Project DS502

Abhishek Shah, Mahdi Alouane, Rahul Pande and Sam Longenbach

Import the training and testing datasets while converting white spaces to NAs as well

Then we first check for the presence of NA values.

```
##           Item_Identifier                Item_Weight
##                         0                      1463
##          Item_Fat_Content            Item_Visibility
##                         0                         0
##                 Item_Type                  Item_MRP
##                         0                         0
##         Outlet_Identifier Outlet_Establishment_Year
##                         0                         0
##               Outlet_Size       Outlet_Location_Type
##                      2410                         0
##               Outlet_Type          Item_Outlet_Sales
##                         0                         0
```

```
##           Item_Identifier                Item_Weight
##                         0                       976
##          Item_Fat_Content            Item_Visibility
##                         0                         0
##                 Item_Type                  Item_MRP
##                         0                         0
##         Outlet_Identifier Outlet_Establishment_Year
##                         0                         0
##               Outlet_Size       Outlet_Location_Type
##                      1606                         0
##               Outlet_Type
##                         0
```

We have missing values in `Item_Weight` and `Outlet_Size`.

Now, we check the frequencies of categorical variables.

```
## $Item_Fat_Content
##
##      LF low fat Low Fat     reg Regular
##     316     112    5089     117    2889
##
## $Item_Type
##
##          Baking Goods                Breads             Breakfast
##                   648                   251                   110
##                Canned                 Dairy          Frozen Foods
##                   649                   682                   856
## Fruits and Vegetables           Hard Drinks    Health and Hygiene
##                  1232                   214                   520
##             Household                  Meat                Others
##                   910                   425                   169
##               Seafood           Snack Foods           Soft Drinks
##                    64                  1200                   445
##         Starchy Foods
```

```
##                   148
##
## $Outlet_Identifier
##
## OUT010 OUT013 OUT017 OUT018 OUT019 OUT027 OUT035 OUT045 OUT046 OUT049
##    555    932    926    928    528    935    930    929    930    930
##
## $Outlet_Size
##
##   High Medium  Small
##    932   2793   2388
##
## $Outlet_Location_Type
##
## Tier 1 Tier 2 Tier 3
##   2388   2785   3350
##
## $Outlet_Type
##
##     Grocery Store Supermarket Type1 Supermarket Type2 Supermarket Type3
##              1083              5577               928               935
```

We aggregate on outlet level to impute outlet size

```
## character(0)
```

```
## character(0)
```

We see that there are no new stores in the test data that are not already encountered in the training data.

```
## -- Attaching packages ---------------------------------------------------------------------------
```

```
## ✓ ggplot2 3.0.0     ✓ purrr   0.2.5
## ✓ tibble  1.4.2     ✓ dplyr   0.7.6
## ✓ tidyr   0.8.1     ✓ stringr 1.3.1
## ✓ readr   1.2.1     ✓ forcats 0.3.0
```

```
## -- Conflicts ------------------------------------------------------------------------------------
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
## # A tibble: 10 x 3
##    Item_Identifier l_u_weights u_weights
##    <chr>                 <int> <chr>
##  1 FDE52                     1 NA
##  2 FDK57                     1 NA
##  3 FDN52                     1 NA
##  4 FDQ60                     1 NA
##  5 FDT16                     2 9.895 | NA
##  6 NCJ54                     2 9.895 | NA
##  7 DRD49                     1 9.895
##  8 FDR13                     1 9.895
##  9 FDA23                     2 9.8 | NA
## 10 FDC10                     2 9.8 | NA
```

We see that in some places weights are NA whereas it is not NA in other rows for the same item. We can just use weights from other observations where weight is not NA (For the same item). For this purpose the whole train and test datasets have been used to impute the missing information. Hence, we define the

following function for treating these missing values.

Then, we call it and check if the problem is resolved.

```
##           Item_Identifier               Item_Weight
##                         0                         0
##          Item_Fat_Content           Item_Visibility
##                         0                         0
##                 Item_Type                  Item_MRP
##                         0                         0
##         Outlet_Identifier Outlet_Establishment_Year
##                         0                         0
##               Outlet_Size      Outlet_Location_Type
##                      2410                         0
##               Outlet_Type         Item_Outlet_Sales
##                         0                         0
```

```
##           Item_Identifier               Item_Weight
##                         0                         0
##          Item_Fat_Content           Item_Visibility
##                         0                         0
##                 Item_Type                  Item_MRP
##                         0                         0
##         Outlet_Identifier Outlet_Establishment_Year
##                         0                         0
##               Outlet_Size      Outlet_Location_Type
##                      1606                         0
##               Outlet_Type
##                         0
```

Since, there is no more missing values for the feature `Item_Weight`, we treat in the following section the missing values for the feature `Outlet_Size`.

Given that `Outlet_Size` is an outlet specific attribute, we first begin by printing all the outlets available in our training set (10 outlets in total). Hence, we figure out that the 2410 missing values in training set belong to only 3 outlets and the size of these outlets is also missing in the testing set.

```
##    Outlet_Identifier Outlet_Size
## 1             OUT049      Medium
## 2             OUT018      Medium
## 4             OUT010        <NA>
## 5             OUT013        High
## 8             OUT027      Medium
## 9             OUT045        <NA>
## 10            OUT017        <NA>
## 12            OUT046       Small
## 20            OUT035       Small
## 24            OUT019       Small
```

In order to achieve this, we start by transforming the categorical attributes into dummy variables using `One Hot Encoding` as shown below:

```
## Loading required package: lattice
```

```
## Loading required package: grid
```

```
##  [1] "Outlet_Establishment_Year_1999" "Outlet_Establishment_Year_2009"
##  [3] "Outlet_Establishment_Year_1998" "Outlet_Establishment_Year_1987"
##  [5] "Outlet_Establishment_Year_1985" "Outlet_Establishment_Year_2002"
```

```
##  [7] "Outlet_Establishment_Year_2007" "Outlet_Establishment_Year_1997"
##  [9] "Outlet_Establishment_Year_2004" "Outlet_Location_Type_Tier 1"
## [11] "Outlet_Location_Type_Tier 3"    "Outlet_Location_Type_Tier 2"
## [13] "Outlet_Size_Medium"             "Outlet_Size_High"
## [15] "Outlet_Size_Small"              "Outlet_Type_Supermarket Type1"
## [17] "Outlet_Type_Supermarket Type2"  "Outlet_Type_Grocery Store"
## [19] "Outlet_Type_Supermarket Type3"
```

Then, we predict the missing values for `Outlet_Size` using the K-Nearest Neighbors with K=5. The algorithm reaches out for the 5 closest neighbors (after scaling) for each observation where the attribute is missing and according to a vote assigns a score using a weighted average (`meth='weighAvg`). Therefore, we compute the maximum among the three possible values (Small, Medium and High) and assign it to the corresponding observation.

We can see here the missing values and their prediction according to 5NN.

```
##    Outlet_Identifier Outlet_Establishment_Year Outlet_Size
## 4             OUT010                      1998      Medium
## 9             OUT045                      2002       Small
## 10            OUT017                      2007       Small
##    Outlet_Location_Type       Outlet_Type
## 4                Tier 3     Grocery Store
## 9                Tier 2 Supermarket Type1
## 10               Tier 2 Supermarket Type1
```

```
##   Outlet_Size_Medium Outlet_Size_High Outlet_Size_Small
## 3          0.4116651        0.2144811         0.3738537
## 6          0.1643578        0.1728448         0.6627974
## 7          0.1643578        0.1728448         0.6627974
```

Finally, we check to see that there is still any missing values:

```
##           Item_Identifier               Item_Weight
##                         0                         0
##          Item_Fat_Content           Item_Visibility
##                         0                         0
##                 Item_Type                  Item_MRP
##                         0                         0
##         Outlet_Identifier Outlet_Establishment_Year
##                         0                         0
##               Outlet_Size      Outlet_Location_Type
##                         0                         0
##               Outlet_Type         Item_Outlet_Sales
##                         0                         0
```

We fill the missing values in the testing set with the above-predicted values for each outlet as shown below:

After this, we check if there is any missing values in the testing set:

```
##           Item_Identifier               Item_Weight
##                         0                         0
##          Item_Fat_Content           Item_Visibility
##                         0                         0
##                 Item_Type                  Item_MRP
##                         0                         0
##         Outlet_Identifier Outlet_Establishment_Year
##                         0                         0
##               Outlet_Size      Outlet_Location_Type
```

```
##                          0                          0
##               Outlet_Type
##                          0
```

Since there are no more missing values we proceed further with data cleaning. After observing the Item_Fat_Content, we found that different labels represented same information. To fix that, remap the labels to only two logically significant labels, namely, low_fat and regular.

Feature Engineering:

1. Since the Outlet_Establishment_Year is in years, which is logically numeric, we transform it to the Years_Operating and then drop the column.
2. We created a feature named Item_Cat which represents the Category of the Item. It's created from the first two letters of Item_Identifier labels which represents the category of the products.
3. We then observed that some Non-consumables have either low_fat or regular, which doesn't really make sense. So we changed those labels accordingly.
4. We observed that a lot of Items with 0% visibility that have made sales. We fixed that by taking the aggregated visibility of the same item and setting the visibility to the obtained aggregated value

Applying the same steps on the test data set, so that are models stay healthy for test set as well.

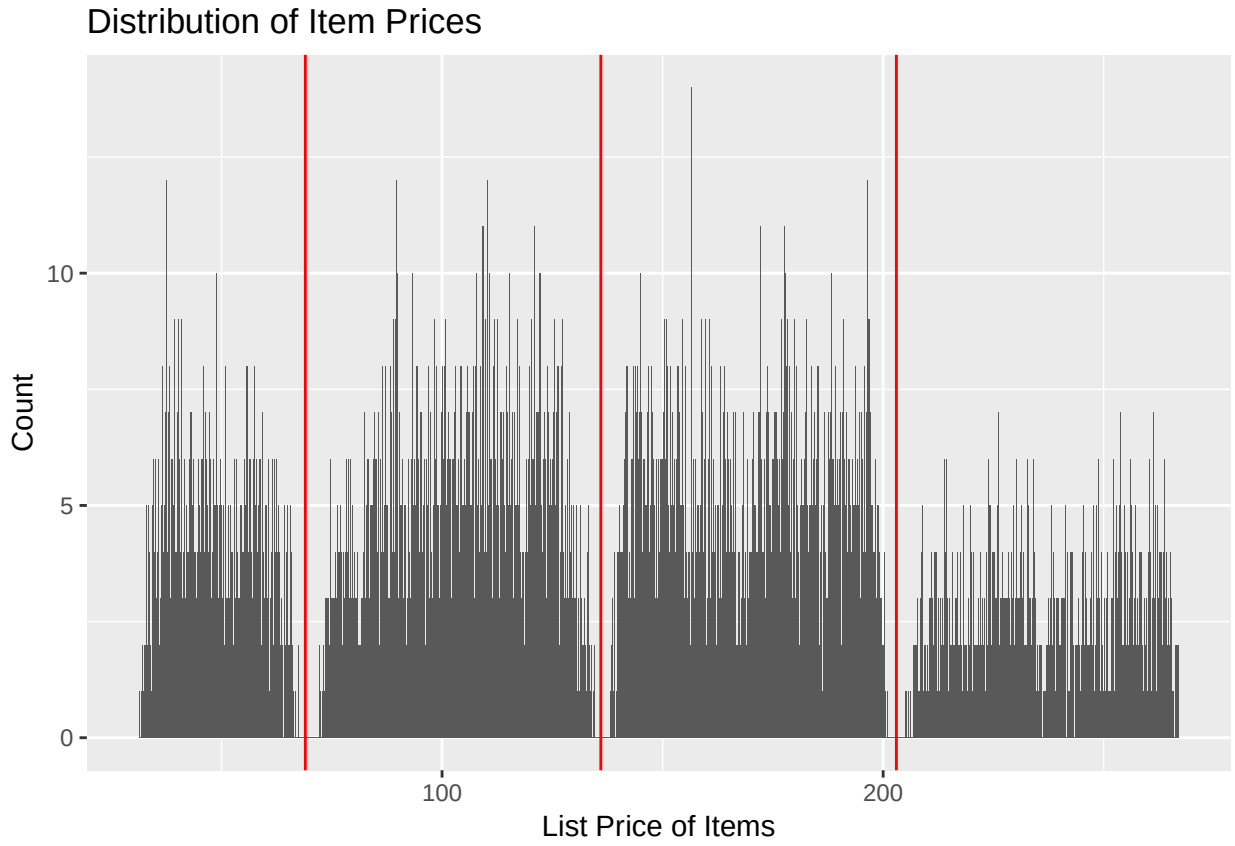
```
## [1] "Item_Outlet_Sales"
```

Finally, we split sample from our training set 1000 observations that we are going to keep aside(in the vault).

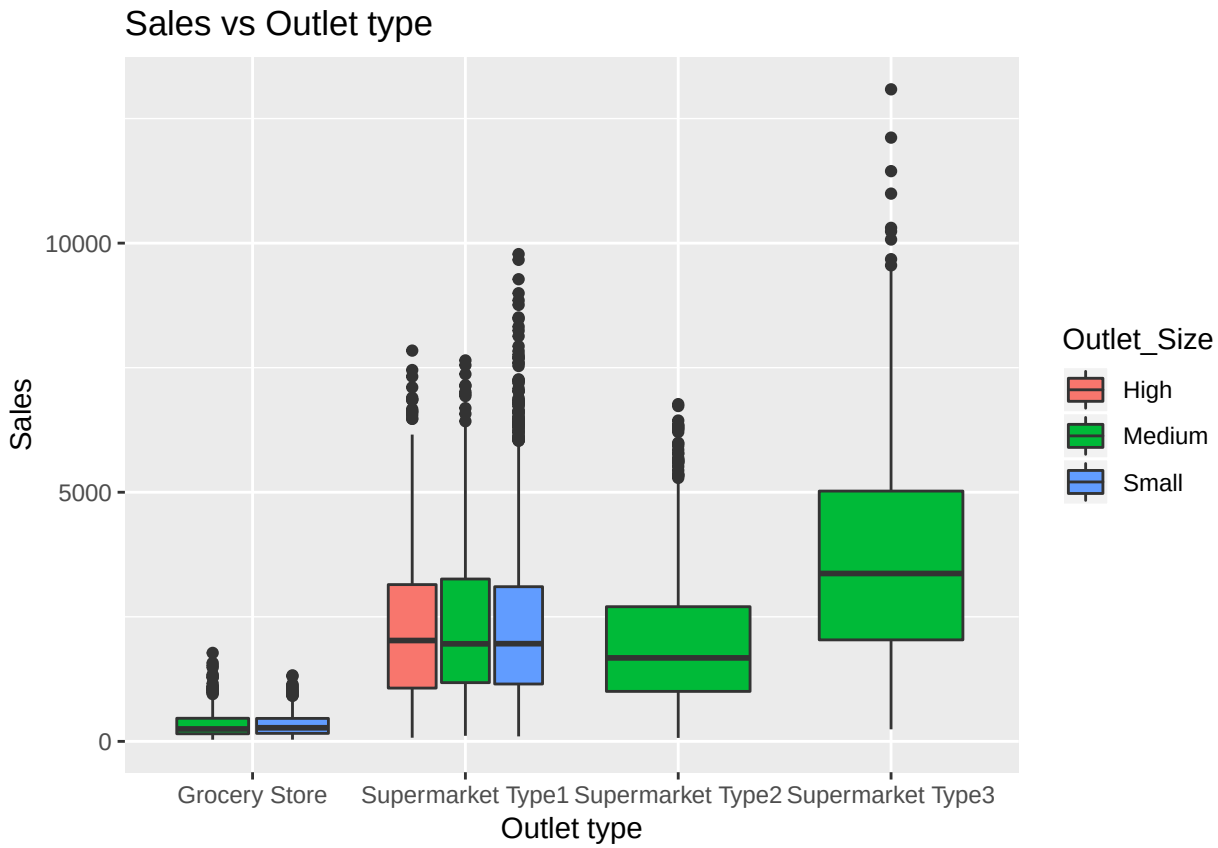
Data Exploration

First, we started by looking at the data to find any interesting relationships between our predictors.

