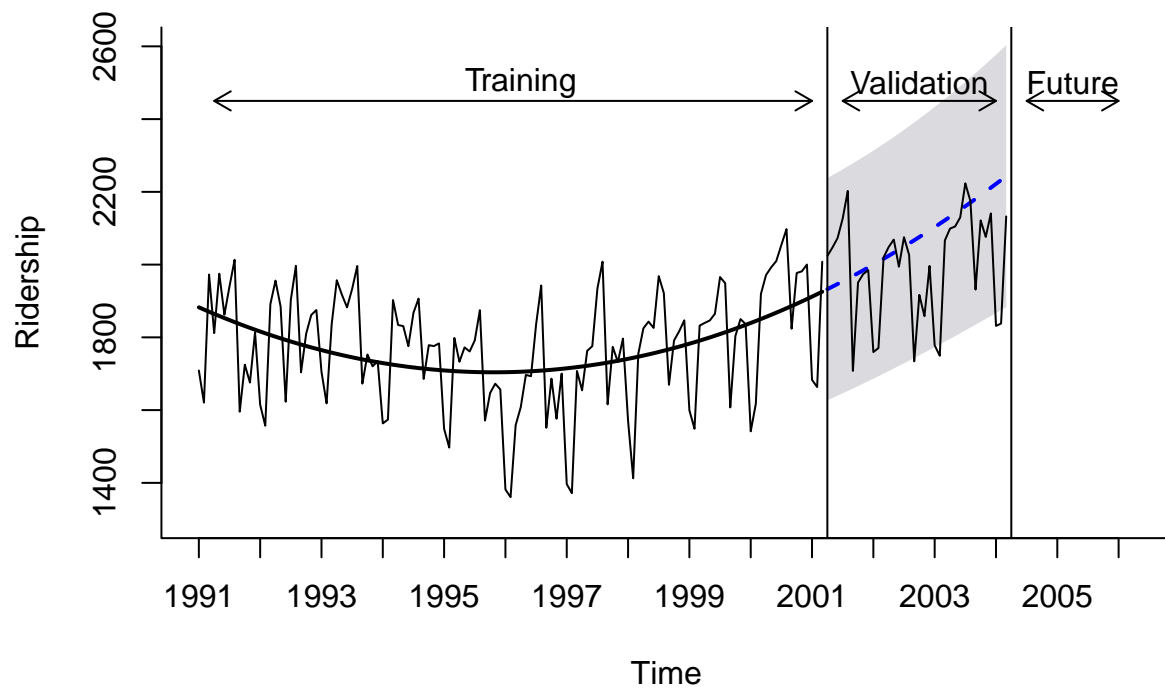


Figure 3.5: Point forecasts and 95% prediction intervals in the validation period gained from a quadratic trend model applied to the Amtrack ridership data. (`level = 95`)

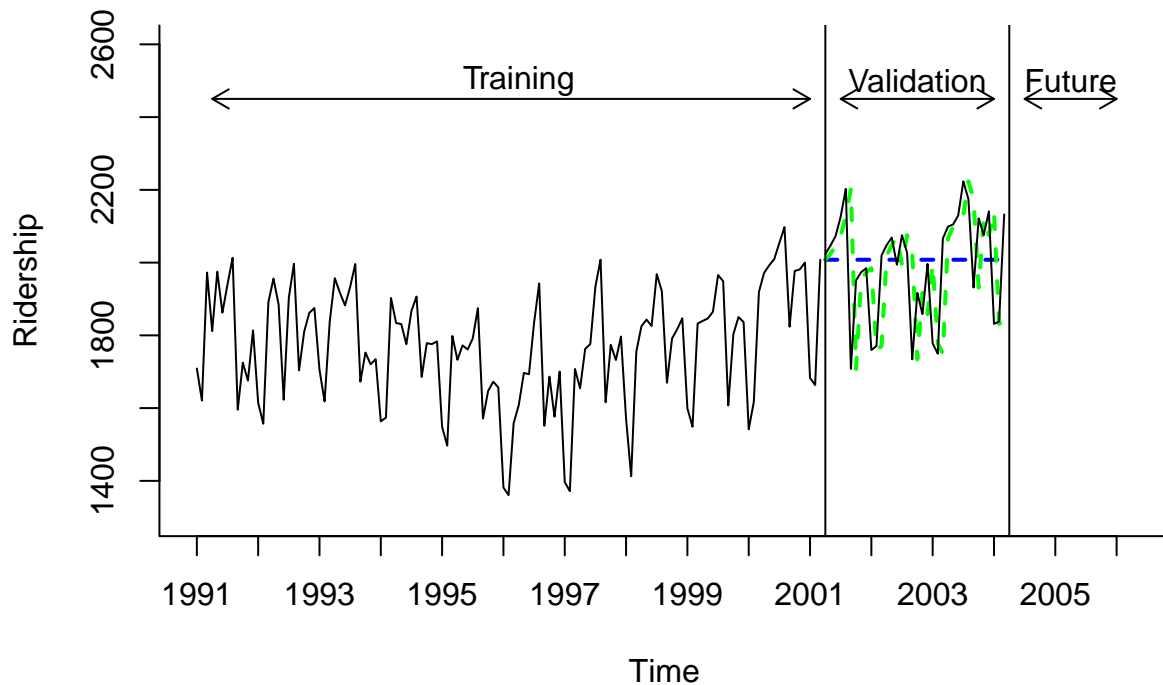


Figure 3.7: Naïve forecasts using a fixed validation period (Dashed horizontal line in blue) vs one-step-ahead Naïve forecasts using monthly roll-forward validation period (other dashed line in green) for Amtrak ridership data. The actual values are plotted with a smooth line.

```
## [1] 119.4289
## [1] 169.1733
## [1] 0.06206066

##           ME      RMSE      MAE      MPE      MAPE      MASE
## Training set   2.45091 168.1470 125.2975 -0.3460027 7.271393 1.518906
## Test set      -14.71772 142.7551 115.9234 -1.2749992 6.021396 1.405269
##           ACF1 Theil's U
## Training set -0.2472621      NA
## Test set      0.2764480 0.8346967

##           ME      RMSE      MAE      MPE      MAPE      MASE
## Training set 13.93991 99.26557 82.49196 0.5850656 4.715251 1.000000
## Test set      54.72961 95.62433 84.09406 2.6527928 4.247656 1.019421
##           ACF1 Theil's U
## Training set 0.6400044      NA
## Test set      0.6373346 0.5532435

## % latex table generated in R 3.5.0 by xtable 1.8-2 package
## % Thu May 31 21:06:37 2018
## \begin{table}[ht]
## \centering
## \begin{tabular}{rrrrr}
```

```

## \hline
## & Actual & Naive & Seasonal.Naive \\
## \hline
## 2001 Apr & 2023.79 & 2007.93 & 1971.49 \\
## 2001 May & 2047.01 & 2007.93 & 1992.30 \\
## 2001 Jun & 2072.91 & 2007.93 & 2009.76 \\
## 2001 Jul & 2126.72 & 2007.93 & 2054.00 \\
## 2001 Aug & 2202.64 & 2007.93 & 2097.47 \\
## 2001 Sep & 1707.69 & 2007.93 & 1823.71 \\
## 2001 Oct & 1950.72 & 2007.93 & 1977.00 \\
## 2001 Nov & 1973.61 & 2007.93 & 1981.41 \\
## 2001 Dec & 1984.73 & 2007.93 & 2000.15 \\
## 2002 Jan & 1759.63 & 2007.93 & 1683.15 \\
## 2002 Feb & 1770.60 & 2007.93 & 1663.40 \\
## 2002 Mar & 2019.91 & 2007.93 & 2007.93 \\
## 2002 Apr & 2048.40 & 2007.93 & 1971.49 \\
## 2002 May & 2068.76 & 2007.93 & 1992.30 \\
## 2002 Jun & 1994.27 & 2007.93 & 2009.76 \\
## 2002 Jul & 2075.26 & 2007.93 & 2054.00 \\
## 2002 Aug & 2026.56 & 2007.93 & 2097.47 \\
## 2002 Sep & 1734.15 & 2007.93 & 1823.71 \\
## 2002 Oct & 1916.77 & 2007.93 & 1977.00 \\
## 2002 Nov & 1858.35 & 2007.93 & 1981.41 \\
## 2002 Dec & 1996.35 & 2007.93 & 2000.15 \\
## 2003 Jan & 1778.03 & 2007.93 & 1683.15 \\
## 2003 Feb & 1749.49 & 2007.93 & 1663.40 \\
## 2003 Mar & 2066.47 & 2007.93 & 2007.93 \\
## 2003 Apr & 2098.90 & 2007.93 & 1971.49 \\
## 2003 May & 2104.91 & 2007.93 & 1992.30 \\
## 2003 Jun & 2129.67 & 2007.93 & 2009.76 \\
## 2003 Jul & 2223.35 & 2007.93 & 2054.00 \\
## 2003 Aug & 2174.36 & 2007.93 & 2097.47 \\
## 2003 Sep & 1931.41 & 2007.93 & 1823.71 \\
## 2003 Oct & 2121.47 & 2007.93 & 1977.00 \\
## 2003 Nov & 2076.05 & 2007.93 & 1981.41 \\
## 2003 Dec & 2140.68 & 2007.93 & 2000.15 \\
## 2004 Jan & 1831.51 & 2007.93 & 1683.15 \\
## 2004 Feb & 1838.01 & 2007.93 & 1663.40 \\
## 2004 Mar & 2132.45 & 2007.93 & 2007.93 \\
## \hline
## \end{tabular}
## \end{table}

##          Actual      Naive Seasonal Naive
## Apr 2001 2023.792 2007.928      1971.493
## May 2001 2047.008 2007.928      1992.301
## Jun 2001 2072.913 2007.928      2009.763
## Jul 2001 2126.717 2007.928      2053.996
## Aug 2001 2202.638 2007.928      2097.471
## Sep 2001 1707.693 2007.928      1823.706

```

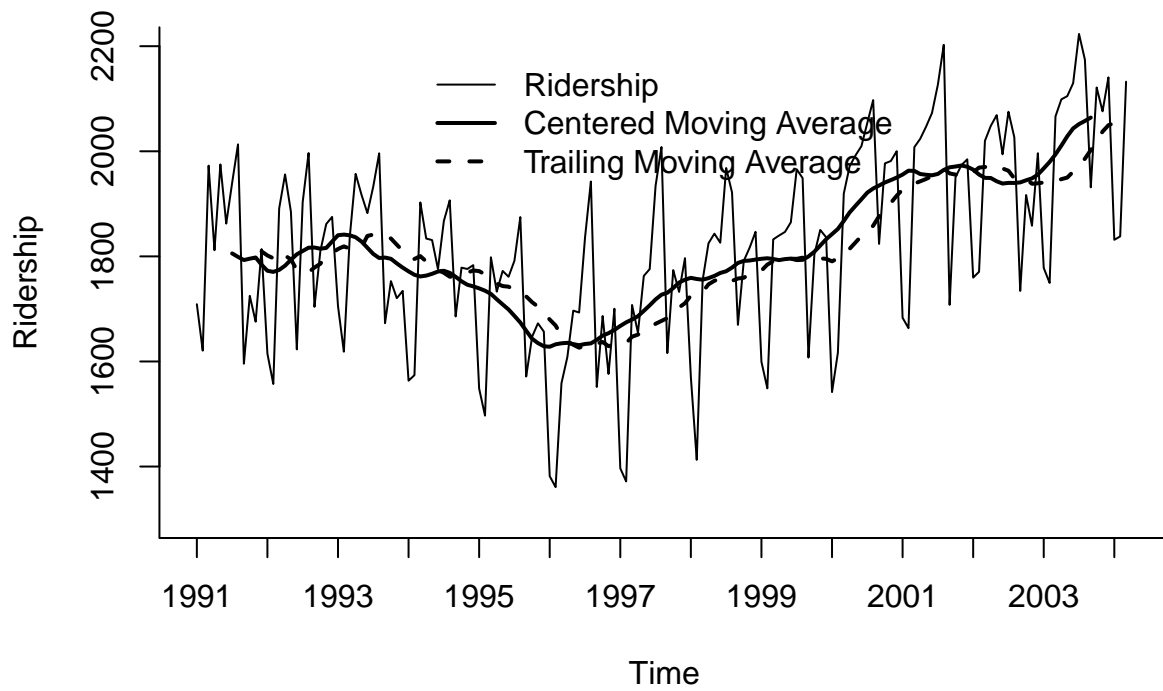
	RMSE	MAE	MPE	MAPE	MASE
--	------	-----	-----	------	------

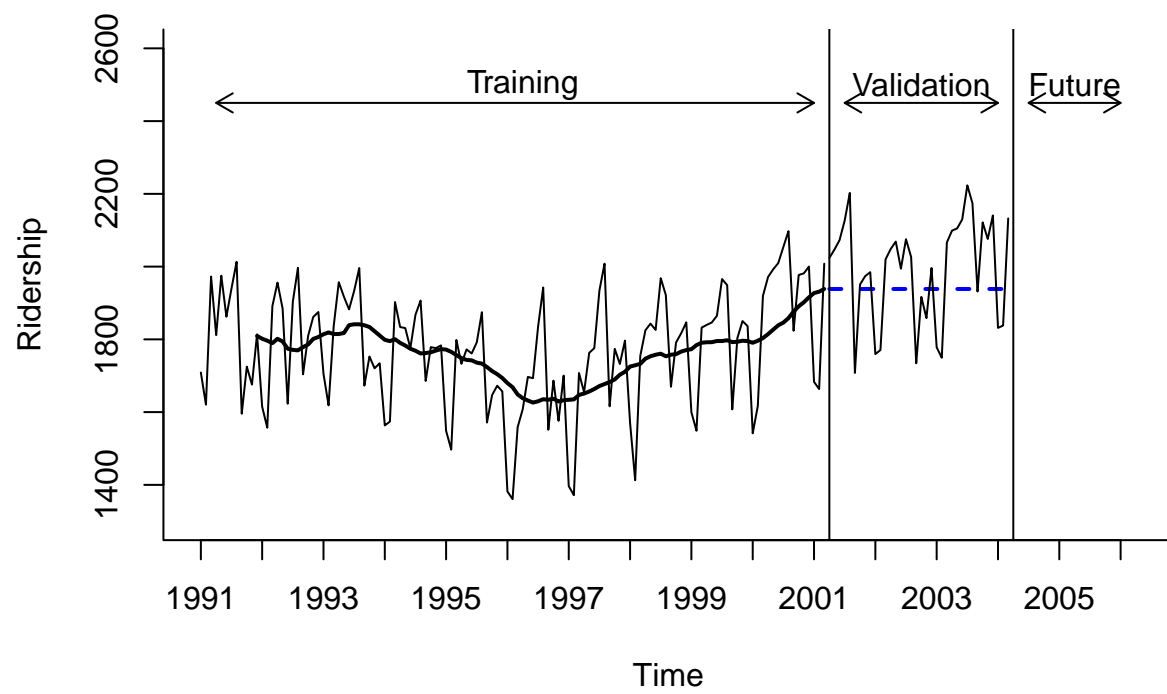
Table 1: Comparison of Accuracy Metrics

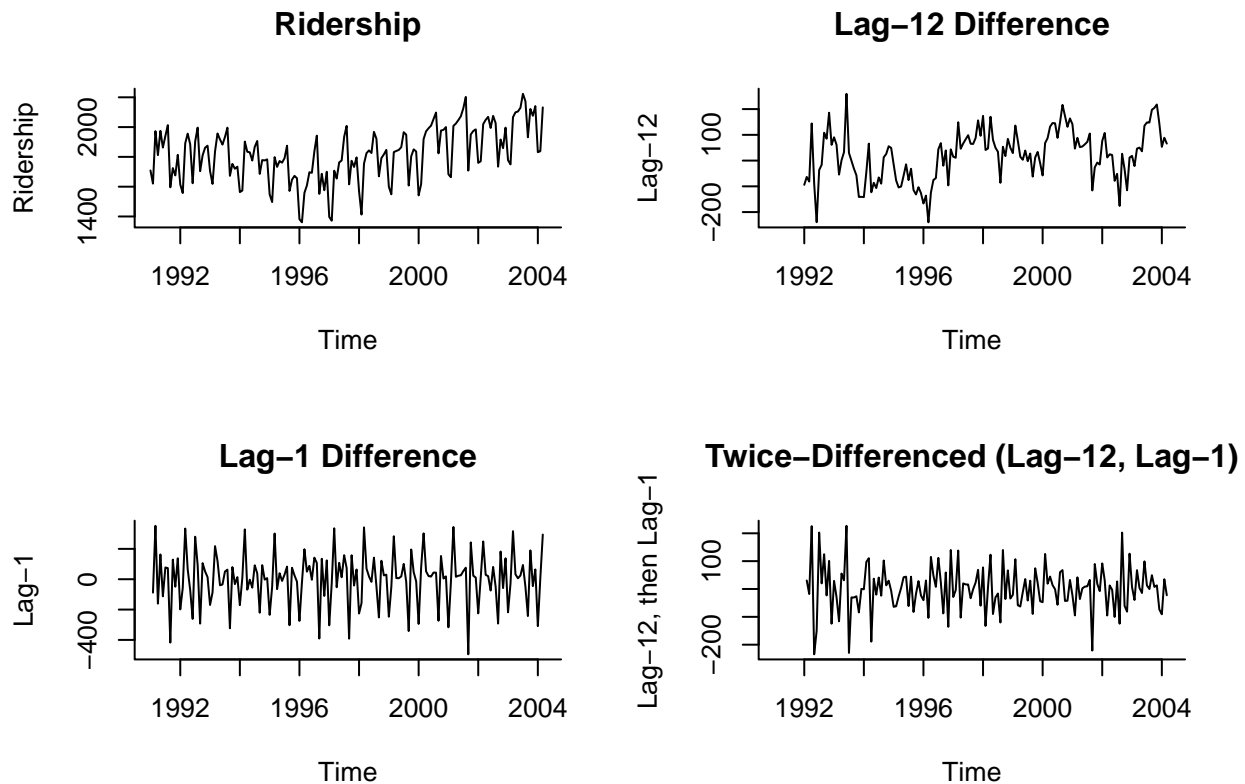
	RMSE	MAE	MPE	MAPE	MASE
Naive	142.75509	115.92339	-1.274999	6.021396	1.405269
Seasonal Naive	95.62433	84.09406	2.652793	4.247656	1.019421
Table 3.4: Naïve and seasonal naïve forecasts for fixed validation period (ridership data)					

Table 3.5: Performance of naïve vs seasonal naïve forecasts using fixed partitioning

Smoothing

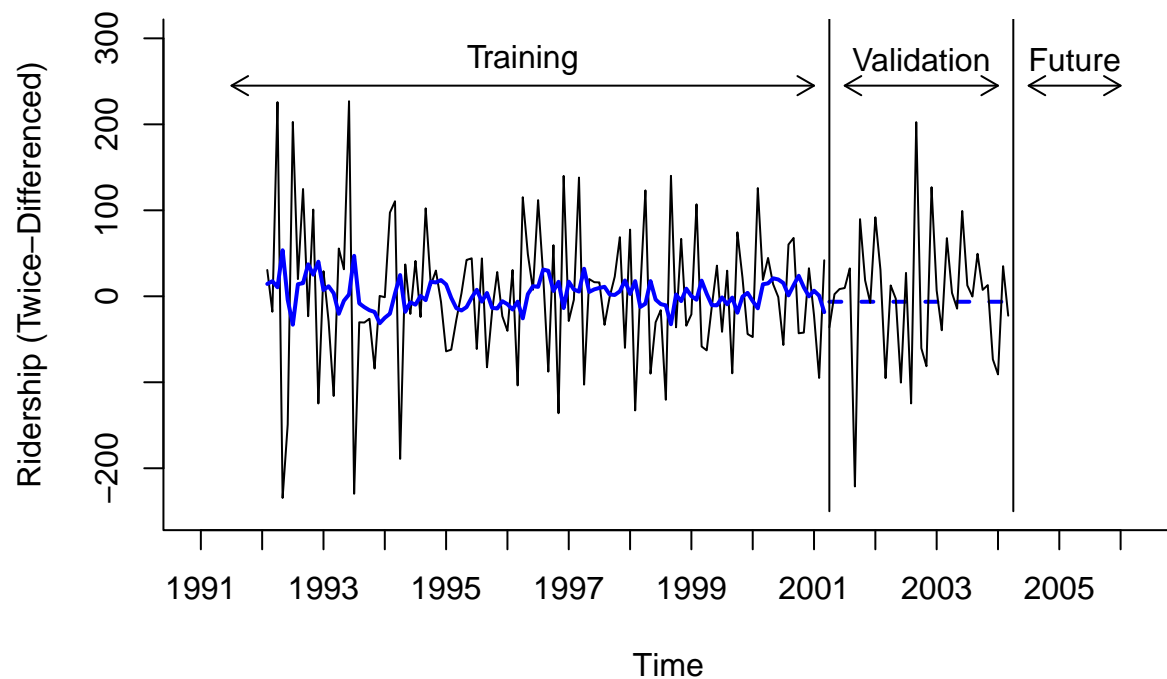






```
## null device
##      1

##
## Call:
## tslm(formula = ridership.deseasonalized ~ trend)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -241.873  -56.022   -0.219   59.150  284.792
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -40.3641    15.0455  -2.683  0.00815 **
## trend         0.8294     0.1764   4.702 5.93e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 90.74 on 145 degrees of freedom
## Multiple R-squared:  0.1323, Adjusted R-squared:  0.1263
## F-statistic: 22.11 on 1 and 145 DF,  p-value: 5.935e-06
```



```
## null device
##      1

## ETS(A,N,N)
##
## Call:
## ets(y = train.ts, model = "ANN")
##
## Smoothing parameters:
##   alpha = 1e-04
##
## Initial states:
##   l = 1.4679
##
## sigma: 83.5845
##
##      AIC      AICc      BIC
## 1494.723 1494.950 1502.825
##
##           ME      RMSE      MAE      MPE      MAPE      MASE
## Training set -0.9407425 90.82254 68.01782 181.35457 225.2854 0.6669040
## Test set      5.7226043 75.99033 54.88964  55.92139 178.3106 0.5381843
##
##           ACF1 Theil's U
## Training set -0.3678952      NA
## Test set      -0.3665235      1.113
##
##           ME      RMSE      MAE      MPE      MAPE      MASE
## Training set  0.1883115 82.82115 62.90072 100.5062 105.4250 0.6167316
```



```

## Test set      -2.0924502 75.80343 53.05667 110.2116 110.2116 0.5202123
##              ACF1 Theil's U
## Training set -0.3398587      NA
## Test set     -0.3665235 0.9662741

## Series: train.ts
## ARIMA(1,0,1)(0,0,1)[12] with non-zero mean
##
## Coefficients:
##          ar1      ma1      sma1      mean
##          0.3850 -0.8181 -0.7545  1.3775
## s.e.    0.1529  0.1032  0.1100  0.7093
##
## sigma^2 estimated as 3894:  log likelihood=-614.1
## AIC=1238.2  AICc=1238.78  BIC=1251.7

## ETS(M,N,A)
##
## Call:
## ets(y = rts)
##
## Smoothing parameters:
##   alpha = 0.5157
##   gamma = 8e-04
##
## Initial states:
##   l = 1813.5087
##   s=28.527 -16.1115 -3.9429 -121.4959 203.2382 154.7662
##       30.7515 74.6798 50.5657 44.6936 -250.4517 -195.2199
##
## sigma: 0.0352
##
##      AIC      AICc      BIC
## 1437.993 1443.100 1478.500

## [1] 56.89533 72.41222 47.58071 109.40784 105.01269 70.84465 64.63404
## [8] 65.44567 80.81070 134.14835 132.05848 103.71279 106.18907 107.98966
## [15] 109.53008 110.97033 112.37201 113.75885 115.13997 116.51889 117.89696
## [22] 119.27470 120.65232 122.02989 123.40744 124.78498 126.16252 127.54006
## [29] 128.91760 130.29514 131.67268 133.05022 134.42776 135.80530 137.18284
## [36] 138.56038

## [1] 1971.493 1992.301 2009.763 2053.996 2097.471 1823.706 1976.997
## [8] 1981.408 2000.153 1683.148 1663.404 2007.928 2028.388 2064.713
## [15] 2057.344 2163.404 2202.484 1894.551 2041.631 2046.854 2080.964
## [22] 1817.296 1795.462 2111.641 2134.577 2172.703 2166.874 2274.374
## [29] 2314.856 2008.310 2156.771 2163.373 2198.861 1936.571 1916.115
## [36] 2233.671 2257.985 2297.488 2293.036 2401.914 2443.773 2138.605
## [43] 2288.444 2296.423 2333.288 2072.376 2053.298 2372.231

## [1] 2028.388 2064.713 2057.344 2163.404 2202.484 1894.551 2041.631
## [8] 2046.854 2080.964 1817.296 1795.462 2111.641 2134.577 2172.703
## [15] 2166.874 2274.374 2314.856 2008.310 2156.771 2163.373 2198.861
## [22] 1936.571 1916.115 2233.671 2257.985 2297.488 2293.036 2401.914
## [29] 2443.773 2138.605 2288.444 2296.423 2333.288 2072.376 2053.298
## [36] 2372.231