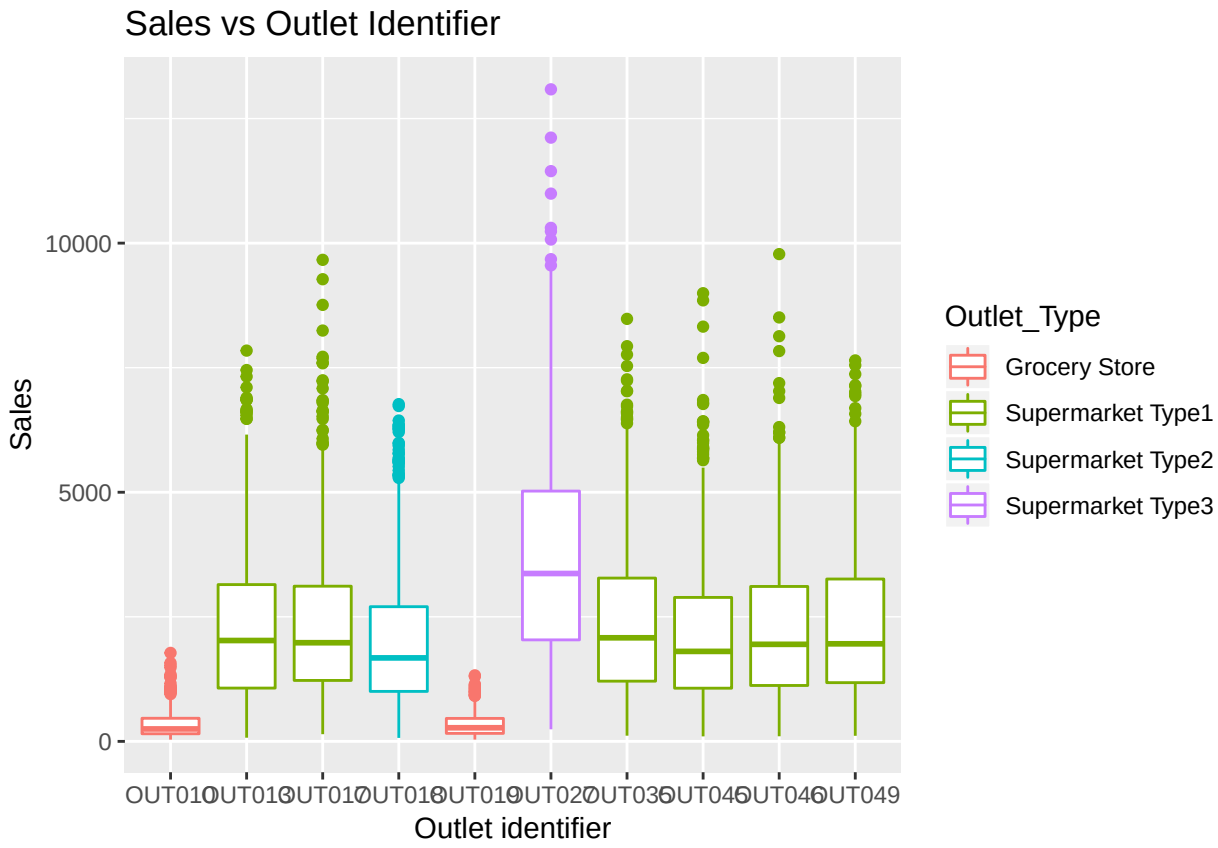
One of the most obvious relashionships is looking at the distribution Retail Price of the Items (Item_MRP) in our training data. We observe that there are 4 major ranges of Item_MRP accross all the items.



We also try to plot the sales against the type of outlet colored based on the outlet size. We get some interesting observations such as sales for a given Outlet Size appear to be similar across Outlet Type. For example, Supermarket Type 1 has all three Outlet Sizes which all have about the same Sales.



Next are the sales of each of the 10 outlets. The intuition behind the plot was to observe which outlets perform well and which do not. Through this plot we see that the two outlets that have extremely low sales are the Grocery Stores.



Simple Linear Models

```
##
## Call:
## lm(formula = Item_Outlet_Sales ~ ., data = subset(train.data,
##     select = -Item_Identifier))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4387.2  -672.6   -83.8   572.0  7914.6
##
## Coefficients: (10 not defined because of singularities)
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                   -1837.6908   148.9258 -12.340   <2e-16 ***
## Outlet_IdentifierOUT013        1952.7800    81.0305  24.099   <2e-16 ***
## Outlet_IdentifierOUT017        2035.6996    80.0415  25.433   <2e-16 ***
## Outlet_IdentifierOUT018        1680.3542    80.0340  20.995   <2e-16 ***
## Outlet_IdentifierOUT019          32.6504    74.4328   0.439    0.661
## Outlet_IdentifierOUT027        3392.0917    82.0306  41.352   <2e-16 ***
## Outlet_IdentifierOUT035        2069.6792    80.5799  25.685   <2e-16 ***
## Outlet_IdentifierOUT045        1852.9558    80.7307  22.952   <2e-16 ***
## Outlet_IdentifierOUT046        1942.2389    80.4290  24.148   <2e-16 ***
## Outlet_IdentifierOUT049        2018.1183    80.8640  24.957   <2e-16 ***
## Item_TypeBreads                 -40.3447    89.2015  -0.452    0.651
## Item_TypeBreakfast               62.9687   122.7321   0.513    0.608
## Item_TypeCanned                  15.9567    66.6322   0.239    0.811
```

```
## Item_TypeDairy                  -57.4553    70.2549  -0.818    0.413
## Item_TypeFrozen Foods           -51.1511    62.2969  -0.821    0.412
## Item_TypeFruits and Vegetables   15.4739    58.0536   0.267    0.790
## Item_TypeHard Drinks            -44.6524   149.1452  -0.299    0.765
## Item_TypeHealth and Hygiene     -38.4097   137.0151  -0.280    0.779
## Item_TypeHousehold              -96.9179   132.2051  -0.733    0.464
## Item_TypeMeat                   -17.2454    74.9751  -0.230    0.818
## Item_TypeOthers                 -64.0078   155.2662  -0.412    0.680
## Item_TypeSeafood                 33.9115   158.8165   0.214    0.831
## Item_TypeSnack Foods            -44.5760    58.5189  -0.762    0.446
## Item_TypeSoft Drinks            -82.9700   137.7023  -0.603    0.547
## Item_TypeStarchy Foods           75.2463   108.3818   0.694    0.488
## Item_Weight                       0.7692     2.8213   0.273    0.785
## Item_Fat_Contentnot_edible            NA         NA      NA       NA
## Item_Fat_Contentregular          48.0357    30.2212   1.589    0.112
## Item_Visibility                -271.1061  1130.4802  -0.240    0.810
## Item_MRP                         15.7435     0.2109  74.649   <2e-16 ***
## Outlet_SizeMedium                     NA         NA      NA       NA
## Outlet_SizeSmall                      NA         NA      NA       NA
## Outlet_Location_TypeTier 2            NA         NA      NA       NA
## Outlet_Location_TypeTier 3            NA         NA      NA       NA
## Outlet_TypeSupermarket Type1          NA         NA      NA       NA
## Outlet_TypeSupermarket Type2          NA         NA      NA       NA
## Outlet_TypeSupermarket Type3          NA         NA      NA       NA
## Years_Operating                       NA         NA      NA       NA
## Item_CatFD                      -55.9546   117.4637  -0.476    0.634
## Item_CatNC                            NA         NA      NA       NA
## Item_Visibility_Ratio             9.5951    80.9093   0.119    0.906
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1124 on 7492 degrees of freedom
## Multiple R-squared:  0.5657, Adjusted R-squared:  0.5639
## F-statistic: 325.2 on 30 and 7492 DF,  p-value: < 2.2e-16

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading
```

```
## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## Warning in predict.lm(linear.fit, newdata = subset(train.data, select = -
## Item_Identifier)[folds == : prediction from a rank-deficient fit may be
## misleading

## [1] 1126.717
```

From the linear model, we can see that the sales of a particular item depends mainly on the store where it is sold and what the MRP is. The rmse is 1124. $R^2 = 0.56$. So only 56% of the variance in the output is explained by this linear model

```
##
## Call:
## lm(formula = Item_Outlet_Sales ~ Item_MRP, data = subset(train.data,
##     select = -Item_Identifier))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3885.0  -755.1   -58.0   688.6  9432.7
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -22.0421    39.9676  -0.551    0.581
## Item_MRP     15.6440     0.2598  60.208   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1398 on 7521 degrees of freedom
## Multiple R-squared:  0.3252, Adjusted R-squared:  0.3251
## F-statistic:  3625 on 1 and 7521 DF,  p-value: < 2.2e-16
```

From the summary, we see that R^2 has dropped to 0.3, far less than the previous linear model with all the variables.

```
##
## Call:
## lm(formula = Item_Outlet_Sales ~ Outlet_Size * Outlet_Type, data = subset(train.data,
##     select = -Item_Identifier))
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -3468.6 -1066.0  -193.9   674.6  9376.7
##
## Coefficients: (5 not defined because of singularities)
##                                                 Estimate Std. Error t value
## (Intercept)                                       312.02      90.54   3.446
## Outlet_SizeMedium                                  31.19     113.41   0.275
## Outlet_SizeSmall                                   29.30      57.49   0.510
## Outlet_TypeSupermarket Type1                     1960.85      74.58  26.291
## Outlet_TypeSupermarket Type2                     1669.52      85.86  19.445
## Outlet_TypeSupermarket Type3                     3367.07      86.03  39.138
## Outlet_SizeMedium:Outlet_TypeSupermarket Type1    23.11     113.73   0.203
## Outlet_SizeSmall:Outlet_TypeSupermarket Type1        NA         NA      NA
## Outlet_SizeMedium:Outlet_TypeSupermarket Type2       NA         NA      NA
## Outlet_SizeSmall:Outlet_TypeSupermarket Type2        NA         NA      NA
## Outlet_SizeMedium:Outlet_TypeSupermarket Type3       NA         NA      NA
## Outlet_SizeSmall:Outlet_TypeSupermarket Type3        NA         NA      NA
##                                                 Pr(>|t|)
## (Intercept)                                     0.000572 ***
## Outlet_SizeMedium                               0.783310
## Outlet_SizeSmall                                0.610338
## Outlet_TypeSupermarket Type1                     < 2e-16 ***
## Outlet_TypeSupermarket Type2                     < 2e-16 ***
## Outlet_TypeSupermarket Type3                     < 2e-16 ***
## Outlet_SizeMedium:Outlet_TypeSupermarket Type1 0.838965
## Outlet_SizeSmall:Outlet_TypeSupermarket Type1        NA
## Outlet_SizeMedium:Outlet_TypeSupermarket Type2       NA
## Outlet_SizeSmall:Outlet_TypeSupermarket Type2        NA
## Outlet_SizeMedium:Outlet_TypeSupermarket Type3       NA
## Outlet_SizeSmall:Outlet_TypeSupermarket Type3        NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1489 on 7516 degrees of freedom
## Multiple R-squared:  0.2354, Adjusted R-squared:  0.2348
## F-statistic: 385.7 on 6 and 7516 DF,  p-value: < 2.2e-16
```

From the summary we see that the interactions are `NA` due to collinearity. That means the interation variables are some linear combination of the other variables and to solve the normal equation. We will park it for now, and then manually one hot encode and add infinitesimal noise to the dummy variables for the linear model to keep them.

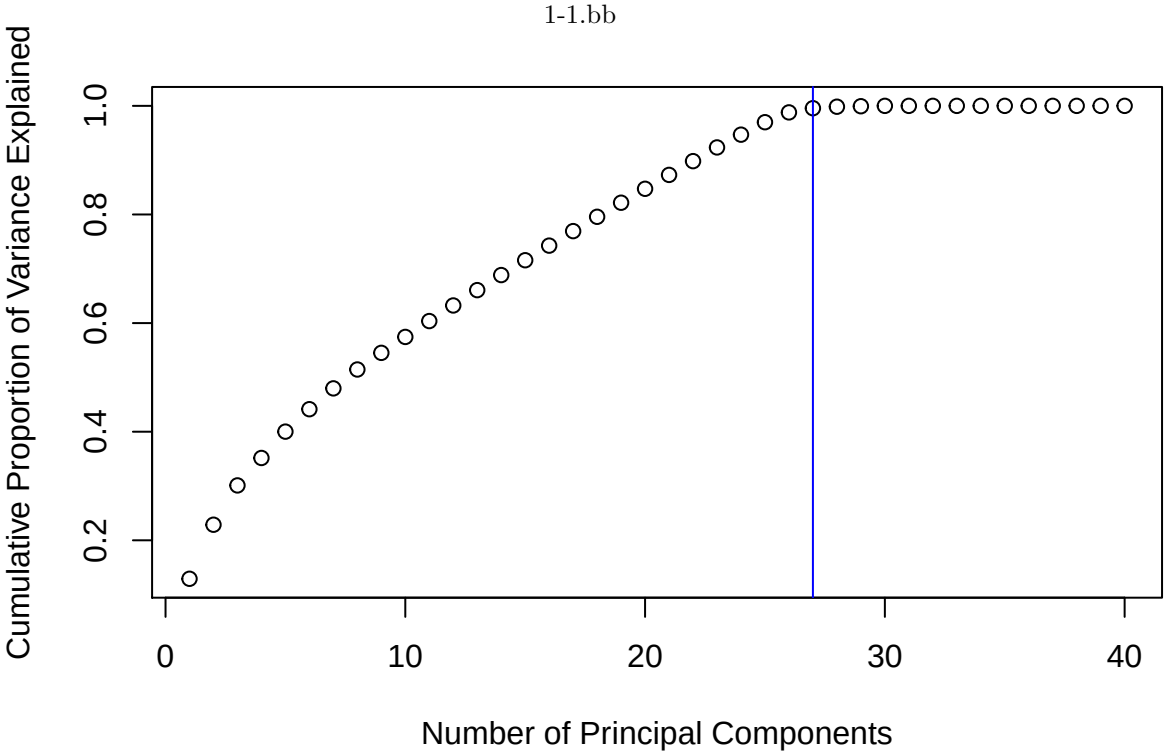
Principal Component Regression

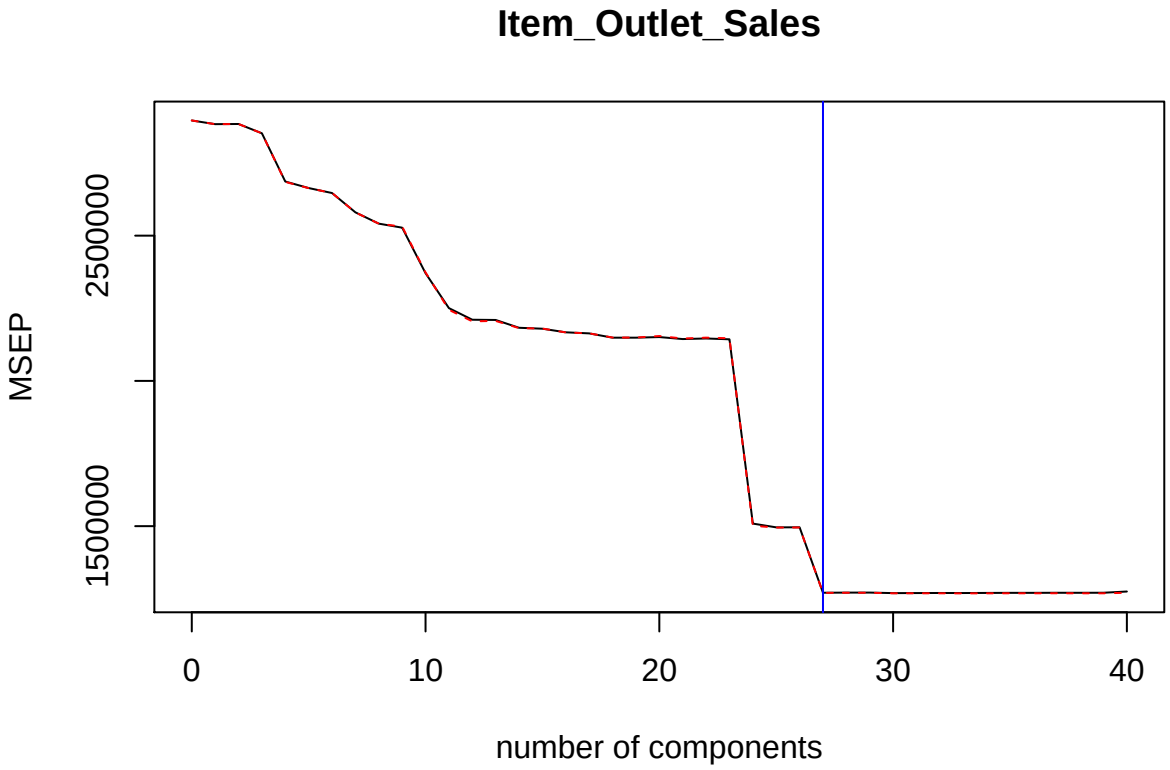
In this section, we fit a Principal Component Regression model. First, we start by find the number of principal components needed to maximize the variance explanation and minimizing the MSE while keeping a reasonable number of components. In our case, the number of Principal Components chosen could be 27 (corresponds to the knee in the curve) as shown on the graphs below:

```
##
## Attaching package: 'pls'
```

```
## The following object is masked from 'package:stats':
##
##     loadings
```

1-1.bb





1-2.bb

Once the `ncomp` value chosen, we proceed to a 10-fold cross validation process where we estimate the RMSE for a Principal Component Regression model fitted with the first 27 PCs.

```
## [1] 1127.49
```

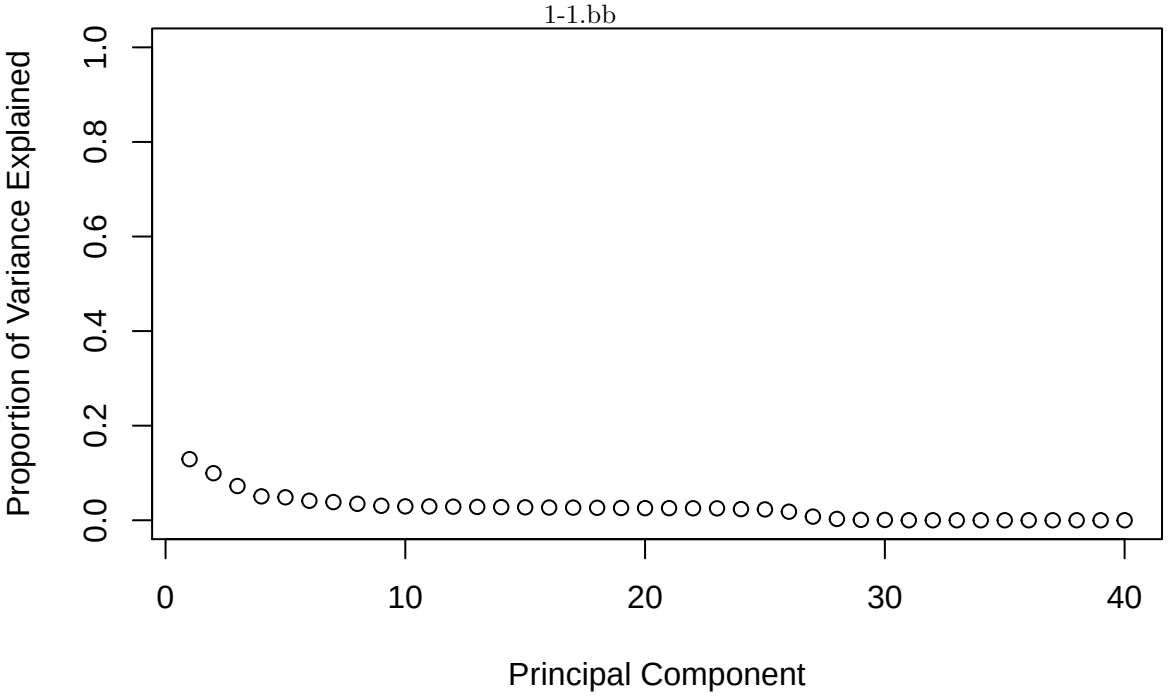
We can observe that the estimated value of the RMSE for this model is around `1126.671`.

PCA

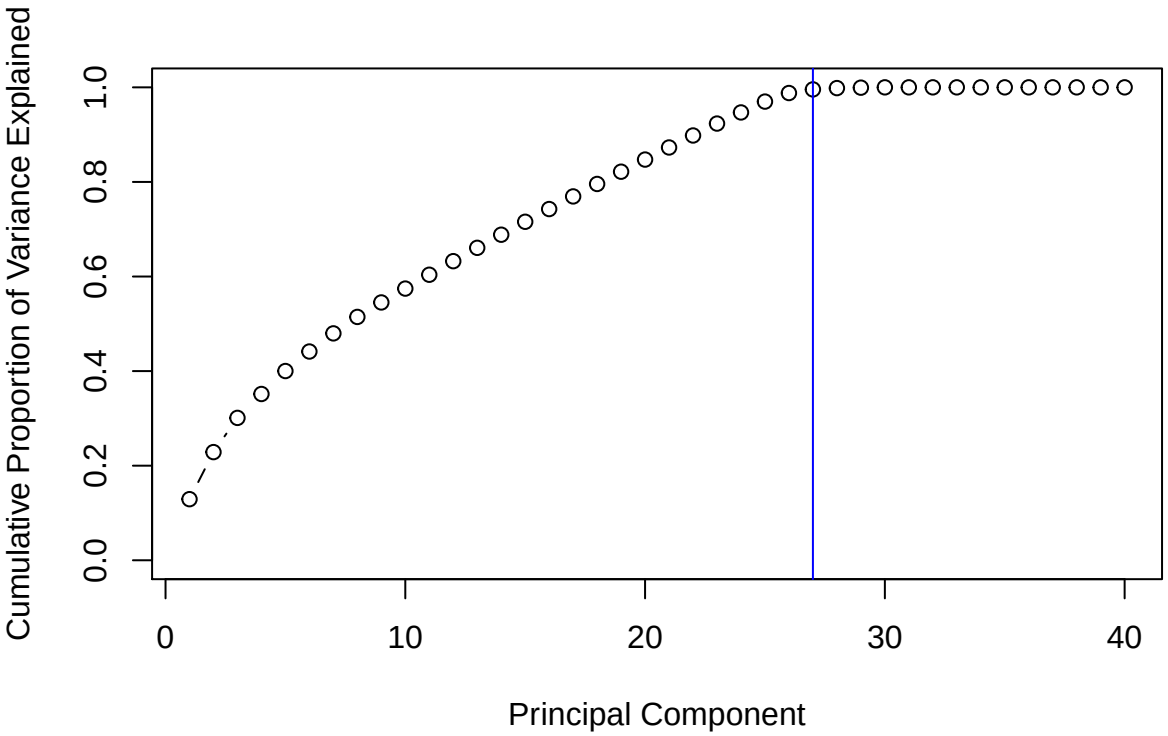
In this section, we are trying to reduce the number of our predictors by finding a normalized linear combination of the original predictors in a data set (41 predictors after hot enconding). In order to do this, we perform a Principal Component Analysis which is a generalization of the above-mentionned PCR where we extract the PCs to give us the possiblity to use them with any other model.

First, we fit our model and plot the proportion of variance explained vs. the number of first principal components chosen.

1-1.bb



1-2.bb

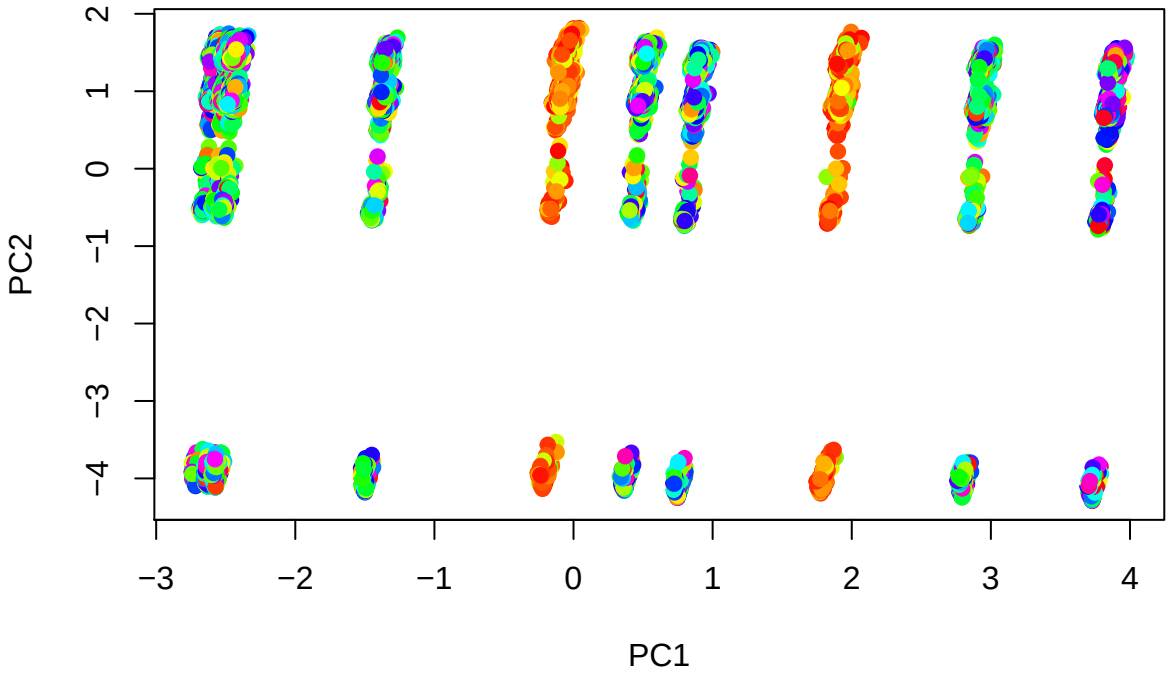



```
## [1] "PC27"
```

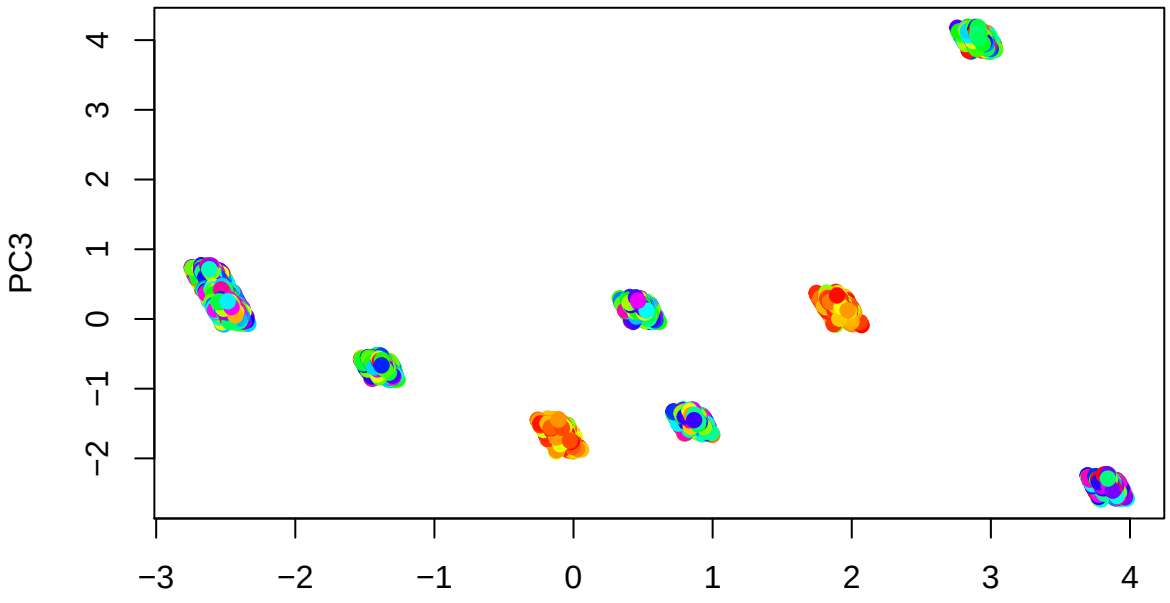
```
##     Standard deviation Proportion of Variance  Cumulative Proportion
##              0.5556148              0.0077200              0.9957000
```

As expected, the number of principal components that corresponds to the knee in the curve is around 27, which confirms the value previously chosen in the PCR section.

Now, we plot our data according to the 1st and 2nd Principal Components and then according to the 1st and 3rd Principal Components.



2-1.bb



2-2.bb

We can observe that, unexpectedly, the representation of the data according to the first and second PCs presents well-spreaded, however, less homogenious repartition of the data accroding to the target class `Item_Outlet_Sales`. On the other side, both of these plots represent a poor visualization of our data since they explain barely 22.8% of the variance for the first two components and even less for the 1st and 3rd combined.

Finally, we assign transform the (aside) testing set according to the same Principal Component Analysis tranformation that resulted above.

Feature selection & Dimensionality reduction

After looking at the data, we noticed that, since our dataset is a mixture of categorical (7) and numerical (7) features, we are going to need to hot encode our data in order to be able to apply a big number of resgression algorithms.

That said, the fact that some of the categorical features have up to 10 different values (10 level factors) would introduce a lot of new features after dummy encoding and we finished up with 41 features after one hot encoding (the first generated feature is always dropped). Hence, a reduction of the number of features should processed.

In the next sections, we are going to try different feature selectio and dimentionality reduction techniques and discuss them.