```

##		ME	RMSE	MAE	MPE	MAPE
##	Test set	-152.0855	174.9945	152.959	-7.714254	7.75637
##		l	s1	s2	s3	s4
##	Dec 1990	1810.451	28.8704914	-14.0943852	-0.4390261	-140.3217427
##	Jan 1991	1870.704	-209.9105160	28.8704914	-14.0943852	-0.4390261
##	Feb 1991	1870.640	-250.0023333	-209.9105160	28.8704914	-14.0943852
##	Mar 1991	1901.262	46.9955194	-250.0023333	-209.9105160	28.8704914
##	Apr 1991	1818.246	59.7228761	46.9955194	-250.0023333	-209.9105160
##	May 1991	1856.980	87.0470861	59.7228761	46.9955194	-250.0023333
##	Jun 1991	1831.789	50.6871461	87.0470861	59.7228761	46.9955194
##	Jul 1991	1806.836	152.9542746	50.6871461	87.0470861	59.7228761
##	Aug 1991	1816.807	188.4935596	152.9542746	50.6871461	87.0470861
##	Sep 1991	1771.881	-140.3425970	188.4935596	152.9542746	50.6871461
##	Oct 1991	1746.026	-0.4510282	-140.3425970	188.4935596	152.9542746
##	Nov 1991	1714.753	-14.1089019	-0.4510282	-140.3425970	188.4935596
##	Dec 1991	1753.793	28.8886138	-14.1089019	-0.4510282	-140.3425970
##	Jan 1992	1793.225	-209.8922117	28.8886138	-14.1089019	-0.4510282
##	Feb 1992	1800.932	-249.9987560	-209.8922117	28.8886138	-14.1089019
##	Mar 1992	1824.996	47.0066901	-249.9987560	-209.8922117	28.8886138
##	Apr 1992	1864.605	59.7412624	47.0066901	-249.9987560	-209.8922117
##	May 1992	1827.400	87.0298155	59.7412624	47.0066901	-249.9987560
##	Jun 1992	1685.641	50.6213421	87.0298155	59.7412624	47.0066901
##	Jul 1992	1721.610	152.9709713	50.6213421	87.0298155	59.7412624
##	Aug 1992	1769.749	188.5159054	152.9709713	50.6213421	87.0298155
##	Sep 1992	1811.152	-140.3233776	188.5159054	152.9709713	50.6213421
##	Oct 1992	1810.762	-0.4512091	-140.3233776	188.5159054	152.9709713
##	Nov 1992	1846.861	-14.0921448	-0.4512091	-140.3233776	188.5159054
##	Dec 1992	1846.512	28.8884518	-14.0921448	-0.4512091	-140.3233776
##	Jan 1993	1884.663	-209.8745022	28.8884518	-14.0921448	-0.4512091
##	Feb 1993	1875.698	-250.0029175	-209.8745022	28.8884518	-14.0921448
##	Mar 1993	1827.900	46.9845024	-250.0029175	-209.8745022	28.8884518
##	Apr 1993	1866.475	59.7591687	46.9845024	-250.0029175	-209.8745022
##	May 1993	1846.288	87.0204447	59.7591687	46.9845024	-250.0029175
##	Jun 1993	1838.222	50.6175981	87.0204447	59.7591687	46.9845024
##	Jul 1993	1805.882	152.9559592	50.6175981	87.0204447	59.7591687
##	Aug 1993	1806.865	188.5163617	152.9559592	50.6175981	87.0204447
##	Sep 1993	1810.367	-140.3217525	188.5163617	152.9559592	50.6175981
##	Oct 1993	1778.636	-0.4659384	-140.3217525	188.5163617	152.9559592
##	Nov 1993	1754.087	-14.1035402	-0.4659384	-140.3217525	188.5163617
##	Dec 1993	1727.028	28.8758910	-14.1035402	-0.4659384	-140.3217525
##	Jan 1994	1752.713	-209.8625792	28.8758910	-14.1035402	-0.4659384
##	Feb 1994	1792.314	-249.9845346	-209.8625792	28.8758910	-14.1035402
##	Mar 1994	1827.520	47.0008447	-249.9845346	-209.8625792	28.8758910
##	Apr 1994	1797.844	59.7453932	47.0008447	-249.9845346	-209.8625792
##	May 1994	1767.933	87.0065597	59.7453932	47.0008447	-249.9845346
##	Jun 1994	1744.146	50.6065565	87.0065597	59.7453932	47.0008447
##	Jul 1994	1727.697	152.9483236	50.6065565	87.0065597	59.7453932
##	Aug 1994	1722.358	188.5138834	152.9483236	50.6065565	87.0065597
##	Sep 1994	1779.938	-140.2950238	188.5138834	152.9483236	50.6065565
##	Oct 1994	1779.423	-0.4661775	-140.2950238	188.5138834	152.9483236
##	Nov 1994	1785.357	-14.1007860	-0.4661775	-140.2950238	188.5138834
##	Dec 1994	1768.192	28.8679229	-14.1007860	-0.4661775	-140.2950238
##	Jan 1995	1762.681	-209.8651371	28.8679229	-14.1007860	-0.4661775

##	Feb	1995	1753.915	-249.9886039	-209.8651371	28.8679229	-14.1007860
##	Mar	1995	1752.470	47.0001739	-249.9886039	-209.8651371	28.8679229
##	Apr	1995	1708.382	59.7249278	47.0001739	-249.9886039	-209.8651371
##	May	1995	1695.574	87.0006142	59.7249278	47.0001739	-249.9886039
##	Jun	1995	1703.926	50.6104335	87.0006142	59.7249278	47.0001739
##	Jul	1995	1667.676	152.9314964	50.6104335	87.0006142	59.7249278
##	Aug	1995	1678.031	188.5186901	152.9314964	50.6104335	87.0006142
##	Sep	1995	1696.691	-140.2863617	188.5186901	152.9314964	50.6104335
##	Oct	1995	1669.302	-0.4788915	-140.2863617	188.5186901	152.9314964
##	Nov	1995	1678.990	-14.0962890	-0.4788915	-140.2863617	188.5186901
##	Dec	1995	1650.636	28.8547611	-14.0962890	-0.4788915	-140.2863617
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##	Dec	1997	1763.340	28.8665820	-14.1292435	-0.4807141	-140.2982933
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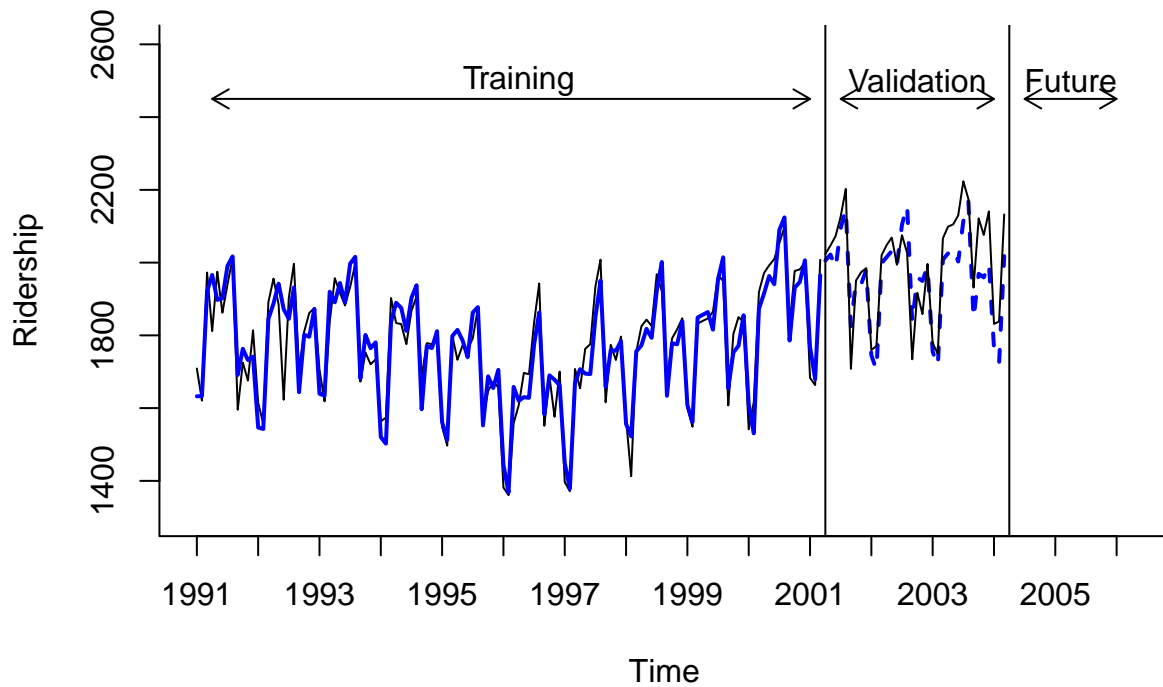
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## Apr 2000	28.8623019	-14.0983255	-0.4687134	-140.2936650	188.5380533
## May 2000	-209.9072619	28.8623019	-14.0983255	-0.4687134	-140.2936650
## Jun 2000	-250.0016904	-209.9072619	28.8623019	-14.0983255	-0.4687134
## Jul 2000	46.9883527	-250.0016904	-209.9072619	28.8623019	-14.0983255
## Aug 2000	59.7358989	46.9883527	-250.0016904	-209.9072619	28.8623019
## Sep 2000	87.0328394	59.7358989	46.9883527	-250.0016904	-209.9072619
## Oct 2000	50.6788749	87.0328394	59.7358989	46.9883527	-250.0016904
## Nov 2000	152.9816226	50.6788749	87.0328394	59.7358989	46.9883527
## Dec 2000	188.5366234	152.9816226	50.6788749	87.0328394	59.7358989
## Jan 2001	-140.2800923	188.5366234	152.9816226	50.6788749	87.0328394
## Feb 2001	-0.4592103	-140.2800923	188.5366234	152.9816226	50.6788749
## Mar 2001	-14.0894497	-0.4592103	-140.2800923	188.5366234	152.9816226
## Apr 2001	28.8599965	-14.0894497	-0.4592103	-140.2800923	188.5366234
## May 2001	-209.9284714	28.8599965	-14.0894497	-0.4592103	-140.2800923
## Jun 2001	-250.0058607	-209.9284714	28.8599965	-14.0894497	-0.4592103
## Jul 2001	46.9987646	-250.0058607	-209.9284714	28.8599965	-14.0894497
## Aug 2001	59.7413278	46.9987646	-250.0058607	-209.9284714	28.8599965
## Sep 2001	87.0341979	59.7413278	46.9987646	-250.0058607	-209.9284714
## Oct 2001	50.6955417	87.0341979	59.7413278	46.9987646	-250.0058607
## Nov 2001	152.9765126	50.6955417	87.0341979	59.7413278	46.9987646
## Dec 2001	188.5447684	152.9765126	50.6955417	87.0341979	59.7413278
## Jan 2002	-140.3193372	188.5447684	152.9765126	50.6955417	87.0341979
## Feb 2002	-0.4500151	-140.3193372	188.5447684	152.9765126	50.6955417
## Mar 2002	-14.0759407	-0.4500151	-140.3193372	188.5447684	152.9765126
## Apr 2002	28.8577834	-14.0759407	-0.4500151	-140.3193372	188.5447684
## May 2002	-209.9259227	28.8577834	-14.0759407	-0.4500151	-140.3193372
## Jun 2002	-249.9915589	-209.9259227	28.8577834	-14.0759407	-0.4500151
## Jul 2002	46.9928133	-249.9915589	-209.9259227	28.8577834	-14.0759407
## Aug 2002	59.7427463	46.9928133	-249.9915589	-209.9259227	28.8577834
## Sep 2002	87.0330405	59.7427463	46.9928133	-249.9915589	-209.9259227
## Oct 2002	50.6851827	87.0330405	59.7427463	46.9928133	-249.9915589
## Nov 2002	152.9664183	50.6851827	87.0330405	59.7427463	46.9928133
## Dec 2002	188.5185432	152.9664183	50.6851827	87.0330405	59.7427463
## Jan 2003	-140.3215792	188.5185432	152.9664183	50.6851827	87.0330405
## Feb 2003	-0.4399819	-140.3215792	188.5185432	152.9664183	50.6851827
## Mar 2003	-14.0830430	-0.4399819	-140.3215792	188.5185432	152.9664183
## Apr 2003	28.8791585	-14.0830430	-0.4399819	-140.3215792	188.5185432
## May 2003	-209.9111482	28.8791585	-14.0830430	-0.4399819	-140.3215792
## Jun 2003	-249.9820236	-209.9111482	28.8791585	-14.0830430	-0.4399819
## Jul 2003	47.0022070	-249.9820236	-209.9111482	28.8791585	-14.0830430
## Aug 2003	59.7519972	47.0022070	-249.9820236	-209.9111482	28.8791585
## Sep 2003	87.0316596	59.7519972	47.0022070	-249.9820236	-209.9111482
## Oct 2003	50.7003357	87.0316596	59.7519972	47.0022070	-249.9820236
## Nov 2003	152.9709293	50.7003357	87.0316596	59.7519972	47.0022070
## Dec 2003	188.4987345	152.9709293	50.7003357	87.0316596	59.7519972
## Jan 2004	-140.3082184	188.4987345	152.9709293	50.7003357	87.0316596
## Feb 2004	-0.4210997	-140.3082184	188.4987345	152.9709293	50.7003357

## Mar 2004	-14.0828536	-0.4210997	-140.3082184	188.4987345	152.9709293
##	s10	s11	s12		
## Dec 1990	46.9813047	-250.0023034	-209.9384853		
## Jan 1991	59.7614120	46.9813047	-250.0023034		
## Feb 1991	87.0291057	59.7614120	46.9813047		
## Mar 1991	50.6988399	87.0291057	59.7614120		
## Apr 1991	152.9658579	50.6988399	87.0291057		
## May 1991	188.4889311	152.9658579	50.6988399		
## Jun 1991	-140.3217427	188.4889311	152.9658579		
## Jul 1991	-0.4390261	-140.3217427	188.4889311		
## Aug 1991	-14.0943852	-0.4390261	-140.3217427		
## Sep 1991	28.8704914	-14.0943852	-0.4390261		
## Oct 1991	-209.9105160	28.8704914	-14.0943852		
## Nov 1991	-250.0023333	-209.9105160	28.8704914		
## Dec 1991	46.9955194	-250.0023333	-209.9105160		
## Jan 1992	59.7228761	46.9955194	-250.0023333		
## Feb 1992	87.0470861	59.7228761	46.9955194		
## Mar 1992	50.6871461	87.0470861	59.7228761		
## Apr 1992	152.9542746	50.6871461	87.0470861		
## May 1992	188.4935596	152.9542746	50.6871461		
## Jun 1992	-140.3425970	188.4935596	152.9542746		
## Jul 1992	-0.4510282	-140.3425970	188.4935596		
## Aug 1992	-14.1089019	-0.4510282	-140.3425970		
## Sep 1992	28.8886138	-14.1089019	-0.4510282		
## Oct 1992	-209.8922117	28.8886138	-14.1089019		
## Nov 1992	-249.9987560	-209.8922117	28.8886138		
## Dec 1992	47.0066901	-249.9987560	-209.8922117		
## Jan 1993	59.7412624	47.0066901	-249.9987560		
## Feb 1993	87.0298155	59.7412624	47.0066901		
## Mar 1993	50.6213421	87.0298155	59.7412624		
## Apr 1993	152.9709713	50.6213421	87.0298155		
## May 1993	188.5159054	152.9709713	50.6213421		
## Jun 1993	-140.3233776	188.5159054	152.9709713		
## Jul 1993	-0.4512091	-140.3233776	188.5159054		
## Aug 1993	-14.0921448	-0.4512091	-140.3233776		
## Sep 1993	28.8884518	-14.0921448	-0.4512091		
## Oct 1993	-209.8745022	28.8884518	-14.0921448		
## Nov 1993	-250.0029175	-209.8745022	28.8884518		
## Dec 1993	46.9845024	-250.0029175	-209.8745022		
## Jan 1994	59.7591687	46.9845024	-250.0029175		
## Feb 1994	87.0204447	59.7591687	46.9845024		
## Mar 1994	50.6175981	87.0204447	59.7591687		
## Apr 1994	152.9559592	50.6175981	87.0204447		
## May 1994	188.5163617	152.9559592	50.6175981		
## Jun 1994	-140.3217525	188.5163617	152.9559592		
## Jul 1994	-0.4659384	-140.3217525	188.5163617		
## Aug 1994	-14.1035402	-0.4659384	-140.3217525		
## Sep 1994	28.8758910	-14.1035402	-0.4659384		
## Oct 1994	-209.8625792	28.8758910	-14.1035402		
## Nov 1994	-249.9845346	-209.8625792	28.8758910		
## Dec 1994	47.0008447	-249.9845346	-209.8625792		
## Jan 1995	59.7453932	47.0008447	-249.9845346		
## Feb 1995	87.0065597	59.7453932	47.0008447		
## Mar 1995	50.6065565	87.0065597	59.7453932		

## Apr 1995	152.9483236	50.6065565	87.0065597
## May 1995	188.5138834	152.9483236	50.6065565
## Jun 1995	-140.2950238	188.5138834	152.9483236
## Jul 1995	-0.4661775	-140.2950238	188.5138834
## Aug 1995	-14.1007860	-0.4661775	-140.2950238
## Sep 1995	28.8679229	-14.1007860	-0.4661775
## Oct 1995	-209.8651371	28.8679229	-14.1007860
## Nov 1995	-249.9886039	-209.8651371	28.8679229
## Dec 1995	47.0001739	-249.9886039	-209.8651371
## Jan 1996	59.7249278	47.0001739	-249.9886039
## Feb 1996	87.0006142	59.7249278	47.0001739
## Mar 1996	50.6104335	87.0006142	59.7249278
## Apr 1996	152.9314964	50.6104335	87.0006142
## May 1996	188.5186901	152.9314964	50.6104335
## Jun 1996	-140.2863617	188.5186901	152.9314964
## Jul 1996	-0.4788915	-140.2863617	188.5186901
## Aug 1996	-14.0962890	-0.4788915	-140.2863617
## Sep 1996	28.8547611	-14.0962890	-0.4788915
## Oct 1996	-209.8803631	28.8547611	-14.0962890
## Nov 1996	-249.9904087	-209.8803631	28.8547611
## Dec 1996	46.9737608	-249.9904087	-209.8803631
## Jan 1997	59.7227729	46.9737608	-249.9904087
## Feb 1997	87.0153957	59.7227729	46.9737608
## Mar 1997	50.6254818	87.0153957	59.7227729
## Apr 1997	152.9485041	50.6254818	87.0153957
## May 1997	188.5446845	152.9485041	50.6254818
## Jun 1997	-140.2909067	188.5446845	152.9485041
## Jul 1997	-0.4821230	-140.2909067	188.5446845
## Aug 1997	-14.1226705	-0.4821230	-140.2909067
## Sep 1997	28.8640134	-14.1226705	-0.4821230
## Oct 1997	-209.8930523	28.8640134	-14.1226705
## Nov 1997	-249.9921202	-209.8930523	28.8640134
## Dec 1997	46.9830288	-249.9921202	-209.8930523
## Jan 1998	59.7099469	46.9830288	-249.9921202
## Feb 1998	87.0305990	59.7099469	46.9830288
## Mar 1998	50.6449513	87.0305990	59.7099469
## Apr 1998	152.9716254	50.6449513	87.0305990
## May 1998	188.5648209	152.9716254	50.6449513
## Jun 1998	-140.2982933	188.5648209	152.9716254
## Jul 1998	-0.4807141	-140.2982933	188.5648209
## Aug 1998	-14.1292435	-0.4807141	-140.2982933
## Sep 1998	28.8665820	-14.1292435	-0.4807141
## Oct 1998	-209.8886963	28.8665820	-14.1292435
## Nov 1998	-250.0205118	-209.8886963	28.8665820
## Dec 1998	46.9820217	-250.0205118	-209.8886963
## Jan 1999	59.7243516	46.9820217	-250.0205118
## Feb 1999	87.0346846	59.7243516	46.9820217
## Mar 1999	50.6516839	87.0346846	59.7243516
## Apr 1999	152.9849057	50.6516839	87.0346846
## May 1999	188.5495320	152.9849057	50.6516839
## Jun 1999	-140.2852653	188.5495320	152.9849057
## Jul 1999	-0.4795562	-140.2852653	188.5495320
## Aug 1999	-14.1186955	-0.4795562	-140.2852653
## Sep 1999	28.8679245	-14.1186955	-0.4795562

##	Oct	1999	-209.8903116	28.8679245	-14.1186955
##	Nov	1999	-250.0239361	-209.8903116	28.8679245
##	Dec	1999	46.9770244	-250.0239361	-209.8903116
##	Jan	2000	59.7207502	46.9770244	-250.0239361
##	Feb	2000	87.0277874	59.7207502	46.9770244
##	Mar	2000	50.6627430	87.0277874	59.7207502
##	Apr	2000	152.9894458	50.6627430	87.0277874
##	May	2000	188.5380533	152.9894458	50.6627430
##	Jun	2000	-140.2936650	188.5380533	152.9894458
##	Jul	2000	-0.4687134	-140.2936650	188.5380533
##	Aug	2000	-14.0983255	-0.4687134	-140.2936650
##	Sep	2000	28.8623019	-14.0983255	-0.4687134
##	Oct	2000	-209.9072619	28.8623019	-14.0983255
##	Nov	2000	-250.0016904	-209.9072619	28.8623019
##	Dec	2000	46.9883527	-250.0016904	-209.9072619
##	Jan	2001	59.7358989	46.9883527	-250.0016904
##	Feb	2001	87.0328394	59.7358989	46.9883527
##	Mar	2001	50.6788749	87.0328394	59.7358989
##	Apr	2001	152.9816226	50.6788749	87.0328394
##	May	2001	188.5366234	152.9816226	50.6788749
##	Jun	2001	-140.2800923	188.5366234	152.9816226
##	Jul	2001	-0.4592103	-140.2800923	188.5366234
##	Aug	2001	-14.0894497	-0.4592103	-140.2800923
##	Sep	2001	28.8599965	-14.0894497	-0.4592103
##	Oct	2001	-209.9284714	28.8599965	-14.0894497
##	Nov	2001	-250.0058607	-209.9284714	28.8599965
##	Dec	2001	46.9987646	-250.0058607	-209.9284714
##	Jan	2002	59.7413278	46.9987646	-250.0058607
##	Feb	2002	87.0341979	59.7413278	46.9987646
##	Mar	2002	50.6955417	87.0341979	59.7413278
##	Apr	2002	152.9765126	50.6955417	87.0341979
##	May	2002	188.5447684	152.9765126	50.6955417
##	Jun	2002	-140.3193372	188.5447684	152.9765126
##	Jul	2002	-0.4500151	-140.3193372	188.5447684
##	Aug	2002	-14.0759407	-0.4500151	-140.3193372
##	Sep	2002	28.8577834	-14.0759407	-0.4500151
##	Oct	2002	-209.9259227	28.8577834	-14.0759407
##	Nov	2002	-249.9915589	-209.9259227	28.8577834
##	Dec	2002	46.9928133	-249.9915589	-209.9259227
##	Jan	2003	59.7427463	46.9928133	-249.9915589
##	Feb	2003	87.0330405	59.7427463	46.9928133
##	Mar	2003	50.6851827	87.0330405	59.7427463
##	Apr	2003	152.9664183	50.6851827	87.0330405
##	May	2003	188.5185432	152.9664183	50.6851827
##	Jun	2003	-140.3215792	188.5185432	152.9664183
##	Jul	2003	-0.4399819	-140.3215792	188.5185432
##	Aug	2003	-14.0830430	-0.4399819	-140.3215792
##	Sep	2003	28.8791585	-14.0830430	-0.4399819
##	Oct	2003	-209.9111482	28.8791585	-14.0830430
##	Nov	2003	-249.9820236	-209.9111482	28.8791585
##	Dec	2003	47.0022070	-249.9820236	-209.9111482
##	Jan	2004	59.7519972	47.0022070	-249.9820236
##	Feb	2004	87.0316596	59.7519972	47.0022070
##	Mar	2004	50.7003357	87.0316596	59.7519972



```
## ETS(M,A,A)
##
## Call:
## ets(y = train.ts, model = "MAA")
##
## Smoothing parameters:
##   alpha = 0.5518
##   beta  = 1e-04
##   gamma = 1e-04
##
## Initial states:
##   l = 1838.577
##   b = 0.8081
##   s=28.4454 -11.2187 -0.5337 -124.2766 200.1969 146.8103
##       36.5908 76.044 60.153 44.1791 -249.4682 -206.9221
##
## sigma: 0.0342
##
##      AIC      AICc      BIC
## 1617.596 1623.424 1665.403
##
##      l      b      s1      s2      s3
## 1838.5770301 0.8081064 28.4453626 -11.2186753 -0.5336870
##      s4      s5      s6      s7      s8
## -124.2766167 200.1968557 146.8102880 36.5907511 76.0439635
##      s9      s10     s11     s12
## 60.1530346 44.1790580 -249.4681974 -206.9221371
```

##	l	b	s1	s2	s3
##	1944.5564806	0.8100101	44.1899049	-249.4709519	-206.9249239
##	s4	s5	s6	s7	s8
##	28.4436406	-11.2161757	-0.5324645	-124.2747514	200.1936173
##	s9	s10	s11	s12	
##	146.8106008	36.5892133	76.0565944	60.1377124	