Forward Feature Selection

First, we start with subset selection and given the fact that we cannot perform a best subset feature selection on our data due to the large computation complexity, we try to approximate it with forward feature selection as shown below:

```
## Reordering variables and trying again:
```

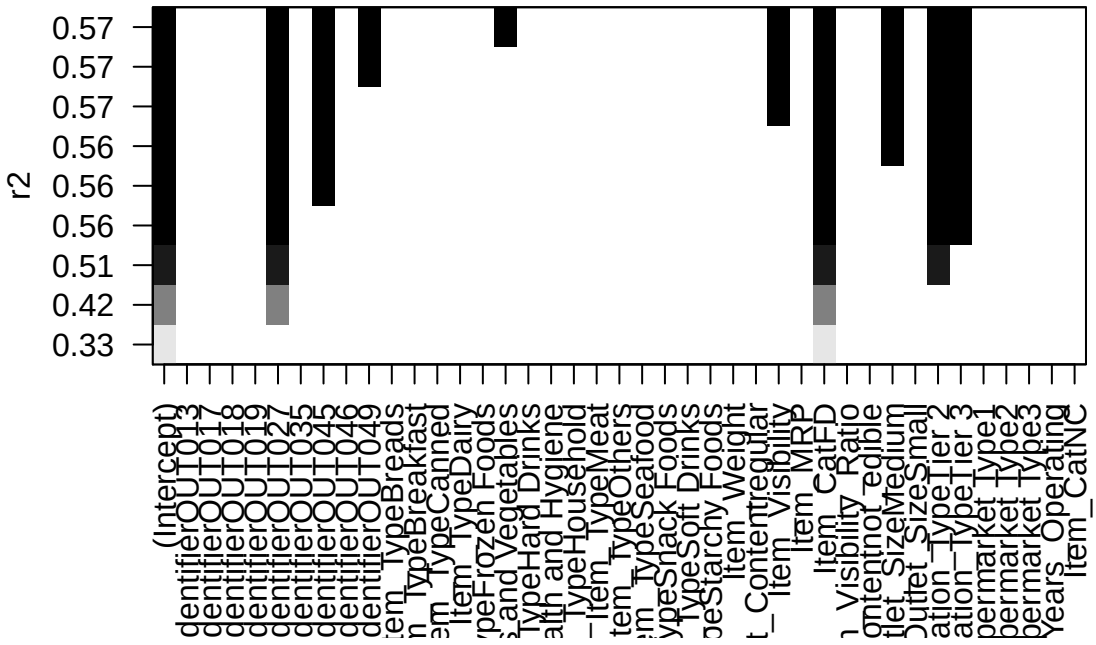


Table 1: Forward Selection

selected_features
Outlet_IdentifierOUT027
Outlet_IdentifierOUT045
Outlet_IdentifierOUT049
Item_TypeFruits and Vegetables
Item_Visibility
Item_CatFD
Outlet_SizeMedium
Outlet_Location_TypeTier 2
Outlet_Location_TypeTier 3

We can see that the forward selection outputs a 9 feature subset (8 + intercept) as an estimation of the best subset features selection with `Item_Visibility`, 3 of the hot encoded `Outlet_Identifier` columns (corresponding to 3 outlets), 2 of the `Outlet_Location` and one `Outlet_Size`. We can interpret that according to FFS, these features are more important than the other, i.e. for `Outlet_Size`, knowing if the outlet is of medium size or not matters more than knowing what exactly is the size of the outlet (small or big).

Backward Feature Selection

In this section, we try again to estimate the best subset of features following another method which is backward subset selection as shown below:

```
## Reordering variables and trying again:
```

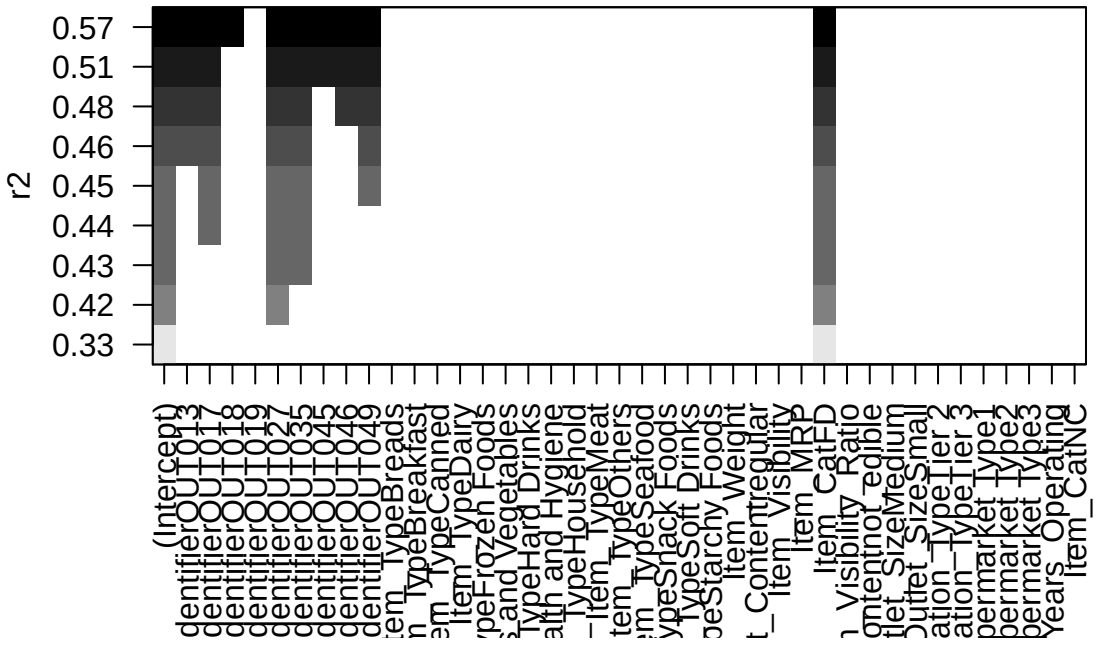


Table 2: Bakcward Selection

selected_features
Outlet_IdentifierOUT013
Outlet_IdentifierOUT017
Outlet_IdentifierOUT018
Outlet_IdentifierOUT027
Outlet_IdentifierOUT035
Outlet_IdentifierOUT045
Outlet_IdentifierOUT046
Outlet_IdentifierOUT049
Item_CatFD

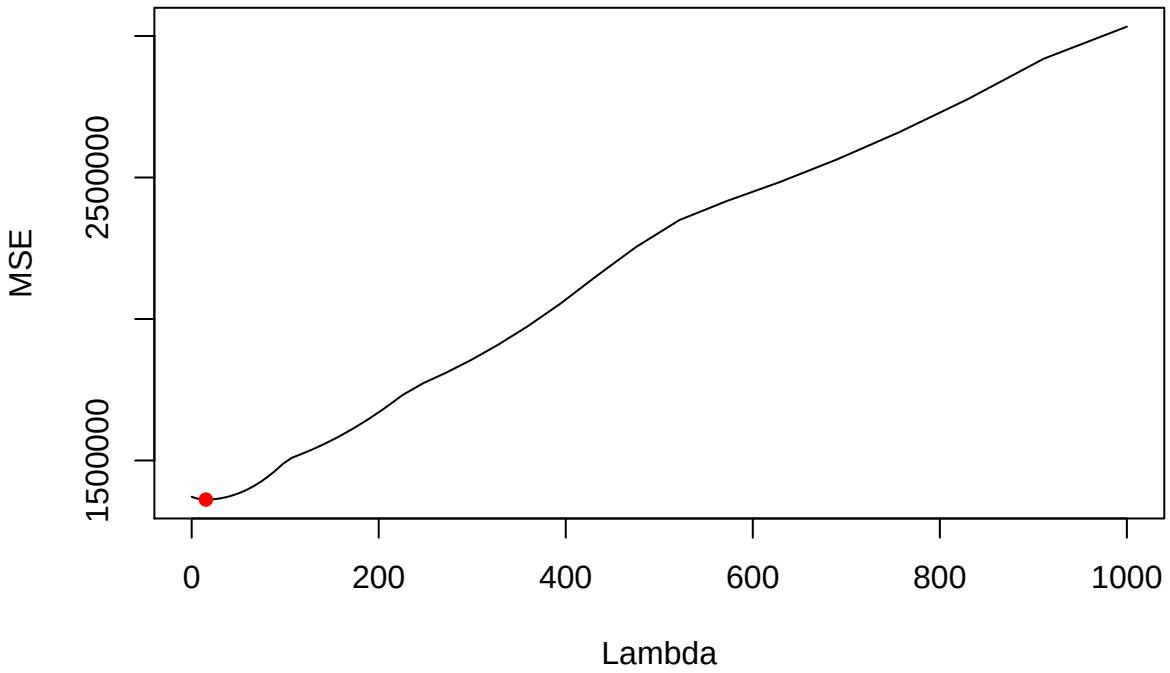
We can observe clearly through the output of BFS that this estimation gives a high importance to the `Outlet_Identifier` feature and we can see again the `Item_Cat` corresponding to the value food which means that knowing if our item is a food product or not would help the prediction of the `Item_Outlet_Sales`.

Lasso Regression

In this section, we are going to try to reduce the number of feature using Lasso. However, the tricky parts resides in choosing the λ value corresponding to the best penalty for our case, namely, a λ value that reduces the variance to prevent overfitting without increasing the bias too much. (yet another variance-bias tradeoff situation)

Hence, we execute a Lasso regression with different values of Lambda, we predict the sales for our validation (aside.test.data) set and then we calculate the error for each λ.

The plot below shows the evolution of the error with respect to different values of λ. The red point show the value corresponding to the lowest MSE.



1-1.bb

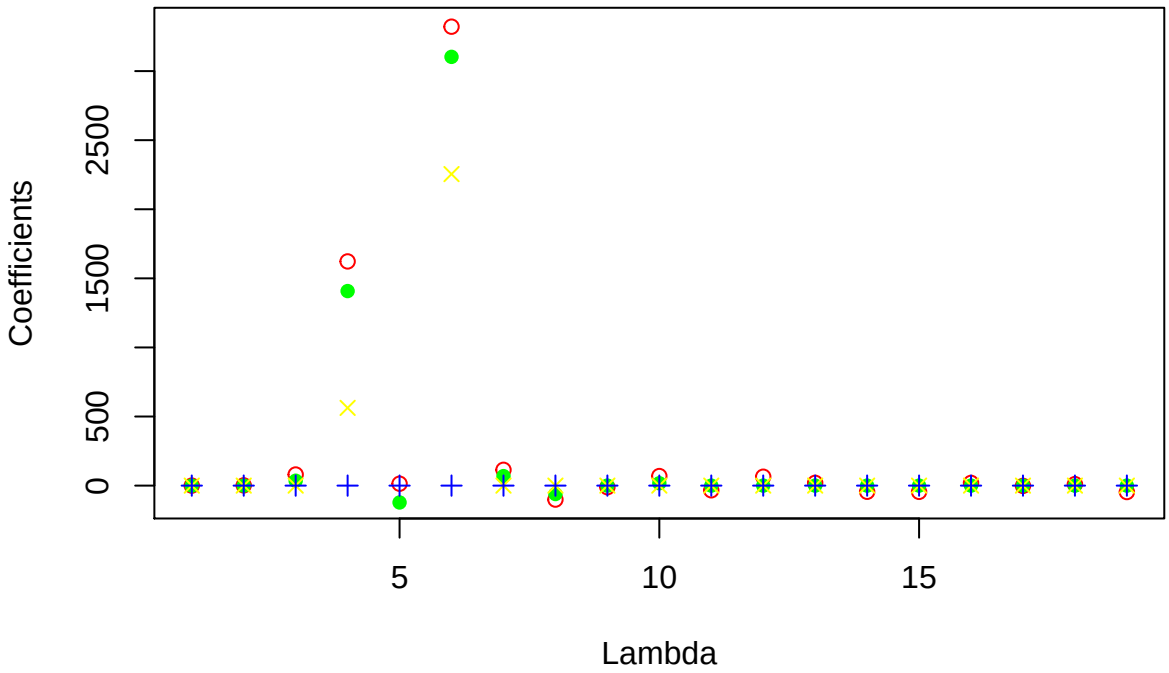
```
## integer(0)
```

	coefficients
Outlet_IdentifierOUT017	35.33963
Outlet_IdentifierOUT018	1408.00854
Outlet_IdentifierOUT019	-121.93867
Outlet_IdentifierOUT027	3102.94673
Outlet_IdentifierOUT035	68.75383
Outlet_IdentifierOUT045	-60.90939
Outlet_IdentifierOUT049	17.26060
Item_Fat_Contentregular	18.54781
Item_Visibility	-113.82002
Item_MRP	15.47142
Outlet_TypeSupermarket Type1	1754.14581
Outlet_TypeSupermarket Type2	26.36374
Outlet_TypeSupermarket Type3	41.99220

```
## Lasso Regression RMSE:  1152.322
```

As we see in the table above, all the `Outlet_Type` and `Outlet_Identifier` (almost) are kept for creating the linear regression model with the lowest RMSE. On the other side, the numerical variables `Item_MRP`and `Item_Visibility` are also kept for this regression.

Below, we can see the plot of the coefficients corresponding to the features for a given λ. The green dots correspond to the λ value (15.1991108) with the lowest error (1152.3220914).



2-1.bb

We can clearly see that for a high value of λ all the coefficients are set to zero which means that the penalty is too large for finding any feature important enough to be kept.

PC-KNN

In the plot of the principal components above we saw some gradient clustering of the `Item_Outlet_Sales`, we want to check if knn on top of PCA performs any better. We determine the best number of neighbours and the best number of principal components by cross-validation.

```
## Loading required package: FNN
```

```
##
## Attaching package: 'reshape2'
```

```
## The following object is masked from 'package:tidyr':
##
##     smiths
```

```
## XGBoost Train RMSE:  1556.834
```

Tree-Based Models

Simple Trees

We implement regression trees on our training data and run a 10-fold cross validation. All predictors except for Item_Identifier for building each tree. Through this approach we obtain a training RMSE of 1276. We will keep this in mind when we run a random Forrest later on in the report.

```
## Simple tree residual RMSE:  952.7941
```

```
## Pruned tree residual RMSE:  1115.177
```

```
## Simple Tree RMSE:  1276.544
```

```
## Pruned Tree RMSE:  1232.276
```