##		l	b	s1	s2	s3
##	Dec 1990	1838.577	0.8081064	28.4453626	-11.2186753	-0.5336870
##	Jan 1991	1881.572	0.8166687	-206.9130684	28.4453626	-11.2186753
##	Feb 1991	1875.582	0.8152873	-249.4696605	-206.9130684	28.4453626
##	Mar 1991	1905.167	0.8211264	44.1852425	-249.4696605	-206.9130684
##	Apr 1991	1820.750	0.8038262	60.1347112	44.1852425	-249.4696605
##	May 1991	1864.244	0.8124907	76.0531404	60.1347112	44.1852425
##	Jun 1991	1843.376	0.8080904	36.5860906	76.0531404	60.1347112
##	Jul 1991	1815.969	0.8023637	146.8042226	36.5860906	76.0531404
##	Aug 1991	1814.727	0.8019489	200.1964164	146.8042226	36.5860906
##	Sep 1991	1762.781	0.7912429	-124.2879560	200.1964164	146.8042226
##	Oct 1991	1742.541	0.7869744	-0.5382079	-124.2879560	200.1964164
##	Nov 1991	1712.184	0.7806532	-11.2253703	-0.5382079	-124.2879560
##	Dec 1991	1752.943	0.7887675	28.4539567	-11.2253703	-0.5382079
##	Jan 1992	1791.258	0.7963839	-206.9050015	28.4539567	-11.2253703
##	Feb 1992	1800.057	0.7980082	-249.4679402	-206.9050015	28.4539567
##	Mar 1992	1826.338	0.8031803	44.1907205	-249.4679402	-206.9050015
##	Apr 1992	1865.052	0.8108747	60.1428607	44.1907205	-249.4679402
##	May 1992	1834.299	0.8044685	76.0463553	60.1428607	44.1907205
##	Jun 1992	1697.903	0.7766217	36.5565967	76.0463553	60.1428607
##	Jul 1992	1730.587	0.7830978	146.8110817	36.5565967	76.0463553
##	Aug 1992	1767.317	0.7903936	200.2041437	146.8110817	36.5565967
##	Sep 1992	1801.257	0.7971219	-124.2808297	200.2041437	146.8110817
##	Oct 1992	1806.736	0.7980720	-0.5372016	-124.2808297	200.2041437
##	Nov 1992	1843.561	0.8053844	-11.2176255	-0.5372016	-124.2808297
##	Dec 1992	1845.637	0.8056421	28.4542297	-11.2176255	-0.5372016
##	Jan 1993	1882.707	0.8130024	-206.8972058	28.4542297	-11.2176255
##	Feb 1993	1874.958	0.8112647	-249.4697807	-206.8972058	28.4542297
##	Mar 1993	1829.832	0.8019412	44.1808456	-249.4697807	-206.8972058
##	Apr 1993	1867.199	0.8093625	60.1507210	44.1808456	-249.4697807
##	May 1993	1853.182	0.8063533	76.0431681	60.1507210	44.1808456
##	Jun 1993	1849.493	0.8054409	36.5556304	76.0431681	60.1507210
##	Jul 1993	1814.928	0.7982621	146.8034783	36.5556304	76.0431681
##	Aug 1993	1804.821	0.7960487	200.2017994	146.8034783	36.5556304
##	Sep 1993	1800.930	0.7950972	-124.2818374	200.2017994	146.8034783
##	Oct 1993	1775.040	0.7896812	-0.5429380	-124.2818374	200.2017994
##	Nov 1993	1751.421	0.7847272	-11.2228725	-0.5429380	-124.2818374
##	Dec 1993	1726.621	0.7795343	28.4487297	-11.2228725	-0.5429380
##	Jan 1994	1751.051	0.7843346	-206.8921216	28.4487297	-11.2228725
##	Feb 1994	1791.340	0.7923525	-249.4612885	-206.8921216	28.4487297
##	Mar 1994	1828.730	0.7997806	44.1887130	-249.4612885	-206.8921216
##	Apr 1994	1798.744	0.7935322	60.1441030	44.1887130	-249.4612885
##	May 1994	1774.965	0.7885450	76.0378859	60.1441030	44.1887130
##	Jun 1994	1755.584	0.7844511	36.5512944	76.0378859	60.1441030
##	Jul 1994	1736.689	0.7804570	146.7992480	36.5512944	76.0378859
##	Aug 1994	1720.329	0.7769781	200.1981147	146.7992480	36.5512944
##	Sep 1994	1770.109	0.7869240	-124.2713033	200.1981147	146.7992480

##	Oct	1994	1775.417	0.7878415	-0.5419662	-124.2713033	200.1981147
##	Nov	1994	1782.282	0.7890749	-11.2215662	-0.5419662	-124.2713033
##	Dec	1994	1767.527	0.7859201	28.4453883	-11.2215662	-0.5419662
##	Jan	1995	1761.137	0.7844635	-206.8936643	28.4453883	-11.2215662
##	Feb	1995	1753.349	0.7827238	-249.4631312	-206.8936643	28.4453883
##	Mar	1995	1754.129	0.7827232	44.1887124	-249.4631312	-206.8936643
##	Apr	1995	1709.576	0.7735218	60.1343574	44.1887124	-249.4631312
##	May	1995	1702.601	0.7719491	76.0362202	60.1343574	44.1887124
##	Jun	1995	1715.117	0.7743326	36.5538189	76.0362202	60.1343574
##	Jul	1995	1676.695	0.7663771	146.7908221	36.5538189	76.0362202
##	Aug	1995	1675.894	0.7660592	200.1977780	146.7908221	36.5538189
##	Sep	1995	1687.100	0.7681781	-124.2690591	200.1977780	146.7908221
##	Oct	1995	1665.588	0.7636560	-0.5467558	-124.2690591	200.1977780
##	Nov	1995	1676.008	0.7656160	-11.2194903	-0.5467558	-124.2690591
##	Dec	1995	1650.082	0.7601984	28.4396503	-11.2194903	-0.5467558
##	Jan	1996	1616.526	0.7532335	-206.9010411	28.4396503	-11.2194903
##	Feb	1996	1613.437	0.7524536	-249.4639573	-206.9010411	28.4396503
##	Mar	1996	1559.119	0.7412764	44.1768742	-249.4639573	-206.9010411
##	Apr	1996	1553.474	0.7399801	60.1329844	44.1768742	-249.4639573
##	May	1996	1590.878	0.7474216	76.0441018	60.1329844	44.1768742
##	Jun	1996	1627.494	0.7547016	36.5615294	76.0441018	60.1329844
##	Jul	1996	1661.619	0.7614746	146.7979956	36.5615294	76.0441018
##	Aug	1996	1706.521	0.7704334	200.2072667	146.7979956	36.5615294
##	Sep	1996	1689.843	0.7668921	-124.2728099	200.2072667	146.7979956
##	Oct	1996	1688.648	0.7664940	-0.5471774	-124.2728099	200.2072667
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##	Dec	1996	1654.916	0.7593388	28.4441697	-11.2315881	-0.5471774
##	Jan	1997	1626.880	0.7534943	-206.9072313	28.4441697	-11.2315881
##	Feb	1997	1624.058	0.7527687	-249.4647258	-206.9072313	28.4441697
##	Mar	1997	1646.074	0.7570842	44.1814450	-249.4647258	-206.9072313
##	Apr	1997	1617.939	0.7512203	60.1267737	44.1814450	-249.4647258
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##	Jun	1997	1702.407	0.7680577	36.5712767	76.0521877	60.1267737
##	Jul	1997	1749.661	0.7774926	146.8079886	36.5712767	76.0521877
##	Aug	1997	1782.116	0.7839221	200.2140764	146.8079886	36.5712767
##	Sep	1997	1759.337	0.7791396	-124.2778752	200.2140764	146.8079886
##	Oct	1997	1768.029	0.7807457	-0.5454763	-124.2778752	200.2140764
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##	Dec	1997	1762.577	0.7793227	28.4456530	-11.2345785	-0.5454763
##	Jan	1998	1771.016	0.7808773	-206.9055848	28.4456530	-11.2345785
##	Feb	1998	1711.298	0.7685983	-249.4777310	-206.9055848	28.4456530
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##	May	1998	1755.875	0.7771768	76.0551945	60.1330434	44.1812544
##	Jun	1998	1774.718	0.7808434	36.5751602	76.0551945	60.1330434
##	Jul	1998	1800.807	0.7859800	146.8134290	36.5751602	76.0551945
##	Aug	1998	1757.360	0.7770024	200.2045679	146.8134290	36.5751602
##	Sep	1998	1777.857	0.7810047	-124.2736362	200.2045679	146.8134290
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##	Nov	1998	1809.507	0.7871113	-11.2296981	-0.5438891	-124.2736362
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##	Jul	1999	1813.583	0.7866642	146.8148440	36.5809988	76.0531217
##	Aug	1999	1778.188	0.7793206	200.1967899	146.8148440	36.5809988
##	Sep	1999	1752.856	0.7740211	-124.2792491	200.1967899	146.8148440
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##	Jun	2000	1942.142	0.8109996	36.5892133	76.0565944	60.1377124
##	Jul	2000	1923.214	0.8069934	146.8106008	36.5892133	76.0565944
##	Aug	2000	1909.263	0.8039979	200.1936173	146.8106008	36.5892133
##	Sep	2000	1930.990	0.8082445	-124.2747514	200.1936173	146.8106008
##	Oct	2000	1957.035	0.8133667	-0.5324645	-124.2747514	200.1936173
##	Nov	2000	1977.040	0.8172618	-11.2161757	-0.5324645	-124.2747514
##	Dec	2000	1974.464	0.8165733	28.4436406	-11.2161757	-0.5324645
##	Jan	2001	1928.259	0.8070294	-206.9249239	28.4436406	-11.2161757
##	Feb	2001	1920.131	0.8052160	-249.4709519	-206.9249239	28.4436406
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##	Dec	1990	-124.2766167	200.1968557	146.8102880	36.5907511	76.0439635
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##	Feb	1991	-11.2186753	-0.5336870	-124.2766167	200.1968557	146.8102880
##	Mar	1991	28.4453626	-11.2186753	-0.5336870	-124.2766167	200.1968557
##	Apr	1991	-206.9130684	28.4453626	-11.2186753	-0.5336870	-124.2766167
##	May	1991	-249.4696605	-206.9130684	28.4453626	-11.2186753	-0.5336870
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##	Jun	1992	44.1907205	-249.4679402	-206.9050015	28.4539567	-11.2253703
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## May 1994	-249.4612885	-206.8921216	28.4487297	-11.2228725	-0.5429380
## Jun 1994	44.1887130	-249.4612885	-206.8921216	28.4487297	-11.2228725
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## May 1996	-249.4639573	-206.9010411	28.4396503	-11.2194903	-0.5467558
## Jun 1996	44.1768742	-249.4639573	-206.9010411	28.4396503	-11.2194903
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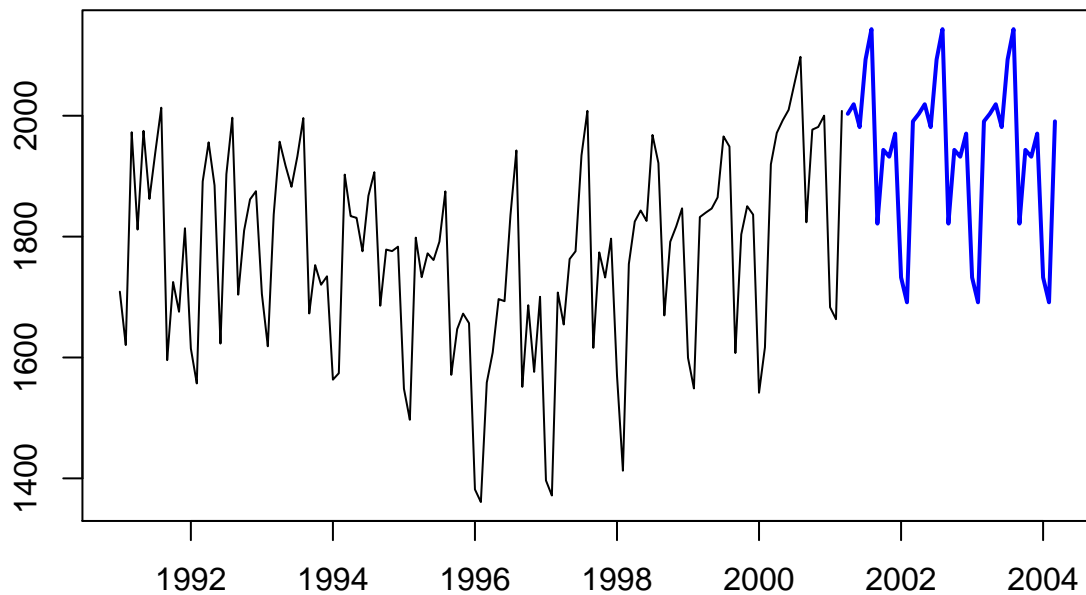
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## Mar 1992	146.8042226	36.5860906	76.0531404	60.1347112
## Apr 1992	200.1964164	146.8042226	36.5860906	76.0531404
## May 1992	-124.2879560	200.1964164	146.8042226	36.5860906
## Jun 1992	-0.5382079	-124.2879560	200.1964164	146.8042226
## Jul 1992	-11.2253703	-0.5382079	-124.2879560	200.1964164
## Aug 1992	28.4539567	-11.2253703	-0.5382079	-124.2879560
## Sep 1992	-206.9050015	28.4539567	-11.2253703	-0.5382079
## Oct 1992	-249.4679402	-206.9050015	28.4539567	-11.2253703
## Nov 1992	44.1907205	-249.4679402	-206.9050015	28.4539567
## Dec 1992	60.1428607	44.1907205	-249.4679402	-206.9050015
## Jan 1993	76.0463553	60.1428607	44.1907205	-249.4679402
## Feb 1993	36.5565967	76.0463553	60.1428607	44.1907205
## Mar 1993	146.8110817	36.5565967	76.0463553	60.1428607
## Apr 1993	200.2041437	146.8110817	36.5565967	76.0463553
## May 1993	-124.2808297	200.2041437	146.8110817	36.5565967
## Jun 1993	-0.5372016	-124.2808297	200.2041437	146.8110817
## Jul 1993	-11.2176255	-0.5372016	-124.2808297	200.2041437
## Aug 1993	28.4542297	-11.2176255	-0.5372016	-124.2808297
## Sep 1993	-206.8972058	28.4542297	-11.2176255	-0.5372016
## Oct 1993	-249.4697807	-206.8972058	28.4542297	-11.2176255
## Nov 1993	44.1808456	-249.4697807	-206.8972058	28.4542297
## Dec 1993	60.1507210	44.1808456	-249.4697807	-206.8972058
## Jan 1994	76.0431681	60.1507210	44.1808456	-249.4697807
## Feb 1994	36.5556304	76.0431681	60.1507210	44.1808456
## Mar 1994	146.8034783	36.5556304	76.0431681	60.1507210
## Apr 1994	200.2017994	146.8034783	36.5556304	76.0431681
## May 1994	-124.2818374	200.2017994	146.8034783	36.5556304
## Jun 1994	-0.5429380	-124.2818374	200.2017994	146.8034783
## Jul 1994	-11.2228725	-0.5429380	-124.2818374	200.2017994
## Aug 1994	28.4487297	-11.2228725	-0.5429380	-124.2818374
## Sep 1994	-206.8921216	28.4487297	-11.2228725	-0.5429380
## Oct 1994	-249.4612885	-206.8921216	28.4487297	-11.2228725
## Nov 1994	44.1887130	-249.4612885	-206.8921216	28.4487297
## Dec 1994	60.1441030	44.1887130	-249.4612885	-206.8921216
## Jan 1995	76.0378859	60.1441030	44.1887130	-249.4612885
## Feb 1995	36.5512944	76.0378859	60.1441030	44.1887130
## Mar 1995	146.7992480	36.5512944	76.0378859	60.1441030
## Apr 1995	200.1981147	146.7992480	36.5512944	76.0378859
## May 1995	-124.2713033	200.1981147	146.7992480	36.5512944
## Jun 1995	-0.5419662	-124.2713033	200.1981147	146.7992480
## Jul 1995	-11.2215662	-0.5419662	-124.2713033	200.1981147
## Aug 1995	28.4453883	-11.2215662	-0.5419662	-124.2713033
## Sep 1995	-206.8936643	28.4453883	-11.2215662	-0.5419662
## Oct 1995	-249.4631312	-206.8936643	28.4453883	-11.2215662
## Nov 1995	44.1887124	-249.4631312	-206.8936643	28.4453883
## Dec 1995	60.1343574	44.1887124	-249.4631312	-206.8936643
## Jan 1996	76.0362202	60.1343574	44.1887124	-249.4631312
## Feb 1996	36.5538189	76.0362202	60.1343574	44.1887124
## Mar 1996	146.7908221	36.5538189	76.0362202	60.1343574
## Apr 1996	200.1977780	146.7908221	36.5538189	76.0362202
## May 1996	-124.2690591	200.1977780	146.7908221	36.5538189