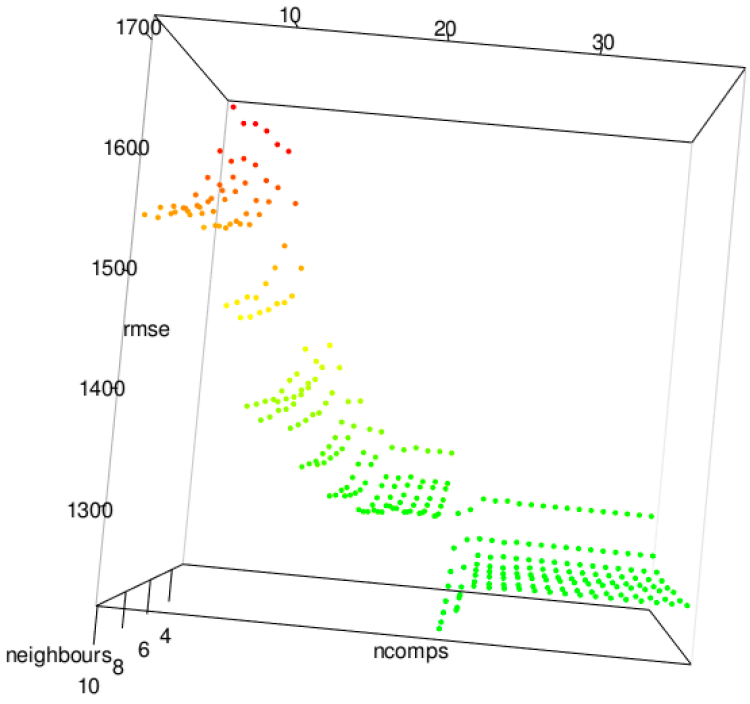
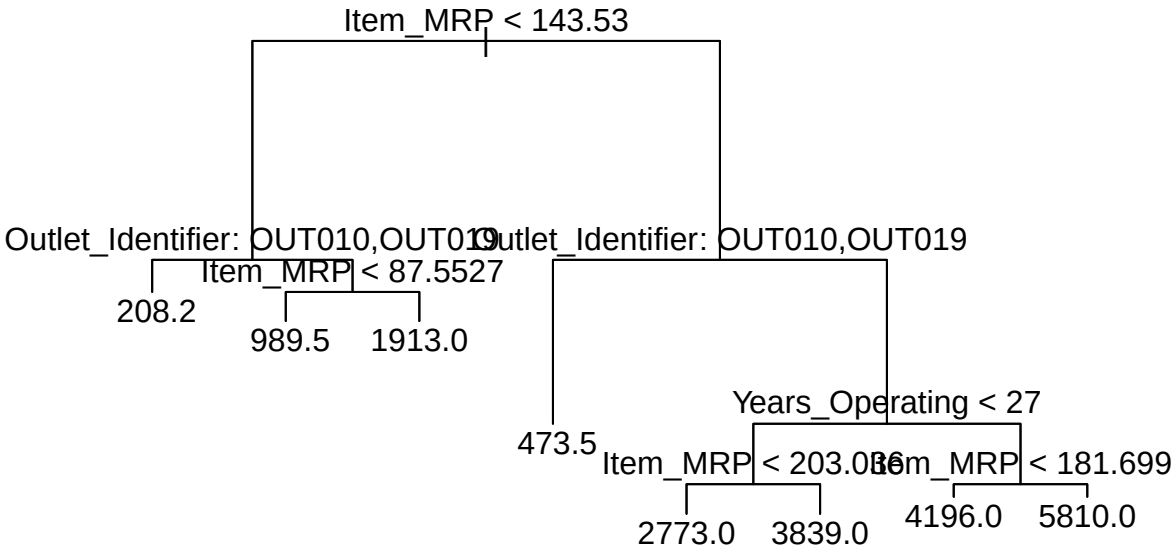


Figure 1: KNN rmse plot

We can see above that pruning the tree actually reduces the RMSE on the validation set (which is an estimation of the real RMSE), however, the complete tree outperforms the pruned tree on the training set. This could simply be explained by the fact that the big tree overfits the data.

On the other side, pruning a tree doesn't only prevent overfitting but helps also having clear visualizations of the tree as shown below:



Ensembles

Boosting

```
## Loaded gbm 2.1.4
```

```
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868533.6429             nan     0.0100 26110.7324
##      2  2842655.1001             nan     0.0100 26058.1003
##      3  2817585.0275             nan     0.0100 25412.4971
##      4  2792592.0123             nan     0.0100 24527.0629
##      5  2768254.7793             nan     0.0100 24806.1458
##      6  2744213.2817             nan     0.0100 24072.3052
##      7  2720982.4248             nan     0.0100 23265.5221
##      8  2699483.8135             nan     0.0100 21302.2177
##      9  2676523.0391             nan     0.0100 22326.7425
##     10  2654872.7140             nan     0.0100 22054.2936
##     20  2454739.3411             nan     0.0100 18340.2512
##     40  2143257.3026             nan     0.0100 12734.7233
##     60  1910868.9715             nan     0.0100 10610.0302
##     80  1734747.9088             nan     0.0100 7621.8957
##    100  1605016.5343             nan     0.0100 5894.0939
##    120  1504205.4424             nan     0.0100 4810.8606
##    140  1422987.2174             nan     0.0100 3392.4096
##    160  1359203.2509             nan     0.0100 2698.7992
##    180  1310479.7147             nan     0.0100 2311.3026
##    200  1270831.3368             nan     0.0100 1929.2500
##    220  1239474.3947             nan     0.0100 1096.6234
```

```
##    240  1215862.7169             nan     0.0100  941.7754
##    250  1205923.3390             nan     0.0100 1134.7912
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2869929.1894             nan     0.0100 26202.3209
##      2  2845452.1403             nan     0.0100 24216.3040
##      3  2820603.4159             nan     0.0100 25083.2481
##      4  2796035.8346             nan     0.0100 24598.8753
##      5  2771197.9399             nan     0.0100 24591.5429
##      6  2746657.7644             nan     0.0100 24873.8948
##      7  2722991.7776             nan     0.0100 23794.6686
##      8  2700070.0803             nan     0.0100 23299.0210
##      9  2677726.9287             nan     0.0100 21653.0486
##     10  2655848.8618             nan     0.0100 22285.1394
##     20  2455445.5096             nan     0.0100 18363.2143
##     40  2145485.4686             nan     0.0100 12551.9562
##     60  1912663.9335             nan     0.0100 8902.6784
##     80  1736796.0285             nan     0.0100 6633.4605
##    100  1605070.0921             nan     0.0100 5504.5455
##    120  1502937.1502             nan     0.0100 3985.5046
##    140  1422896.3689             nan     0.0100 3391.7100
##    160  1361390.5041             nan     0.0100 2386.5192
##    180  1310015.2418             nan     0.0100 2312.3020
##    200  1269963.7349             nan     0.0100 1390.2430
##    220  1239665.5711             nan     0.0100 1465.2263
##    240  1215257.3120             nan     0.0100  881.8873
##    260  1195717.9878             nan     0.0100  459.7908
##    280  1180439.3527             nan     0.0100  286.9980
##    300  1168364.5952             nan     0.0100  572.3349
##    320  1158525.1929             nan     0.0100  241.8438
##    340  1150908.1798             nan     0.0100   19.8813
##    360  1144239.0449             nan     0.0100  220.4425
##    380  1138461.2237             nan     0.0100   60.9933
##    400  1133977.4896             nan     0.0100  -58.9233
##    420  1130102.5722             nan     0.0100   94.2945
##    440  1126716.7472             nan     0.0100   95.9842
##    460  1123620.4695             nan     0.0100   61.3690
##    480  1120792.9689             nan     0.0100  -89.6966
##    500  1118797.8522             nan     0.0100   17.1352
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2869157.0800             nan     0.0100 26765.0354
##      2  2843795.3765             nan     0.0100 26297.8595
##      3  2817816.5666             nan     0.0100 24813.0721
##      4  2792142.3093             nan     0.0100 25459.0351
##      5  2767674.5666             nan     0.0100 23871.6925
##      6  2743539.8086             nan     0.0100 23618.5133
##      7  2721639.0109             nan     0.0100 21883.4957
##      8  2698207.6697             nan     0.0100 22675.3185
##      9  2675332.1762             nan     0.0100 23084.3329
##     10  2652495.1881             nan     0.0100 22212.7905
##     20  2453271.0710             nan     0.0100 18124.9456
```

```
##     40  2144795.5058             nan     0.0100 12465.7456
##     60  1909168.8510             nan     0.0100 10498.6967
##     80  1739570.9036             nan     0.0100 7383.5113
##    100  1605858.6661             nan     0.0100 5281.1072
##    120  1503142.7558             nan     0.0100 3963.1425
##    140  1421696.2674             nan     0.0100 3263.5707
##    160  1359824.9937             nan     0.0100 2379.3668
##    180  1310785.5766             nan     0.0100 2052.9192
##    200  1270811.6730             nan     0.0100 1535.9256
##    220  1239902.6863             nan     0.0100 1236.3366
##    240  1216074.4837             nan     0.0100 1082.2156
##    260  1197399.7918             nan     0.0100  591.6830
##    280  1182324.9741             nan     0.0100  535.2898
##    300  1170333.4502             nan     0.0100  362.9690
##    320  1160240.0491             nan     0.0100   82.3585
##    340  1152179.6053             nan     0.0100  201.8985
##    360  1145375.8459             nan     0.0100  185.0795
##    380  1139337.5019             nan     0.0100  229.4153
##    400  1134561.7231             nan     0.0100   24.7608
##    420  1130617.0603             nan     0.0100   86.4456
##    440  1127233.5149             nan     0.0100   18.9724
##    460  1124036.0942             nan     0.0100  112.4753
##    480  1121672.3511             nan     0.0100  -85.7902
##    500  1119306.0475             nan     0.0100  -35.0372
##    520  1117266.4977             nan     0.0100    5.2441
##    540  1115275.2898             nan     0.0100  -88.2495
##    560  1113561.6512             nan     0.0100   71.4088
##    580  1111899.6705             nan     0.0100  -41.1958
##    600  1110274.6696             nan     0.0100 -143.5666
##    620  1108873.8528             nan     0.0100  -97.9833
##    640  1107460.3829             nan     0.0100  -92.5500
##    660  1106028.6835             nan     0.0100  -64.2114
##    680  1104696.1292             nan     0.0100  -52.2873
##    700  1103342.8166             nan     0.0100  -62.8297
##    720  1102093.5371             nan     0.0100  -34.8098
##    740  1100595.3668             nan     0.0100  -38.4296
##    750  1099928.3170             nan     0.0100  -30.8034
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868686.0534             nan     0.0100 26670.8475
##      2  2842775.0417             nan     0.0100 26017.7589
##      3  2817510.5702             nan     0.0100 25760.5877
##      4  2792487.2696             nan     0.0100 24530.8680
##      5  2767970.0362             nan     0.0100 24745.0613
##      6  2744010.2642             nan     0.0100 23496.2059
##      7  2720715.6891             nan     0.0100 23743.4205
##      8  2697484.8072             nan     0.0100 23400.1609
##      9  2675276.4919             nan     0.0100 20481.7161
##     10  2652945.4956             nan     0.0100 21944.9894
##     20  2453875.4121             nan     0.0100 18254.9712
##     40  2141347.8950             nan     0.0100 13108.9006
##     60  1911440.4625             nan     0.0100 9131.6014
##     80  1739386.3836             nan     0.0100 8007.1033
```

```
##    100  1607341.3336             nan     0.0100 5173.5467
##    120  1505540.3399             nan     0.0100 3821.4743
##    140  1424513.6568             nan     0.0100 3811.4902
##    160  1360880.9073             nan     0.0100 2360.5931
##    180  1311534.8560             nan     0.0100 2333.7376
##    200  1273433.3253             nan     0.0100 1668.6381
##    220  1242254.5948             nan     0.0100 1657.9922
##    240  1217858.6291             nan     0.0100 1263.8694
##    260  1198268.9658             nan     0.0100  249.1841
##    280  1182796.8379             nan     0.0100  234.7603
##    300  1170379.8458             nan     0.0100  440.4217
##    320  1161028.6268             nan     0.0100  388.7237
##    340  1152919.7422             nan     0.0100  355.3225
##    360  1146273.7357             nan     0.0100  238.0684
##    380  1140428.7451             nan     0.0100   80.6607
##    400  1135648.8459             nan     0.0100  179.0039
##    420  1131409.2320             nan     0.0100   87.8688
##    440  1127765.0144             nan     0.0100    0.3025
##    460  1124759.4354             nan     0.0100  -42.4881
##    480  1122048.6429             nan     0.0100  -52.0442
##    500  1119875.5058             nan     0.0100  -54.8560
##    520  1117705.0935             nan     0.0100   22.0619
##    540  1115614.8260             nan     0.0100  -49.9301
##    560  1113540.2441             nan     0.0100  -11.8330
##    580  1111815.4016             nan     0.0100 -112.6707
##    600  1110110.1617             nan     0.0100  -63.4440
##    620  1108545.4084             nan     0.0100  -75.4167
##    640  1106899.2784             nan     0.0100  -83.1875
##    660  1105264.1248             nan     0.0100 -139.2667
##    680  1103833.7279             nan     0.0100  -60.5293
##    700  1102541.6815             nan     0.0100  -72.9155
##    720  1101429.9534             nan     0.0100 -100.4869
##    740  1099983.8444             nan     0.0100  -69.3147
##    760  1098658.8534             nan     0.0100 -138.9659
##    780  1097424.5748             nan     0.0100  -12.6882
##    800  1096241.4429             nan     0.0100 -104.4628
##    820  1094961.7312             nan     0.0100 -187.5858
##    840  1093692.1789             nan     0.0100  -91.3267
##    860  1092437.7661             nan     0.0100  -79.0751
##    880  1091078.6631             nan     0.0100  -93.9889
##    900  1089993.0641             nan     0.0100  -78.3540
##    920  1088758.4555             nan     0.0100  -47.4202
##    940  1087525.9439             nan     0.0100  -51.7933
##    960  1086313.1927             nan     0.0100   11.0710
##    980  1085203.4347             nan     0.0100  -19.9005
##   1000  1084224.4429             nan     0.0100 -117.5924
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2869436.3729             nan     0.0100 26317.1288
##      2  2842766.1016             nan     0.0100 25847.8304
##      3  2817320.5115             nan     0.0100 25170.9685
##      4  2792370.7590             nan     0.0100 25232.3011
##      5  2767289.7300             nan     0.0100 23971.5005
```

```
##      6  2742727.2582           nan     0.0100 24755.3896
##      7  2718651.7272           nan     0.0100 23719.3421
##      8  2696844.2386           nan     0.0100 21052.0590
##      9  2673954.2363           nan     0.0100 22755.5331
##     10  2651860.7110           nan     0.0100 21902.2593
##     20  2451889.2735           nan     0.0100 17631.1284
##     40  2141439.4039           nan     0.0100 13606.0995
##     60  1907146.0833           nan     0.0100 10708.1280
##     80  1738226.1286           nan     0.0100 7865.4853
##    100  1606153.2746           nan     0.0100 5020.8995
##    120  1503221.9183           nan     0.0100 3463.5717
##    140  1421645.1829           nan     0.0100 3458.5675
##    160  1359043.2276           nan     0.0100 2984.0398
##    180  1309401.9310           nan     0.0100 2159.4815
##    200  1270041.3770           nan     0.0100 1417.7375
##    220  1240692.4199           nan     0.0100 1169.7984
##    240  1216283.1650           nan     0.0100 1041.0047
##    260  1197133.3951           nan     0.0100  907.4286
##    280  1181637.6989           nan     0.0100  545.3426
##    300  1169354.2079           nan     0.0100  325.3120
##    320  1159573.0700           nan     0.0100  510.1538
##    340  1151591.9963           nan     0.0100  107.7102
##    360  1145111.3845           nan     0.0100   15.4600
##    380  1139804.1101           nan     0.0100   52.1688
##    400  1135049.7090           nan     0.0100   34.9894
##    420  1131031.5365           nan     0.0100   72.1652
##    440  1127488.1063           nan     0.0100   24.3250
##    460  1124464.4958           nan     0.0100  102.5384
##    480  1121594.2423           nan     0.0100   26.8819
##    500  1119232.6456           nan     0.0100  -21.2151
##    520  1117156.5117           nan     0.0100  -86.6785
##    540  1115155.8982           nan     0.0100   10.4127
##    560  1113135.5322           nan     0.0100  -28.9571
##    580  1111486.5832           nan     0.0100  -32.7660
##    600  1109844.5894           nan     0.0100   -9.4078
##    620  1108254.9231           nan     0.0100 -112.7798
##    640  1106760.2788           nan     0.0100  -55.4034
##    660  1105443.7544           nan     0.0100 -160.8232
##    680  1104016.2415           nan     0.0100  -88.9174
##    700  1102651.2890           nan     0.0100  -25.0105
##    720  1101343.9016           nan     0.0100  -38.0246
##    740  1099926.3672           nan     0.0100 -154.5417
##    760  1098708.8292           nan     0.0100  -36.5261
##    780  1097456.2962           nan     0.0100  -91.8941
##    800  1096282.3175           nan     0.0100  -84.1147
##    820  1095045.0231           nan     0.0100  -20.1624
##    840  1093858.0273           nan     0.0100  -70.2435
##    860  1092634.3593           nan     0.0100 -183.1310
##    880  1091571.5391           nan     0.0100  -60.4972
##    900  1090264.5892           nan     0.0100 -129.3492
##    920  1088803.0939           nan     0.0100 -125.9073
##    940  1087691.4280           nan     0.0100  -52.4619
##    960  1086459.6000           nan     0.0100  -34.4486
##    980  1085397.5617           nan     0.0100  -17.5039
```

```
##   1000  1084383.5950             nan     0.0100 -106.0299
##   1020  1083512.8034             nan     0.0100  -44.5951
##   1040  1082432.7248             nan     0.0100  -69.0152
##   1060  1081418.2594             nan     0.0100  -55.3441
##   1080  1080450.9594             nan     0.0100 -128.0575
##   1100  1079384.3147             nan     0.0100 -175.6722
##   1120  1078184.9809             nan     0.0100  -65.2588
##   1140  1077286.5232             nan     0.0100  -20.9974
##   1160  1076190.7190             nan     0.0100 -106.3613
##   1180  1075179.5356             nan     0.0100  -80.8306
##   1200  1073944.2240             nan     0.0100  -71.7357
##   1220  1072629.3072             nan     0.0100  -65.3322
##   1240  1071499.6245             nan     0.0100  -48.4387
##   1250  1070970.6101             nan     0.0100 -106.6493
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2871203.4967             nan     0.0100 23359.5574
##      2  2844912.5208             nan     0.0100 26524.0126
##      3  2819249.9186             nan     0.0100 26141.6692
##      4  2794029.1284             nan     0.0100 24466.0675
##      5  2769475.6022             nan     0.0100 24532.8257
##      6  2744966.3896             nan     0.0100 23640.5372
##      7  2720597.5418             nan     0.0100 23975.8333
##      8  2697968.1465             nan     0.0100 23534.3814
##      9  2675517.1595             nan     0.0100 22582.0955
##     10  2653110.4707             nan     0.0100 21736.3087
##     20  2454217.0774             nan     0.0100 18833.7235
##     40  2143398.8945             nan     0.0100 12540.8380
##     60  1911287.1904             nan     0.0100 9670.6616
##     80  1738274.5947             nan     0.0100 6682.1238
##    100  1604825.2624             nan     0.0100 5572.9034
##    120  1504856.0911             nan     0.0100 3883.5555
##    140  1424196.2395             nan     0.0100 3690.6212
##    160  1362214.0782             nan     0.0100 2445.3816
##    180  1311646.7458             nan     0.0100 2442.5131
##    200  1272634.5540             nan     0.0100 1380.9854
##    220  1241451.8754             nan     0.0100 1398.2695
##    240  1216909.8111             nan     0.0100  825.7363
##    260  1197354.8212             nan     0.0100  731.2949
##    280  1182053.0898             nan     0.0100  569.1245
##    300  1170176.3840             nan     0.0100  358.3415
##    320  1160182.4019             nan     0.0100  442.0170
##    340  1151956.7650             nan     0.0100  268.6833
##    360  1145411.1268             nan     0.0100  155.8151
##    380  1139977.5207             nan     0.0100   -7.2255
##    400  1135181.9716             nan     0.0100   23.8199
##    420  1130952.1860             nan     0.0100  -67.5141
##    440  1127577.1629             nan     0.0100   55.7416
##    460  1124562.0579             nan     0.0100  -90.8196
##    480  1122196.5873             nan     0.0100   41.0353
##    500  1119606.1742             nan     0.0100 -125.9682
##    520  1117617.2902             nan     0.0100  -69.8553
##    540  1115676.0850             nan     0.0100   62.2807
```

```
##    560  1113793.0453             nan     0.0100   -6.6140
##    580  1112075.4170             nan     0.0100  -93.9842
##    600  1110454.7717             nan     0.0100  -25.7714
##    620  1108671.6976             nan     0.0100  -81.2094
##    640  1107004.6959             nan     0.0100  -78.3065
##    660  1105719.5621             nan     0.0100  -11.6001
##    680  1104405.4166             nan     0.0100  -79.3138
##    700  1103207.1571             nan     0.0100 -128.5559
##    720  1101809.8521             nan     0.0100    3.0159
##    740  1100459.6961             nan     0.0100 -103.7328
##    760  1099233.5790             nan     0.0100  -46.8838
##    780  1098103.4166             nan     0.0100  -57.2036
##    800  1096974.3183             nan     0.0100  -46.4174
##    820  1095617.4455             nan     0.0100 -108.8261
##    840  1094479.3383             nan     0.0100  -94.6741
##    860  1093196.9689             nan     0.0100  -28.5239
##    880  1091841.6077             nan     0.0100  -18.2871
##    900  1090694.5368             nan     0.0100  -36.1023
##    920  1089626.8841             nan     0.0100  -90.8679
##    940  1088062.2707             nan     0.0100  -30.0954
##    960  1086825.4060             nan     0.0100  -38.8878
##    980  1085785.9544             nan     0.0100 -141.2595
##   1000  1084667.2606             nan     0.0100 -182.9446
##   1020  1083259.0828             nan     0.0100  -54.4415
##   1040  1081887.6678             nan     0.0100  -70.7878
##   1060  1080628.8037             nan     0.0100  -28.3066
##   1080  1079646.6165             nan     0.0100  -86.1913
##   1100  1078437.6924             nan     0.0100 -133.2993
##   1120  1077295.3928             nan     0.0100  -35.3929
##   1140  1076174.5098             nan     0.0100  -47.0751
##   1160  1075232.0824             nan     0.0100 -117.3055
##   1180  1073974.3587             nan     0.0100  -96.4463
##   1200  1072858.3669             nan     0.0100 -140.2881
##   1220  1071932.9468             nan     0.0100  -51.7329
##   1240  1070820.6045             nan     0.0100  -22.5621
##   1260  1069931.3254             nan     0.0100  -95.7887
##   1280  1069102.7791             nan     0.0100  -41.1297
##   1300  1068089.6523             nan     0.0100  -82.7089
##   1320  1067096.5408             nan     0.0100  -91.8984
##   1340  1066169.5147             nan     0.0100  -21.2525
##   1360  1065254.8570             nan     0.0100  -84.3716
##   1380  1064515.8723             nan     0.0100 -108.5711
##   1400  1063460.9608             nan     0.0100  -39.1323
##   1420  1062245.7545             nan     0.0100  -17.8134
##   1440  1061282.9947             nan     0.0100  -72.7922
##   1460  1060428.0526             nan     0.0100  -35.5533
##   1480  1059683.3544             nan     0.0100  -22.3468
##   1500  1058686.1007             nan     0.0100 -103.7832
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2869418.8973             nan     0.0100 26582.4825
##      2  2843963.8940             nan     0.0100 25763.3111
##      3  2818657.6499             nan     0.0100 25845.0542
```

```
##      4  2793710.2978           nan     0.0100 25204.4635
##      5  2769071.9231           nan     0.0100 24033.0060
##      6  2745423.7234           nan     0.0100 24383.4440
##      7  2722009.5551           nan     0.0100 23353.5818
##      8  2699067.6743           nan     0.0100 22953.0719
##      9  2675966.1299           nan     0.0100 22325.9836
##     10  2653487.0489           nan     0.0100 21536.1971
##     20  2455715.0831           nan     0.0100 17387.3000
##     40  2139589.3454           nan     0.0100 14772.0945
##     60  1911579.6558           nan     0.0100 8994.9648
##     80  1738083.6228           nan     0.0100 7731.1467
##    100  1605291.2805           nan     0.0100 5731.6965
##    120  1501853.6544           nan     0.0100 3966.3391
##    140  1421064.6127           nan     0.0100 3259.0441
##    160  1358953.1054           nan     0.0100 2770.3710
##    180  1308837.5395           nan     0.0100 2596.4347
##    200  1269108.5132           nan     0.0100 1469.8052
##    220  1238765.5885           nan     0.0100 1101.8449
##    240  1215215.9620           nan     0.0100  924.4905
##    260  1196327.9370           nan     0.0100  709.0958
##    280  1181112.2262           nan     0.0100  669.9336
##    300  1169084.2041           nan     0.0100  332.3605
##    320  1159537.5742           nan     0.0100  252.7337
##    340  1151339.1908           nan     0.0100  177.5853
##    360  1144746.9110           nan     0.0100   90.2748
##    380  1139040.3887           nan     0.0100  286.2570
##    400  1134361.5364           nan     0.0100  138.3262
##    420  1130621.6507           nan     0.0100   27.0947
##    440  1127371.8896           nan     0.0100  -45.6120
##    460  1124527.6706           nan     0.0100  -63.8356
##    480  1121600.4370           nan     0.0100  -11.5294
##    500  1119080.8052           nan     0.0100   -1.3626
##    520  1116894.3955           nan     0.0100 -157.5662
##    540  1114735.1715           nan     0.0100   36.5804
##    560  1112997.3543           nan     0.0100  -60.8168
##    580  1111335.7383           nan     0.0100    9.5603
##    600  1109674.1693           nan     0.0100  -16.2110
##    620  1107830.9126           nan     0.0100 -112.3448
##    640  1106396.7521           nan     0.0100 -147.9388
##    660  1104939.0174           nan     0.0100 -114.0090
##    680  1103571.7272           nan     0.0100   -8.1192
##    700  1102326.2285           nan     0.0100  -39.2868
##    720  1100952.9824           nan     0.0100  -69.4138
##    740  1099605.0377           nan     0.0100 -158.4942
##    760  1098080.9719           nan     0.0100  -81.1908
##    780  1096744.8630           nan     0.0100  -77.0652
##    800  1095154.1273           nan     0.0100  -63.3020
##    820  1093836.8539           nan     0.0100  -76.1285
##    840  1092707.1331           nan     0.0100  -56.0257
##    860  1091708.4328           nan     0.0100  -89.8271
##    880  1090373.4033           nan     0.0100  -45.2815
##    900  1089268.5725           nan     0.0100 -104.9085
##    920  1087895.6856           nan     0.0100 -112.1177
##    940  1086717.7867           nan     0.0100 -169.2714
```

```
##    960  1085587.8111             nan     0.0100  -80.9181
##    980  1084419.3250             nan     0.0100  -15.7923
##   1000  1083282.8788             nan     0.0100  -38.8559
##   1020  1082087.9457             nan     0.0100  -55.6178
##   1040  1081016.3899             nan     0.0100  -69.8136
##   1060  1080003.3313             nan     0.0100  -39.7109
##   1080  1078885.1253             nan     0.0100    9.8001
##   1100  1077695.4248             nan     0.0100  -82.2176
##   1120  1076489.6175             nan     0.0100 -113.3548
##   1140  1075506.2502             nan     0.0100 -122.3523
##   1160  1074735.4641             nan     0.0100 -128.7505
##   1180  1073812.7016             nan     0.0100  -87.8454
##   1200  1072768.8427             nan     0.0100 -246.6389
##   1220  1071734.4049             nan     0.0100 -121.2453
##   1240  1070660.3615             nan     0.0100  -11.5678
##   1260  1069732.6981             nan     0.0100  -86.6417
##   1280  1068676.3110             nan     0.0100 -126.6451
##   1300  1067575.7302             nan     0.0100  -43.1571
##   1320  1066555.2716             nan     0.0100  -81.5558
##   1340  1065682.9989             nan     0.0100  -70.6035
##   1360  1064726.4901             nan     0.0100 -129.5595
##   1380  1063705.9895             nan     0.0100  -72.6869
##   1400  1062603.5243             nan     0.0100  -76.9143
##   1420  1061734.2856             nan     0.0100  -96.0006
##   1440  1060826.5736             nan     0.0100  -68.3309
##   1460  1060101.0482             nan     0.0100  -50.3174
##   1480  1059145.5724             nan     0.0100 -225.5919
##   1500  1058316.3980             nan     0.0100  -94.5178
##   1520  1057528.7671             nan     0.0100  -66.2158
##   1540  1056624.8075             nan     0.0100   16.7218
##   1560  1055646.0666             nan     0.0100  -95.1207
##   1580  1054640.2819             nan     0.0100  -74.7926
##   1600  1053946.7144             nan     0.0100 -140.6818
##   1620  1053266.0346             nan     0.0100  -83.5339
##   1640  1052555.1096             nan     0.0100  -82.9417
##   1660  1051770.9383             nan     0.0100 -111.8030
##   1680  1051024.0205             nan     0.0100   -1.0233
##   1700  1050135.3080             nan     0.0100  -97.2717
##   1720  1049349.3552             nan     0.0100 -102.9224
##   1740  1048492.6943             nan     0.0100  -70.2760
##   1750  1048101.9642             nan     0.0100  -70.1620
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868649.8049             nan     0.0100 26053.6846
##      2  2842159.9871             nan     0.0100 25397.2448
##      3  2817743.5390             nan     0.0100 23387.7780
##      4  2793604.4703             nan     0.0100 23633.0872
##      5  2769169.0639             nan     0.0100 24362.8019
##      6  2744909.9661             nan     0.0100 23767.9338
##      7  2721060.3512             nan     0.0100 23759.9507
##      8  2697474.1850             nan     0.0100 23364.2679
##      9  2674479.4337             nan     0.0100 22447.6857
##     10  2652132.3923             nan     0.0100 22272.0920
```

```
##     20  2453477.8368           nan     0.0100 19337.1892
##     40  2139957.6961           nan     0.0100 14474.7110
##     60  1910021.7019           nan     0.0100 9475.4316
##     80  1735324.5066           nan     0.0100 7488.8655
##    100  1605758.8524           nan     0.0100 5271.4964
##    120  1503224.0704           nan     0.0100 3860.5510
##    140  1424643.3305           nan     0.0100 3988.2396
##    160  1361473.2573           nan     0.0100 2492.3276
##    180  1311029.5704           nan     0.0100 1961.4120
##    200  1271597.1196           nan     0.0100 1692.1294
##    220  1240297.4873           nan     0.0100 1152.2094
##    240  1216255.2663           nan     0.0100  669.1258
##    260  1197519.8190           nan     0.0100  882.2056
##    280  1182136.1282           nan     0.0100  701.8176
##    300  1169808.8157           nan     0.0100  392.0457
##    320  1159711.9446           nan     0.0100  130.6225
##    340  1151815.1672           nan     0.0100  197.9704
##    360  1144794.4310           nan     0.0100  -38.1449
##    380  1139470.1227           nan     0.0100  139.1931
##    400  1134811.5419           nan     0.0100  195.4730
##    420  1130715.9350           nan     0.0100  157.1059
##    440  1127342.7799           nan     0.0100   20.6457
##    460  1124345.7876           nan     0.0100    1.8295
##    480  1121722.6342           nan     0.0100   10.7394
##    500  1119424.0980           nan     0.0100   47.0572
##    520  1117217.8213           nan     0.0100   27.6550
##    540  1115333.7026           nan     0.0100    9.9808
##    560  1113322.4173           nan     0.0100   -9.7818
##    580  1111456.8220           nan     0.0100    0.4014
##    600  1110002.9637           nan     0.0100  -95.4279
##    620  1108464.0808           nan     0.0100   29.9729
##    640  1107042.5418           nan     0.0100  -25.8450
##    660  1105443.6402           nan     0.0100  -39.1873
##    680  1104182.0572           nan     0.0100  -71.4667
##    700  1102732.8481           nan     0.0100  -78.2317
##    720  1101390.9342           nan     0.0100  -58.4004
##    740  1099831.6628           nan     0.0100   -7.7509
##    760  1098501.1747           nan     0.0100 -191.3378
##    780  1097137.4849           nan     0.0100  -97.8664
##    800  1095516.8488           nan     0.0100 -133.7810
##    820  1094488.6960           nan     0.0100 -122.7158
##    840  1093410.9759           nan     0.0100  -25.3590
##    860  1092070.9844           nan     0.0100  -63.6507
##    880  1090935.2133           nan     0.0100 -113.0890
##    900  1089702.9941           nan     0.0100   39.3108
##    920  1088387.7044           nan     0.0100  -81.7236
##    940  1087389.3566           nan     0.0100  -60.8909
##    960  1086187.1133           nan     0.0100    5.1972
##    980  1085225.3987           nan     0.0100  -19.7787
##   1000  1084282.2028           nan     0.0100  -84.1498
##   1020  1083281.8359           nan     0.0100 -153.8193
##   1040  1082239.9766           nan     0.0100  -70.5783
##   1060  1081142.0289           nan     0.0100  -59.6515
##   1080  1080042.6389           nan     0.0100  -73.4387
```

```
##   1100  1078988.0782             nan     0.0100 -120.5378
##   1120  1078069.0558             nan     0.0100  -69.7506
##   1140  1077231.5730             nan     0.0100 -135.3079
##   1160  1076135.7838             nan     0.0100  -89.0182
##   1180  1075107.8782             nan     0.0100 -187.4821
##   1200  1074094.5101             nan     0.0100  -61.0703
##   1220  1072932.4337             nan     0.0100 -136.1942
##   1240  1071988.0299             nan     0.0100  -85.2042
##   1260  1071003.9095             nan     0.0100 -128.7775
##   1280  1070132.7286             nan     0.0100  -88.6093
##   1300  1069073.2394             nan     0.0100  -25.8089
##   1320  1068114.8386             nan     0.0100  -64.4848
##   1340  1067200.3395             nan     0.0100  -19.7592
##   1360  1066288.1212             nan     0.0100 -117.9356
##   1380  1065509.7149             nan     0.0100  -33.6749
##   1400  1064429.1183             nan     0.0100 -105.3369
##   1420  1063568.9288             nan     0.0100  -42.2963
##   1440  1062757.7210             nan     0.0100  -79.9663
##   1460  1061879.5037             nan     0.0100 -132.1889
##   1480  1060839.5540             nan     0.0100 -115.8083
##   1500  1059941.9909             nan     0.0100  -97.1521
##   1520  1058913.0763             nan     0.0100  -36.9438
##   1540  1058148.9614             nan     0.0100  -60.8525
##   1560  1057194.7461             nan     0.0100 -130.9059
##   1580  1056294.3761             nan     0.0100  -52.7228
##   1600  1055328.6945             nan     0.0100  -95.3553
##   1620  1054404.2972             nan     0.0100 -158.9543
##   1640  1053606.1323             nan     0.0100  -81.7000
##   1660  1052634.0572             nan     0.0100 -141.3816
##   1680  1051634.6175             nan     0.0100  -69.6149
##   1700  1050874.8110             nan     0.0100 -135.3675
##   1720  1049951.4685             nan     0.0100  -48.2811
##   1740  1049225.5000             nan     0.0100    4.1152
##   1760  1048459.1632             nan     0.0100    1.7485
##   1780  1047746.9787             nan     0.0100 -106.6245
##   1800  1046915.2233             nan     0.0100  -55.5865
##   1820  1046093.5675             nan     0.0100  -82.0482
##   1840  1045336.5214             nan     0.0100  -63.3596
##   1860  1044410.5719             nan     0.0100 -103.2269
##   1880  1043611.2077             nan     0.0100  -52.0675
##   1900  1042789.3149             nan     0.0100 -145.1339
##   1920  1042029.8378             nan     0.0100  -97.0048
##   1940  1041051.3095             nan     0.0100  -65.6867
##   1960  1040262.8750             nan     0.0100  -26.7319
##   1980  1039527.0355             nan     0.0100  -69.8661
##   2000  1038654.4655             nan     0.0100 -121.6354
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868452.9603             nan     0.0100 26368.9345
##      2  2842275.6474             nan     0.0100 26035.8646
##      3  2817130.9410             nan     0.0100 25941.4575
##      4  2792669.1617             nan     0.0100 25075.6482
##      5  2767836.8022             nan     0.0100 23543.7099
```

```
##      6  2744143.1464           nan     0.0100 23899.4147
##      7  2722062.6614           nan     0.0100 21841.9778
##      8  2699528.6361           nan     0.0100 22363.6428
##      9  2676830.7291           nan     0.0100 22523.7820
##     10  2656696.6422           nan     0.0100 18633.7874
##     20  2457514.9177           nan     0.0100 17618.3548
##     40  2137160.9190           nan     0.0100 13133.0204
##     60  1908914.5989           nan     0.0100 9149.8511
##     80  1740934.9564           nan     0.0100 6904.7000
##    100  1606963.7031           nan     0.0100 5455.8416
##    120  1504369.7997           nan     0.0100 3990.9638
##    140  1424030.0945           nan     0.0100 3071.2366
##    160  1360732.0568           nan     0.0100 2996.2665
##    180  1311255.8261           nan     0.0100 2234.7745
##    200  1272112.0483           nan     0.0100 1936.2924
##    220  1241822.8062           nan     0.0100  964.5881
##    240  1217770.0645           nan     0.0100  920.9271
##    260  1197931.5899           nan     0.0100  999.1382
##    280  1182417.4767           nan     0.0100  425.0819
##    300  1169536.5783           nan     0.0100  554.7073
##    320  1159574.1067           nan     0.0100   49.9619
##    340  1151419.3356           nan     0.0100  253.0980
##    360  1144527.4818           nan     0.0100  360.2470
##    380  1139335.1127           nan     0.0100  112.9259
##    400  1134732.6898           nan     0.0100  -61.3198
##    420  1130707.7872           nan     0.0100  112.5110
##    440  1127381.7750           nan     0.0100   77.7056
##    460  1124380.4703           nan     0.0100   15.9732
##    480  1121785.1717           nan     0.0100  -30.5536
##    500  1119713.4912           nan     0.0100  -47.7422
##    520  1117643.1450           nan     0.0100   33.0875
##    540  1115684.7713           nan     0.0100  -21.5475
##    560  1114086.2016           nan     0.0100 -101.5679
##    580  1112460.8633           nan     0.0100 -164.1038
##    600  1110585.5084           nan     0.0100  -42.9653
##    620  1109170.2964           nan     0.0100  -90.8311
##    640  1107773.9602           nan     0.0100 -100.3331
##    660  1106117.7284           nan     0.0100  -22.9184
##    680  1104862.3433           nan     0.0100  -96.7105
##    700  1103306.5980           nan     0.0100 -169.3660
##    720  1102182.2169           nan     0.0100  -32.0998
##    740  1100736.1007           nan     0.0100  -78.5002
##    760  1099609.1181           nan     0.0100  -58.9136
##    780  1097929.3260           nan     0.0100 -141.0077
##    800  1096560.4595           nan     0.0100  -50.7546
##    820  1095118.3050           nan     0.0100 -159.9223
##    840  1094017.0719           nan     0.0100  -59.2050
##    860  1092803.8104           nan     0.0100  -62.0436
##    880  1091307.9126           nan     0.0100 -104.1422
##    900  1089961.9398           nan     0.0100  -39.5766
##    920  1088818.3183           nan     0.0100  -74.0103
##    940  1087715.2151           nan     0.0100 -165.4164
##    960  1086414.5737           nan     0.0100  -36.9915
##    980  1085030.2205           nan     0.0100 -205.2125
```

```
##   1000  1083753.9280           nan     0.0100  -31.6682
##   1020  1082913.0088           nan     0.0100  -88.9346
##   1040  1081829.0842           nan     0.0100  -67.1907
##   1060  1080804.5056           nan     0.0100  -69.9521
##   1080  1079713.2537           nan     0.0100  -37.1715
##   1100  1078716.4329           nan     0.0100 -145.3875
##   1120  1077770.1636           nan     0.0100  -14.2824
##   1140  1076779.3051           nan     0.0100  -61.7557
##   1160  1075857.5912           nan     0.0100 -139.2117
##   1180  1074856.6207           nan     0.0100 -162.2497
##   1200  1073723.2775           nan     0.0100  -62.6513
##   1220  1072821.4134           nan     0.0100  -99.3550
##   1240  1071786.4699           nan     0.0100  -73.0533
##   1260  1070697.9298           nan     0.0100   12.5657
##   1280  1069968.3638           nan     0.0100 -100.2002
##   1300  1069071.9197           nan     0.0100  -72.5228
##   1320  1068210.8930           nan     0.0100 -135.1308
##   1340  1067111.4534           nan     0.0100  -56.4627
##   1360  1066073.4367           nan     0.0100 -100.1157
##   1380  1065264.9859           nan     0.0100  -52.8424
##   1400  1064424.1051           nan     0.0100  -29.1478
##   1420  1063630.7244           nan     0.0100 -181.0030
##   1440  1062740.3993           nan     0.0100 -117.0255
##   1460  1061864.8111           nan     0.0100  -57.5329
##   1480  1060769.7527           nan     0.0100  -85.4940
##   1500  1059818.8581           nan     0.0100 -100.9668
##   1520  1058778.0037           nan     0.0100  -24.7056
##   1540  1057739.3499           nan     0.0100 -107.4978
##   1560  1056710.9697           nan     0.0100 -107.9566
##   1580  1055748.0939           nan     0.0100 -104.6696
##   1600  1054974.8896           nan     0.0100  -74.5820
##   1620  1054152.0399           nan     0.0100 -117.4766
##   1640  1053305.8268           nan     0.0100 -140.1057
##   1660  1052344.8274           nan     0.0100  -99.3086
##   1680  1051305.2708           nan     0.0100  -62.7553
##   1700  1050467.8033           nan     0.0100  -95.9726
##   1720  1049688.1299           nan     0.0100 -119.7720
##   1740  1048743.4571           nan     0.0100  -22.3956
##   1760  1047860.5421           nan     0.0100  -77.4726
##   1780  1046964.0929           nan     0.0100 -102.4858
##   1800  1045951.7153           nan     0.0100 -161.4880
##   1820  1044992.6633           nan     0.0100 -106.2292
##   1840  1044161.1643           nan     0.0100 -117.4942
##   1860  1043359.7768           nan     0.0100 -100.2691
##   1880  1042496.8411           nan     0.0100  -67.0178
##   1900  1041738.0650           nan     0.0100  -94.0471
##   1920  1041079.9308           nan     0.0100  -92.7106
##   1940  1040268.5612           nan     0.0100 -151.5156
##   1960  1039544.5923           nan     0.0100 -193.1577
##   1980  1038818.8197           nan     0.0100 -113.1345
##   2000  1037897.7206           nan     0.0100  -64.6389
##   2020  1037196.9094           nan     0.0100  -48.0731
##   2040  1036459.3183           nan     0.0100  -91.2537
##   2060  1035749.8744           nan     0.0100 -119.1463
```