## Jun 1996	-0.5467558	-124.2690591	200.1977780	146.7908221
## Jul 1996	-11.2194903	-0.5467558	-124.2690591	200.1977780
## Aug 1996	28.4396503	-11.2194903	-0.5467558	-124.2690591
## Sep 1996	-206.9010411	28.4396503	-11.2194903	-0.5467558
## Oct 1996	-249.4639573	-206.9010411	28.4396503	-11.2194903
## Nov 1996	44.1768742	-249.4639573	-206.9010411	28.4396503
## Dec 1996	60.1329844	44.1768742	-249.4639573	-206.9010411
## Jan 1997	76.0441018	60.1329844	44.1768742	-249.4639573
## Feb 1997	36.5615294	76.0441018	60.1329844	44.1768742
## Mar 1997	146.7979956	36.5615294	76.0441018	60.1329844
## Apr 1997	200.2072667	146.7979956	36.5615294	76.0441018
## May 1997	-124.2728099	200.2072667	146.7979956	36.5615294
## Jun 1997	-0.5471774	-124.2728099	200.2072667	146.7979956
## Jul 1997	-11.2315881	-0.5471774	-124.2728099	200.2072667
## Aug 1997	28.4441697	-11.2315881	-0.5471774	-124.2728099
## Sep 1997	-206.9072313	28.4441697	-11.2315881	-0.5471774
## Oct 1997	-249.4647258	-206.9072313	28.4441697	-11.2315881
## Nov 1997	44.1814450	-249.4647258	-206.9072313	28.4441697
## Dec 1997	60.1267737	44.1814450	-249.4647258	-206.9072313
## Jan 1998	76.0521877	60.1267737	44.1814450	-249.4647258
## Feb 1998	36.5712767	76.0521877	60.1267737	44.1814450
## Mar 1998	146.8079886	36.5712767	76.0521877	60.1267737
## Apr 1998	200.2140764	146.8079886	36.5712767	76.0521877
## May 1998	-124.2778752	200.2140764	146.8079886	36.5712767
## Jun 1998	-0.5454763	-124.2778752	200.2140764	146.8079886
## Jul 1998	-11.2345785	-0.5454763	-124.2778752	200.2140764
## Aug 1998	28.4456530	-11.2345785	-0.5454763	-124.2778752
## Sep 1998	-206.9055848	28.4456530	-11.2345785	-0.5454763
## Oct 1998	-249.4777310	-206.9055848	28.4456530	-11.2345785
## Nov 1998	44.1812544	-249.4777310	-206.9055848	28.4456530
## Dec 1998	60.1330434	44.1812544	-249.4777310	-206.9055848
## Jan 1999	76.0551945	60.1330434	44.1812544	-249.4777310
## Feb 1999	36.5751602	76.0551945	60.1330434	44.1812544
## Mar 1999	146.8134290	36.5751602	76.0551945	60.1330434
## Apr 1999	200.2045679	146.8134290	36.5751602	76.0551945
## May 1999	-124.2736362	200.2045679	146.8134290	36.5751602
## Jun 1999	-0.5438891	-124.2736362	200.2045679	146.8134290
## Jul 1999	-11.2296981	-0.5438891	-124.2736362	200.2045679
## Aug 1999	28.4466036	-11.2296981	-0.5438891	-124.2736362
## Sep 1999	-206.9066727	28.4466036	-11.2296981	-0.5438891
## Oct 1999	-249.4792670	-206.9066727	28.4466036	-11.2296981
## Nov 1999	44.1792712	-249.4792670	-206.9066727	28.4466036
## Dec 1999	60.1310456	44.1792712	-249.4792670	-206.9066727
## Jan 2000	76.0531217	60.1310456	44.1792712	-249.4792670
## Feb 2000	36.5809988	76.0531217	60.1310456	44.1792712
## Mar 2000	146.8148440	36.5809988	76.0531217	60.1310456
## Apr 2000	200.1967899	146.8148440	36.5809988	76.0531217
## May 2000	-124.2792491	200.1967899	146.8148440	36.5809988
## Jun 2000	-0.5378897	-124.2792491	200.1967899	146.8148440
## Jul 2000	-11.2203012	-0.5378897	-124.2792491	200.1967899
## Aug 2000	28.4443699	-11.2203012	-0.5378897	-124.2792491
## Sep 2000	-206.9148156	28.4443699	-11.2203012	-0.5378897
## Oct 2000	-249.4690312	-206.9148156	28.4443699	-11.2203012
## Nov 2000	44.1848272	-249.4690312	-206.9148156	28.4443699

```
## Dec 2000    60.1377124    44.1848272 -249.4690312 -206.9148156
## Jan 2001    76.0565944    60.1377124    44.1848272 -249.4690312
## Feb 2001    36.5892133    76.0565944    60.1377124    44.1848272
## Mar 2001    146.8106008    36.5892133    76.0565944    60.1377124
```

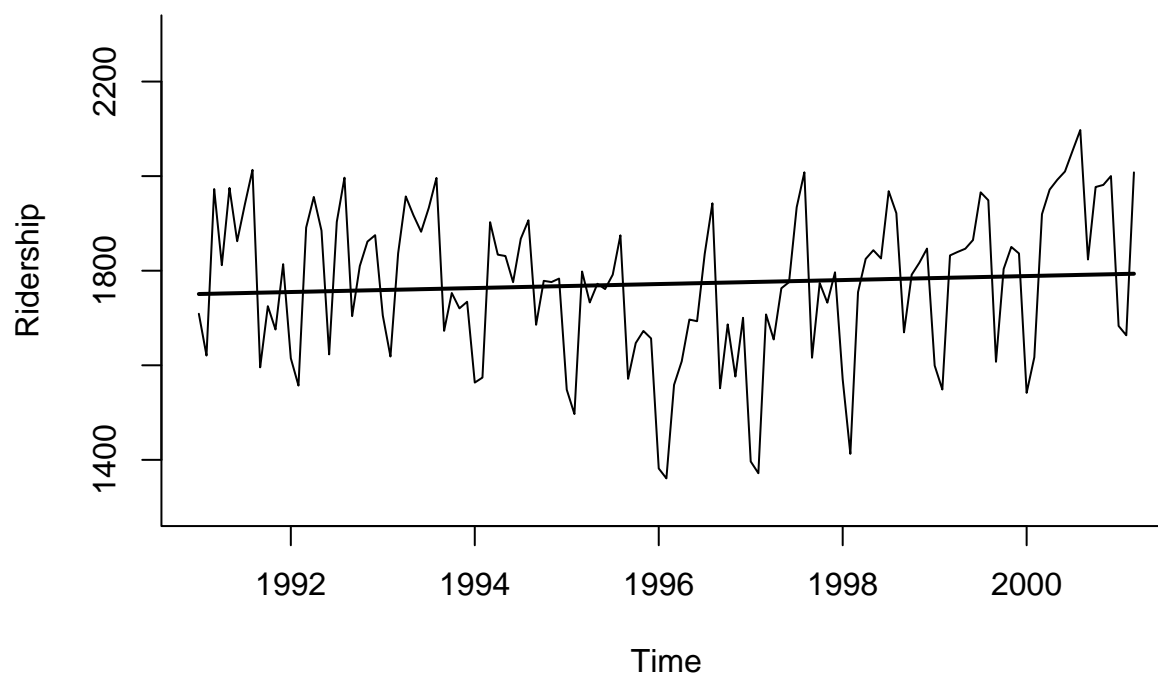
Forecasts from ETS(M,N,A)



```
##              ME      RMSE      MAE      MPE      MAPE      MASE
## Training set  0.1382018 56.49150 45.22527 -0.07920944 2.579613 0.5482385
## Test set      33.6684422 76.65107 62.16977  1.58152634 3.122042 0.7536464
##              ACF1 Theil's U
## Training set  0.06063493      NA
## Test set      0.61655528 0.4430438

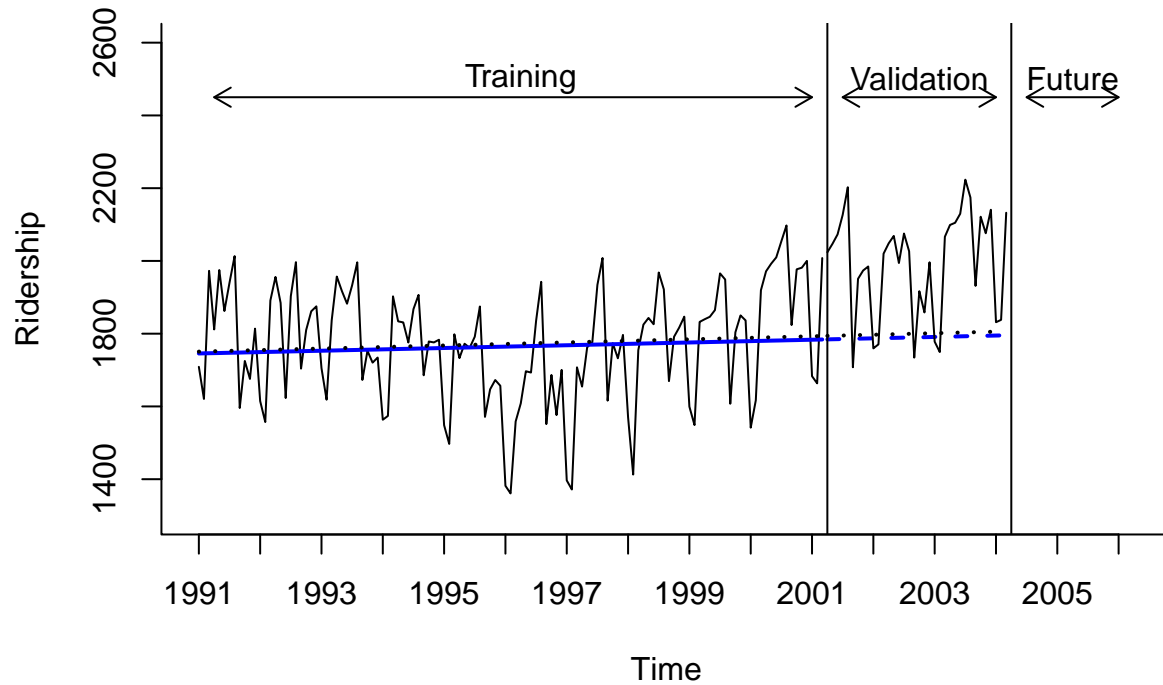
##              ME      RMSE      MAE      MPE      MAPE      MASE
## Training set  1.98570 56.86248 45.21332 0.02883941 2.576978 0.5480937
## Test set      49.72735 88.62810 73.96379 2.39118826 3.707185 0.8966182
##              ACF1 Theil's U
## Training set  0.06113138      NA
## Test set      0.65425349 0.5135193
```

Smoothing



```
##
## Call:
## tslm(formula = train.ts ~ trend)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -411.29 -114.02   16.06  129.28  306.35
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 1750.3595    29.0729   60.206  <2e-16 ***
## trend         0.3514     0.4069    0.864    0.39
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 160.2 on 121 degrees of freedom
## Multiple R-squared:  0.006125,    Adjusted R-squared:  -0.002089
## F-statistic: 0.7456 on 1 and 121 DF,  p-value: 0.3896
```

Box-Cox Transformation

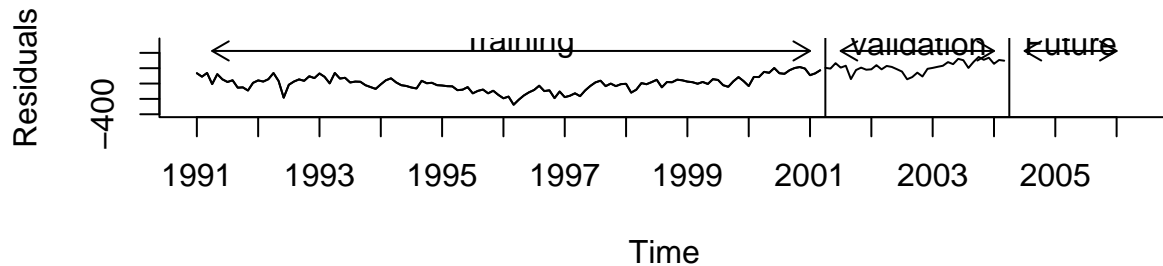
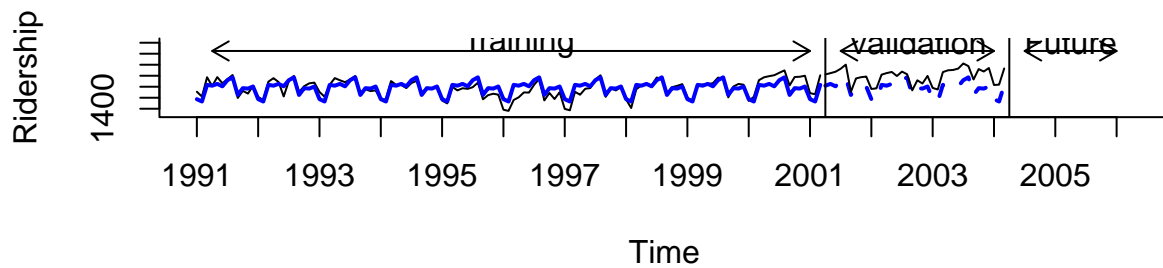


##	Jan	Feb	Mar	Apr	May	Jun	Jul
## 1991	7.443615	7.390543	7.587166	7.502002	7.588305	7.529598	7.570371
## 1992	7.386983	7.350573	7.544979	7.578647	7.541531	7.392057	7.551349
## 1993	7.441472	7.389277	7.515731	7.579190	7.558613	7.540302	7.566833
## 1994	7.354596	7.361349	7.550997	7.514194	7.512644	7.481981	7.532360
## 1995	7.344987	7.311168	7.494606	7.457549	7.480059	7.473755	7.490895
## 1996	7.231112	7.215866	7.351527	7.383008	7.436438	7.434365	7.515081
## 1997	7.241787	7.223799	7.442798	7.411317	7.474717	7.482006	7.567459
## 1998	7.359041	7.253252	7.470020	7.509298	7.519307	7.509863	7.584860
## 1999	7.377401	7.345238	7.513345	7.517369	7.521046	7.530937	7.583626
## 2000	7.340615	7.388283	7.559840	7.586546	7.597046	7.605772	7.627542
## 2001	7.428421	7.416621	7.604859				
##	Aug	Sep	Oct	Nov	Dec		
## 1991	7.607513	7.375041	7.452938	7.423967	7.503214		
## 1992	7.599257	7.440673	7.501082	7.529192	7.536429		
## 1993	7.598984	7.422279	7.468985	7.450299	7.458355		
## 1994	7.553081	7.429896	7.483551	7.482116	7.486249		
## 1995	7.536268	7.359664	7.406679	7.422153	7.412670		
## 1996	7.571769	7.346914	7.430415	7.362775	7.438638		
## 1997	7.604922	7.387662	7.480941	7.457245	7.493666		
## 1998	7.560937	7.420338	7.490794	7.504785	7.521185		
## 1999	7.575073	7.382356	7.497575	7.523108	7.515581		
## 2000	7.648488	7.508626	7.589334	7.591563	7.600979		
## 2001							

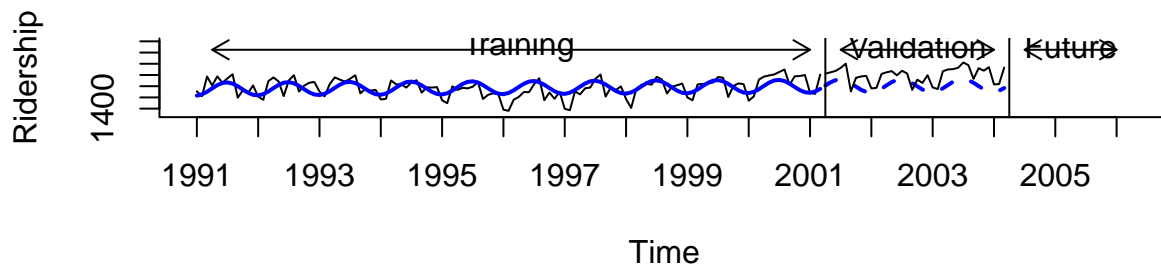
Smoothing with various Permutations of Interaction Terms

```
##
## Call:
## tslm(formula = train.ts ~ trend + I(trend^2))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -344.79 -101.86   40.89   98.54  279.81
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 1888.88401   40.91521  46.166 < 2e-16 ***
## trend        -6.29780    1.52327  -4.134 6.63e-05 ***
## I(trend^2)     0.05362    0.01190   4.506 1.55e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 148.8 on 120 degrees of freedom
## Multiple R-squared:  0.1499, Adjusted R-squared:  0.1358
## F-statistic: 10.58 on 2 and 120 DF,  p-value: 5.844e-05

##
## Call:
## tslm(formula = train.ts ~ season)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -276.165  -52.934    5.868   54.544  215.081
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1573.97      30.58  51.475 < 2e-16 ***
## season2       -42.93      43.24  -0.993  0.3230
## season3       260.77      43.24   6.030 2.19e-08 ***
## season4       245.09      44.31   5.531 2.14e-07 ***
## season5       278.22      44.31   6.279 6.81e-09 ***
## season6       233.46      44.31   5.269 6.82e-07 ***
## season7       345.33      44.31   7.793 3.79e-12 ***
## season8       396.66      44.31   8.952 9.19e-15 ***
## season9        75.76      44.31   1.710  0.0901 .
## season10      200.61      44.31   4.527 1.51e-05 ***
## season11      192.36      44.31   4.341 3.14e-05 ***
## season12      230.42      44.31   5.200 9.18e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 101.4 on 111 degrees of freedom
## Multiple R-squared:  0.6348, Adjusted R-squared:  0.5986
## F-statistic: 17.54 on 11 and 111 DF,  p-value: < 2.2e-16
```



```
##
## Call:
## tslm(formula = train.ts ~ trend + I(sin(2 * pi * trend/12)) +
##       I(cos(2 * pi * trend/12)))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -318.34  -96.30    8.04   89.73  307.89
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   1748.0335    25.0477   69.788 < 2e-16 ***
## trend           0.4229     0.3507    1.206  0.23015
## I(sin(2 * pi * trend/12)) -48.2666    17.5260  -2.754  0.00681 **
## I(cos(2 * pi * trend/12)) -106.5245    17.6773  -6.026 1.93e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 137.9 on 119 degrees of freedom
## Multiple R-squared:  0.2762, Adjusted R-squared:  0.2579
## F-statistic: 15.14 on 3 and 119 DF, p-value: 2.088e-08
```



```
##
## Call:
## tslm(formula = train.ts ~ trend + I(trend^2) + season)
##
## Residuals:
```

	Min	1Q	Median	3Q	Max
	-213.775	-39.363	9.711	42.422	152.187

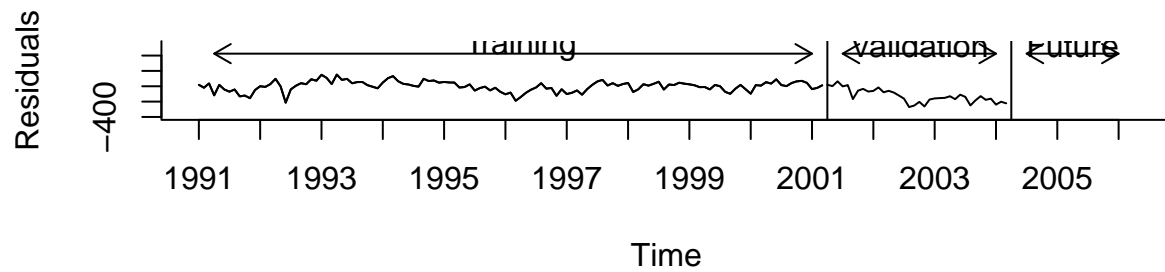
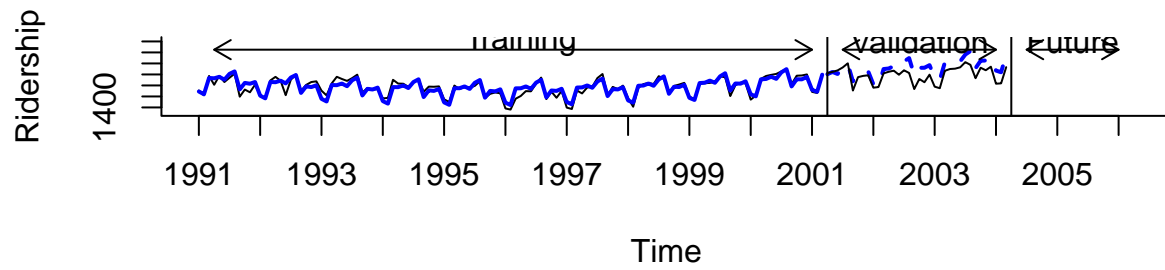
```
##
## Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	1.697e+03	2.768e+01	61.318	< 2e-16 ***
trend	-7.156e+00	7.293e-01	-9.812	< 2e-16 ***
I(trend^2)	6.074e-02	5.698e-03	10.660	< 2e-16 ***
season2	-4.325e+01	3.024e+01	-1.430	0.15556
season3	2.600e+02	3.024e+01	8.598	6.60e-14 ***
season4	2.606e+02	3.102e+01	8.401	1.83e-13 ***
season5	2.938e+02	3.102e+01	9.471	6.89e-16 ***
season6	2.490e+02	3.102e+01	8.026	1.26e-12 ***
season7	3.606e+02	3.102e+01	11.626	< 2e-16 ***
season8	4.117e+02	3.102e+01	13.270	< 2e-16 ***
season9	9.032e+01	3.102e+01	2.911	0.00437 **
season10	2.146e+02	3.102e+01	6.917	3.29e-10 ***
season11	2.057e+02	3.103e+01	6.629	1.34e-09 ***
season12	2.429e+02	3.103e+01	7.829	3.44e-12 ***

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

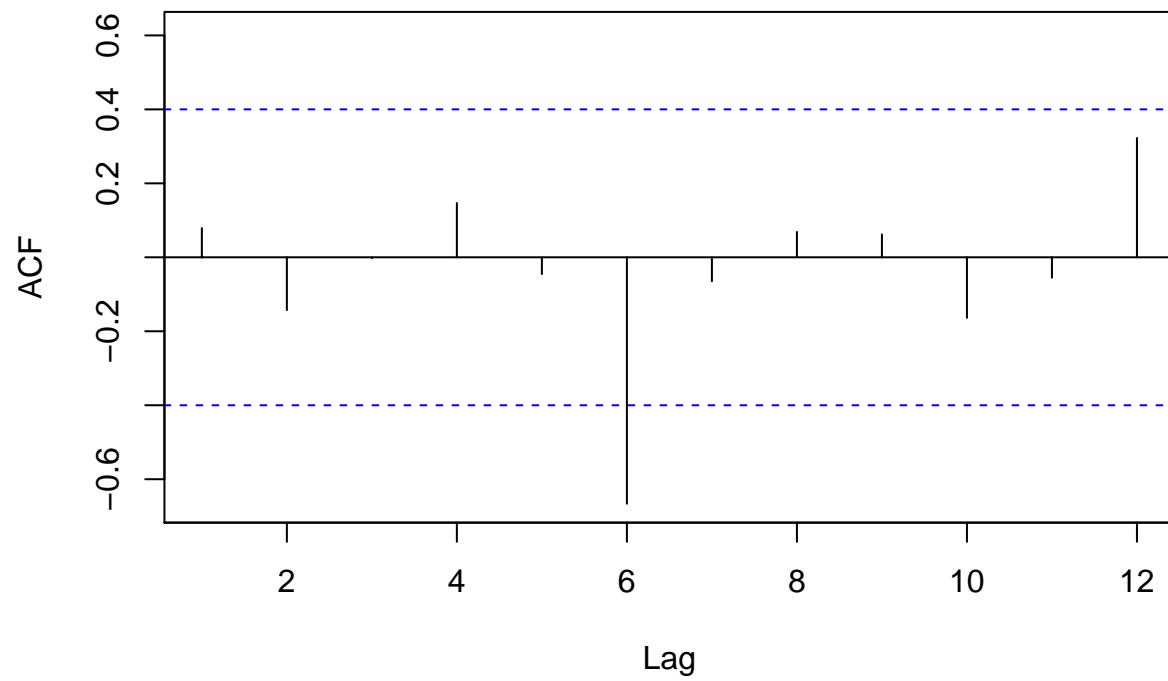


```
##
## Residual standard error: 70.92 on 109 degrees of freedom
## Multiple R-squared:  0.8246, Adjusted R-squared:  0.8037
## F-statistic: 39.42 on 13 and 109 DF,  p-value: < 2.2e-16
```

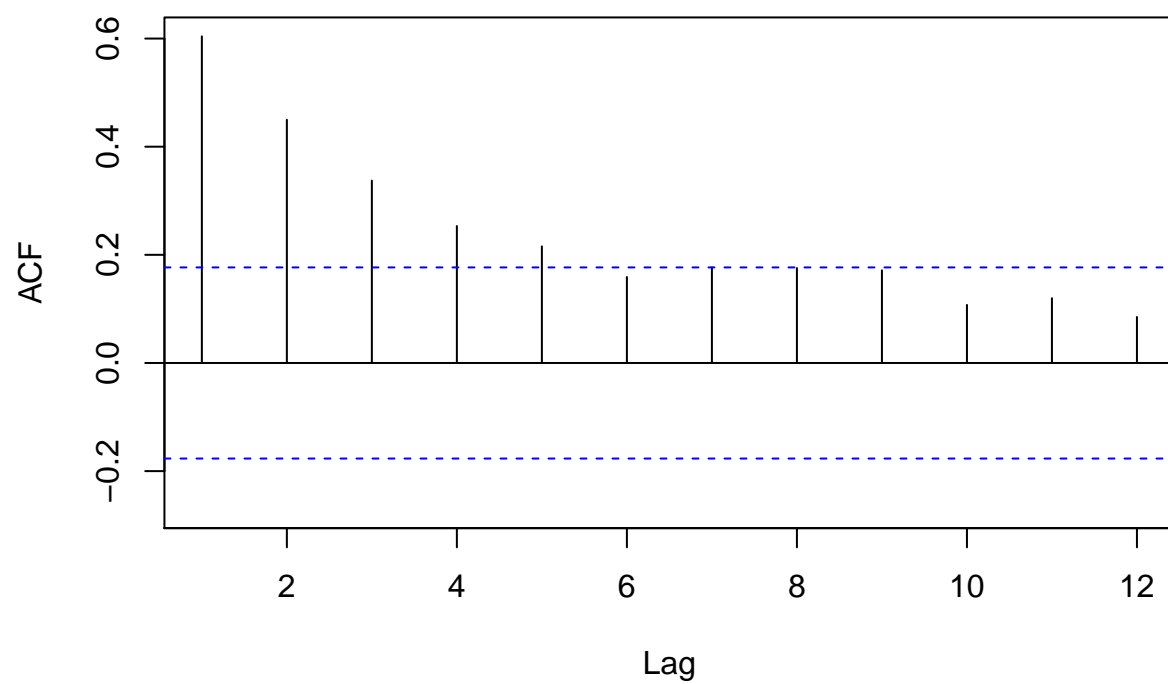


```
## null device
##          1
```

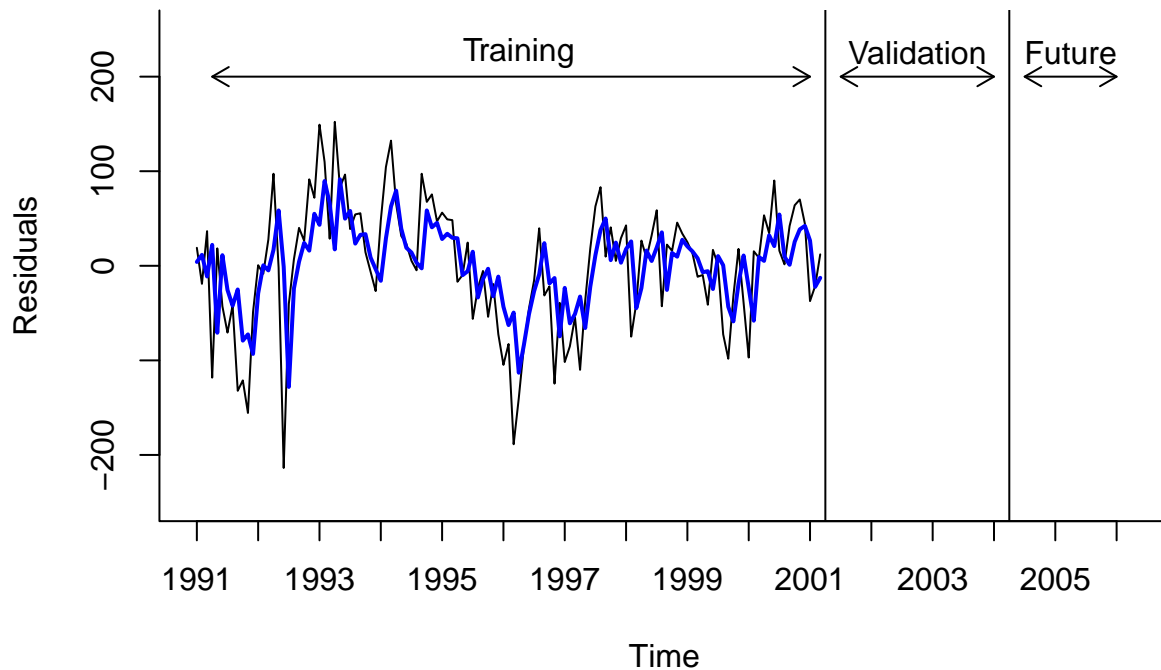
Auto Correlations Plot and Treatment



Accountitng for Seasonality and Autocorrelation



```
## , , 1
##
##      [,1]
## [1,] 1.00000000
## [2,] 0.60405883
## [3,] 0.44983171
## [4,] 0.33730830
## [5,] 0.25329034
## [6,] 0.21565844
## [7,] 0.15901326
## [8,] 0.17676683
## [9,] 0.17553762
## [10,] 0.17140882
## [11,] 0.10739472
## [12,] 0.11976519
## [13,] 0.08512942
```



```
## null device
##          1

## Series: train.lm.trend.season$residuals
## ARIMA(1,0,0) with non-zero mean
##
## Coefficients:
##          ar1      mean
##          0.5998  0.3728
## s.e.  0.0712  11.8408
##
## sigma^2 estimated as 2876:  log likelihood=-663.54
## AIC=1333.08  AICc=1333.29  BIC=1341.52
##
## Training set error measures:
##              ME      RMSE      MAE      MPE      MAPE      MASE
## Training set -0.1223159  53.19141  39.8277  103.3885  175.2219  0.5721356
##              ACF1
## Training set -0.07509305
```

Fitting Neural Nets to forecasting

```
## [1] 159

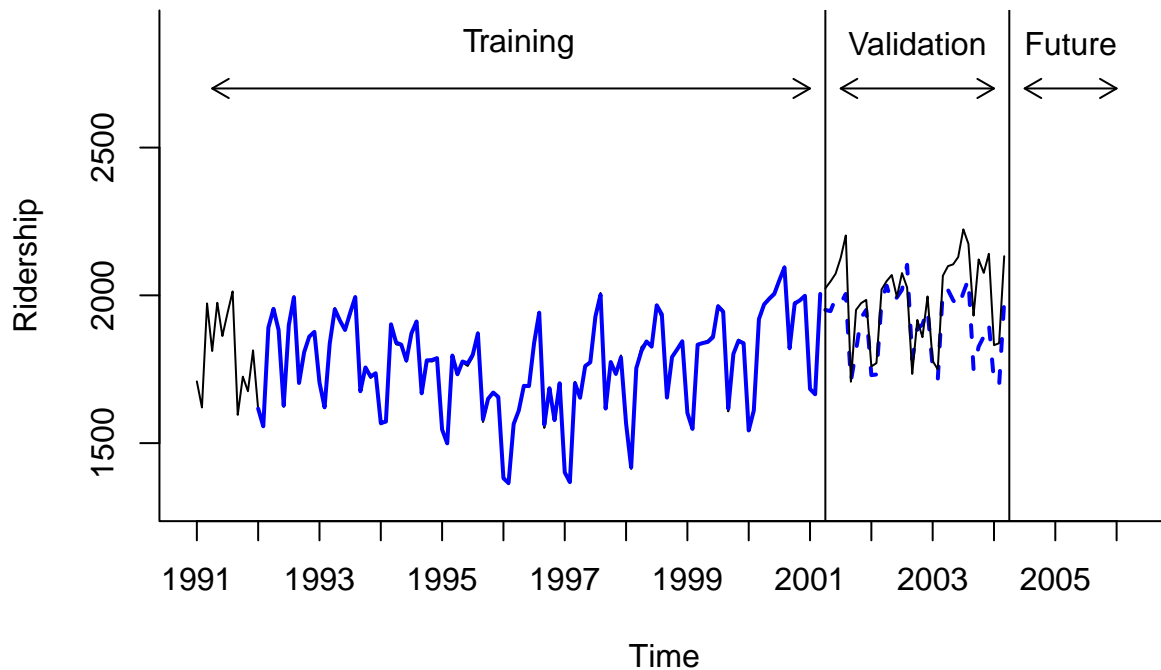
## a 12-7-1 network with 99 weights
## options were - linear output units
```

```

## b->h1 i1->h1 i2->h1 i3->h1 i4->h1 i5->h1 i6->h1 i7->h1 i8->h1
## 7.62 3.26 -0.51 -7.79 -0.40 4.18 -3.67 4.26 -6.99
## i9->h1 i10->h1 i11->h1 i12->h1
## 4.26 -0.37 1.22 4.58
## b->h2 i1->h2 i2->h2 i3->h2 i4->h2 i5->h2 i6->h2 i7->h2 i8->h2
## 0.84 -0.47 4.11 -6.37 -7.74 8.22 -6.46 2.65 -6.84
## i9->h2 i10->h2 i11->h2 i12->h2
## 8.29 1.42 5.43 -0.05
## b->h3 i1->h3 i2->h3 i3->h3 i4->h3 i5->h3 i6->h3 i7->h3 i8->h3
## 7.45 -7.59 -4.51 5.28 -2.60 -2.31 -7.64 1.37 -1.36
## i9->h3 i10->h3 i11->h3 i12->h3
## 3.91 4.33 -1.65 0.83
## b->h4 i1->h4 i2->h4 i3->h4 i4->h4 i5->h4 i6->h4 i7->h4 i8->h4
## -4.48 1.53 -1.92 -1.55 -6.22 8.73 -2.41 -1.68 -0.84
## i9->h4 i10->h4 i11->h4 i12->h4
## 9.37 -10.92 5.00 4.68
## b->h5 i1->h5 i2->h5 i3->h5 i4->h5 i5->h5 i6->h5 i7->h5 i8->h5
## 0.27 -2.11 -3.05 -3.50 -5.15 0.64 8.94 -6.71 -0.37
## i9->h5 i10->h5 i11->h5 i12->h5
## 12.48 -2.84 -0.30 -0.55
## b->h6 i1->h6 i2->h6 i3->h6 i4->h6 i5->h6 i6->h6 i7->h6 i8->h6
## -6.31 -4.68 1.54 -7.47 3.65 3.42 4.15 0.39 0.70
## i9->h6 i10->h6 i11->h6 i12->h6
## 0.28 -5.94 -4.73 -0.23
## b->h7 i1->h7 i2->h7 i3->h7 i4->h7 i5->h7 i6->h7 i7->h7 i8->h7
## 0.70 7.03 -8.27 2.06 -13.59 -0.39 8.68 2.16 3.89
## i9->h7 i10->h7 i11->h7 i12->h7
## 9.90 -1.84 -4.01 -4.10
## b->o h1->o h2->o h3->o h4->o h5->o h6->o h7->o
## 0.60 1.05 -1.05 -1.11 1.33 -1.64 -1.58 1.28

## ME RMSE MAE MPE MAPE
## Training set 0.1345029 4.60624 3.355614 0.001476058 0.1921153
## Test set 87.7655536 121.60742 97.251127 4.250144613 4.7525810
## MASE ACF1 Theil's U
## Training set 0.04067807 -0.03689506 NA
## Test set 1.17891637 0.62628789 0.6955393

```



```
## Series: train.ts
## Model: NNAR(2,1,2)[12]
## Call: nnetar(y = train.ts)
##
## Average of 20 networks, each of which is
## a 3-2-1 network with 11 weights
## options were - linear output units
##
## sigma^2 estimated as 6766
##
```

	ME	RMSE	MAE	MPE	MAPE	MASE
## Training set	-0.3492673	82.25378	67.07129	-0.2610314	3.875977	0.8130646
## Test set	-37.1540134	130.87578	100.48248	-2.2095656	5.236845	1.2180881

```
##
```

	ACF1	Theil's U
## Training set	0.3979050	NA
## Test set	0.3529398	0.762112