```
##   2080  1035042.6156             nan     0.0100 -105.9927
##   2100  1034344.4921             nan     0.0100  -77.1410
##   2120  1033554.1486             nan     0.0100  -26.8129
##   2140  1032812.5183             nan     0.0100  -32.4657
##   2160  1031976.8454             nan     0.0100  -83.8737
##   2180  1031127.1001             nan     0.0100  -33.2761
##   2200  1030425.7083             nan     0.0100  -33.4523
##   2220  1029490.9530             nan     0.0100  -47.9258
##   2240  1028568.1214             nan     0.0100  -66.3490
##   2250  1028243.2654             nan     0.0100  -52.2577
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2869260.0391             nan     0.0100 26684.9098
##      2  2843378.0476             nan     0.0100 26152.8429
##      3  2818642.7606             nan     0.0100 23783.6107
##      4  2793346.9885             nan     0.0100 24747.8947
##      5  2769165.8702             nan     0.0100 24630.9047
##      6  2745011.4433             nan     0.0100 24515.6269
##      7  2721522.5653             nan     0.0100 22925.5032
##      8  2698323.5748             nan     0.0100 23157.9186
##      9  2675667.4578             nan     0.0100 23398.2613
##     10  2653675.6148             nan     0.0100 21663.2113
##     20  2456271.1166             nan     0.0100 17516.9551
##     40  2141682.2512             nan     0.0100 13645.8148
##     60  1910767.7931             nan     0.0100 10587.1548
##     80  1739997.9141             nan     0.0100 6692.7619
##    100  1608559.2173             nan     0.0100 5037.9412
##    120  1503449.5037             nan     0.0100 4199.3805
##    140  1424614.1190             nan     0.0100 3142.3171
##    160  1359433.9572             nan     0.0100 3008.2221
##    180  1309335.0416             nan     0.0100 1968.3809
##    200  1271892.0312             nan     0.0100 1816.6283
##    220  1241277.7543             nan     0.0100 1264.0513
##    240  1216081.0211             nan     0.0100 1185.7906
##    260  1197132.1089             nan     0.0100  668.9924
##    280  1181121.8588             nan     0.0100  593.4950
##    300  1169277.5982             nan     0.0100  258.3800
##    320  1159417.5942             nan     0.0100  264.9998
##    340  1151259.3079             nan     0.0100  120.6637
##    360  1144574.5633             nan     0.0100  146.9308
##    380  1139201.8273             nan     0.0100    8.5692
##    400  1134403.3692             nan     0.0100   35.1692
##    420  1130487.1066             nan     0.0100   74.7628
##    440  1126803.3360             nan     0.0100  -23.5328
##    460  1123767.9830             nan     0.0100   20.1948
##    480  1120977.2420             nan     0.0100  -46.0223
##    500  1118697.2833             nan     0.0100   24.0402
##    520  1116732.4518             nan     0.0100  -45.4300
##    540  1114977.1445             nan     0.0100  -21.8310
##    560  1113200.7835             nan     0.0100   44.1429
##    580  1111323.5910             nan     0.0100  -61.7828
##    600  1109630.8189             nan     0.0100  -49.3255
##    620  1108065.0111             nan     0.0100  -41.9545
```

```
##    640  1106625.5598           nan     0.0100  -87.6429
##    660  1105394.8695           nan     0.0100 -203.8442
##    680  1103937.9837           nan     0.0100 -158.5508
##    700  1102401.9831           nan     0.0100  -82.6795
##    720  1100936.9029           nan     0.0100  -43.6114
##    740  1099341.1429           nan     0.0100  -13.9164
##    760  1097836.2438           nan     0.0100 -130.1147
##    780  1096590.8758           nan     0.0100 -227.0051
##    800  1095473.1871           nan     0.0100  -89.3246
##    820  1094252.8837           nan     0.0100  -26.0893
##    840  1093007.4959           nan     0.0100   -7.3034
##    860  1091781.1750           nan     0.0100 -143.8236
##    880  1090600.3142           nan     0.0100  -89.3383
##    900  1089197.3948           nan     0.0100  -25.8505
##    920  1088061.3124           nan     0.0100  -67.9901
##    940  1086877.9863           nan     0.0100  -50.3064
##    960  1085970.0503           nan     0.0100  -97.7397
##    980  1084774.1015           nan     0.0100 -126.3769
##   1000  1083343.2580           nan     0.0100  -55.9152
##   1020  1082345.4256           nan     0.0100 -169.0244
##   1040  1081495.9895           nan     0.0100  -23.4370
##   1060  1080560.6148           nan     0.0100  -67.4544
##   1080  1079474.6572           nan     0.0100  -41.4980
##   1100  1078412.9267           nan     0.0100  -47.5090
##   1120  1077346.9231           nan     0.0100 -108.7750
##   1140  1076049.3572           nan     0.0100 -146.8108
##   1160  1074916.8289           nan     0.0100  -27.0659
##   1180  1073850.5225           nan     0.0100 -112.4416
##   1200  1072818.5188           nan     0.0100  -94.9782
##   1220  1071622.7088           nan     0.0100 -154.0628
##   1240  1070743.8189           nan     0.0100  -89.3688
##   1260  1069735.1181           nan     0.0100  -68.4752
##   1280  1068834.5028           nan     0.0100 -143.2878
##   1300  1067800.3129           nan     0.0100  -90.6619
##   1320  1066791.0063           nan     0.0100 -113.6451
##   1340  1065782.4624           nan     0.0100  -92.2040
##   1360  1064845.6269           nan     0.0100  -84.9638
##   1380  1063877.8161           nan     0.0100  -90.7735
##   1400  1062871.8310           nan     0.0100 -185.8364
##   1420  1061752.2365           nan     0.0100  -99.4958
##   1440  1060895.3107           nan     0.0100  -95.4210
##   1460  1059928.8992           nan     0.0100  -29.7134
##   1480  1059069.5621           nan     0.0100   -9.7200
##   1500  1058044.4907           nan     0.0100  -31.0604
##   1520  1056911.0094           nan     0.0100  -35.8124
##   1540  1056077.0583           nan     0.0100  -74.2458
##   1560  1055181.4366           nan     0.0100  -59.6645
##   1580  1054434.5308           nan     0.0100  -81.4436
##   1600  1053480.0508           nan     0.0100  -64.4919
##   1620  1052528.8633           nan     0.0100  -64.1118
##   1640  1051567.5069           nan     0.0100  -84.4254
##   1660  1050598.2063           nan     0.0100  -84.7356
##   1680  1049442.5430           nan     0.0100  -54.9160
##   1700  1048436.4513           nan     0.0100 -133.3198
```

```
##   1720  1047674.5095             nan     0.0100  -68.3338
##   1740  1046943.9304             nan     0.0100 -101.3035
##   1760  1046151.5761             nan     0.0100  -82.3387
##   1780  1045344.5967             nan     0.0100  -87.8428
##   1800  1044444.9276             nan     0.0100 -156.0533
##   1820  1043765.6911             nan     0.0100  -93.3474
##   1840  1042827.7408             nan     0.0100 -118.7715
##   1860  1041985.6694             nan     0.0100  -28.7624
##   1880  1041183.2360             nan     0.0100  -86.0140
##   1900  1040335.6108             nan     0.0100  -48.2303
##   1920  1039669.8958             nan     0.0100 -116.3329
##   1940  1038761.5765             nan     0.0100 -138.8378
##   1960  1038023.1014             nan     0.0100 -124.2436
##   1980  1037185.9297             nan     0.0100  -42.4050
##   2000  1036419.7566             nan     0.0100  -71.4865
##   2020  1035594.4235             nan     0.0100  -62.9763
##   2040  1034922.1464             nan     0.0100  -61.8375
##   2060  1034083.1400             nan     0.0100 -137.6609
##   2080  1033403.1137             nan     0.0100  -64.5303
##   2100  1032727.4489             nan     0.0100  -72.6270
##   2120  1031821.2562             nan     0.0100  -51.1071
##   2140  1031048.5687             nan     0.0100 -104.1204
##   2160  1030190.7176             nan     0.0100  -15.0941
##   2180  1029426.2999             nan     0.0100  -91.5783
##   2200  1028550.6995             nan     0.0100   23.3390
##   2220  1027869.8476             nan     0.0100  -24.0162
##   2240  1027015.4903             nan     0.0100 -120.1444
##   2260  1026178.6408             nan     0.0100  -92.1320
##   2280  1025464.0508             nan     0.0100 -146.0378
##   2300  1024870.8452             nan     0.0100 -135.4088
##   2320  1024153.8063             nan     0.0100  -50.5667
##   2340  1023343.5608             nan     0.0100  -45.0667
##   2360  1022569.4829             nan     0.0100  -44.3982
##   2380  1021871.1819             nan     0.0100 -105.7142
##   2400  1021167.4403             nan     0.0100  -90.4871
##   2420  1020432.6597             nan     0.0100  -44.6667
##   2440  1019535.3984             nan     0.0100  -58.6271
##   2460  1018594.4173             nan     0.0100  -14.5622
##   2480  1017765.0416             nan     0.0100  -76.0441
##   2500  1017005.7868             nan     0.0100  -57.8982
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868586.8765             nan     0.0100 26897.0793
##      2  2842658.0230             nan     0.0100 25870.1939
##      3  2817419.1819             nan     0.0100 24760.8552
##      4  2792882.0239             nan     0.0100 24483.2544
##      5  2768145.2534             nan     0.0100 24641.9738
##      6  2744065.8655             nan     0.0100 23988.6854
##      7  2721058.4049             nan     0.0100 23716.0899
##      8  2699683.4088             nan     0.0100 20659.9672
##      9  2676549.4512             nan     0.0100 23099.1827
##     10  2653666.2828             nan     0.0100 22595.1425
##     20  2457278.4810             nan     0.0100 17714.6307
```

```
##     40  2139344.2412           nan     0.0100 12637.8408
##     60  1904858.0735           nan     0.0100 10011.3803
##     80  1734542.9535           nan     0.0100 7105.9579
##    100  1604443.6380           nan     0.0100 6518.1858
##    120  1502712.1889           nan     0.0100 4371.6427
##    140  1424237.4636           nan     0.0100 2959.5575
##    160  1361921.9105           nan     0.0100 3028.5881
##    180  1313169.7069           nan     0.0100 2382.3782
##    200  1273318.0207           nan     0.0100 1787.8075
##    220  1242022.3937           nan     0.0100  960.7314
##    240  1216879.9501           nan     0.0100  886.7213
##    260  1197512.4008           nan     0.0100  668.7755
##    280  1182035.1892           nan     0.0100  494.6936
##    300  1170203.1636           nan     0.0100  542.2510
##    320  1160211.3925           nan     0.0100  165.3797
##    340  1152208.5535           nan     0.0100  119.3866
##    360  1145294.7073           nan     0.0100  334.9331
##    380  1139691.9907           nan     0.0100 -121.1031
##    400  1135102.3116           nan     0.0100  194.8185
##    420  1131277.9609           nan     0.0100  -53.4984
##    440  1127811.8010           nan     0.0100  -59.9708
##    460  1124884.1748           nan     0.0100  111.6503
##    480  1122205.0163           nan     0.0100  -19.0956
##    500  1119777.2639           nan     0.0100 -105.7700
##    520  1117565.8676           nan     0.0100    0.6097
##    540  1115769.2764           nan     0.0100  -22.1718
##    560  1113917.1096           nan     0.0100   36.6549
##    580  1112045.6344           nan     0.0100  -64.4484
##    600  1110508.6794           nan     0.0100  -64.0319
##    620  1109118.2580           nan     0.0100  -92.2743
##    640  1107402.3129           nan     0.0100  -70.6494
##    660  1105973.9437           nan     0.0100  -59.0330
##    680  1104599.8938           nan     0.0100 -113.3339
##    700  1103357.9323           nan     0.0100  -24.8811
##    720  1101634.1034           nan     0.0100  -27.6263
##    740  1100181.2227           nan     0.0100  -86.6068
##    760  1098693.1924           nan     0.0100   -3.3076
##    780  1097339.5509           nan     0.0100  -43.0022
##    800  1095910.2745           nan     0.0100    4.9879
##    820  1094785.4906           nan     0.0100  -67.6805
##    840  1093398.1806           nan     0.0100  -63.5219
##    860  1092382.5816           nan     0.0100  -53.7520
##    880  1091086.4009           nan     0.0100  -63.0027
##    900  1090091.5818           nan     0.0100  -30.4446
##    920  1088798.4582           nan     0.0100  -78.7321
##    940  1087670.0673           nan     0.0100 -120.0338
##    960  1086692.9494           nan     0.0100  -50.0792
##    980  1085346.8819           nan     0.0100 -149.8522
##   1000  1084401.7683           nan     0.0100   -3.9989
##   1020  1083171.1757           nan     0.0100 -125.3201
##   1040  1082159.7144           nan     0.0100  -49.8262
##   1060  1081125.6824           nan     0.0100  -81.7978
##   1080  1079941.8124           nan     0.0100  -68.9474
##   1100  1079073.4295           nan     0.0100  -40.1074
```

```
##   1120  1077811.2746           nan     0.0100  -50.4428
##   1140  1076835.1310           nan     0.0100 -129.5762
##   1160  1075765.9815           nan     0.0100 -187.9729
##   1180  1074726.2143           nan     0.0100  -55.7855
##   1200  1073592.9471           nan     0.0100  -94.1313
##   1220  1072554.2510           nan     0.0100  -40.2356
##   1240  1071546.4249           nan     0.0100  -42.7399
##   1260  1070529.2107           nan     0.0100 -172.8111
##   1280  1069423.7065           nan     0.0100  -98.7472
##   1300  1068350.3324           nan     0.0100  -62.1061
##   1320  1067422.3516           nan     0.0100  -34.7045
##   1340  1066489.1349           nan     0.0100   17.5812
##   1360  1065592.3671           nan     0.0100  -86.1566
##   1380  1064560.4340           nan     0.0100 -248.7579
##   1400  1063611.3048           nan     0.0100  -16.3461
##   1420  1062446.6327           nan     0.0100 -102.4834
##   1440  1061515.8331           nan     0.0100  -42.7817
##   1460  1060505.7794           nan     0.0100  -10.8256
##   1480  1059438.5738           nan     0.0100  -51.9338
##   1500  1058471.6806           nan     0.0100  -68.2277
##   1520  1057438.1348           nan     0.0100 -128.1621
##   1540  1056600.1078           nan     0.0100  -50.7788
##   1560  1055624.2882           nan     0.0100 -109.8645
##   1580  1054797.8017           nan     0.0100  -67.5191
##   1600  1053836.4368           nan     0.0100  -97.1239
##   1620  1053005.1247           nan     0.0100  -55.0793
##   1640  1052094.3679           nan     0.0100  -17.0855
##   1660  1051214.3990           nan     0.0100 -105.5312
##   1680  1050351.8204           nan     0.0100  -59.8611
##   1700  1049550.8987           nan     0.0100  -24.7775
##   1720  1048741.3585           nan     0.0100  -81.2640
##   1740  1047845.5196           nan     0.0100  -95.4212
##   1760  1046862.6360           nan     0.0100  -59.4266
##   1780  1046093.4619           nan     0.0100 -127.1520
##   1800  1045292.2573           nan     0.0100  -66.6080
##   1820  1044526.7534           nan     0.0100  -27.8825
##   1840  1043542.6532           nan     0.0100  -94.1071
##   1860  1042828.3228           nan     0.0100 -104.9722
##   1880  1042157.8121           nan     0.0100  -39.4080
##   1900  1041293.3787           nan     0.0100 -178.6531
##   1920  1040517.7814           nan     0.0100  -87.6991
##   1940  1039776.6499           nan     0.0100 -125.0262
##   1960  1038954.0761           nan     0.0100  -93.0910
##   1980  1038139.2030           nan     0.0100  -28.4190
##   2000  1037271.2621           nan     0.0100  -65.8857
##   2020  1036384.3290           nan     0.0100 -100.1870
##   2040  1035572.0244           nan     0.0100 -149.7964
##   2060  1034955.0494           nan     0.0100  -97.0281
##   2080  1034118.6122           nan     0.0100  -67.1185
##   2100  1033417.1221           nan     0.0100 -101.8477
##   2120  1032656.8930           nan     0.0100 -106.0406
##   2140  1032098.1875           nan     0.0100 -180.1860
##   2160  1031359.6443           nan     0.0100  -90.6587
##   2180  1030545.8225           nan     0.0100  -28.0001
```

```
##   2200  1029952.0642             nan     0.0100 -113.5355
##   2220  1029032.6409             nan     0.0100  -30.4443
##   2240  1028363.5183             nan     0.0100  -18.6007
##   2260  1027640.0637             nan     0.0100 -145.6038
##   2280  1026988.9642             nan     0.0100  -46.4491
##   2300  1026201.6578             nan     0.0100  -49.4573
##   2320  1025590.5327             nan     0.0100  -66.3979
##   2340  1024927.2948             nan     0.0100 -188.2934
##   2360  1024194.6093             nan     0.0100 -106.1464
##   2380  1023405.3987             nan     0.0100   -5.6901
##   2400  1022706.0461             nan     0.0100 -132.7637
##   2420  1021947.8481             nan     0.0100 -108.2503
##   2440  1021369.0851             nan     0.0100  -78.8628
##   2460  1020795.8652             nan     0.0100 -184.5450
##   2480  1020194.9963             nan     0.0100  -77.9600
##   2500  1019390.3020             nan     0.0100  -40.6488
##   2520  1018669.5844             nan     0.0100  -74.8542
##   2540  1017951.3088             nan     0.0100  -80.3409
##   2560  1017113.7643             nan     0.0100  -86.9234
##   2580  1016482.3644             nan     0.0100  -97.4917
##   2600  1015684.2416             nan     0.0100  -44.3564
##   2620  1015099.8023             nan     0.0100  -66.3750
##   2640  1014442.7787             nan     0.0100 -126.0156
##   2660  1013805.5814             nan     0.0100  -91.7129
##   2680  1013102.8007             nan     0.0100  -87.0448
##   2700  1012471.2976             nan     0.0100  -49.5780
##   2720  1011670.1345             nan     0.0100  -69.7754
##   2740  1010883.7985             nan     0.0100  -97.6465
##   2750  1010606.5482             nan     0.0100  -69.5824
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2869566.6148             nan     0.0100 26359.2521
##      2  2842611.1013             nan     0.0100 25623.7602
##      3  2817219.1429             nan     0.0100 25943.5469
##      4  2792443.5741             nan     0.0100 25630.4455
##      5  2767981.8435             nan     0.0100 23878.2602
##      6  2745462.0803             nan     0.0100 22279.6888
##      7  2722196.0772             nan     0.0100 23097.7041
##      8  2698298.1641             nan     0.0100 23647.2220
##      9  2674858.8322             nan     0.0100 22723.3495
##     10  2653962.7560             nan     0.0100 20811.1281
##     20  2458380.8480             nan     0.0100 16432.1240
##     40  2144813.4099             nan     0.0100 13146.2515
##     60  1911252.8889             nan     0.0100 9073.4491
##     80  1740035.9480             nan     0.0100 8105.0383
##    100  1605958.7087             nan     0.0100 5710.7084
##    120  1504399.9404             nan     0.0100 4983.8504
##    140  1424839.9410             nan     0.0100 3244.1522
##    160  1361001.1387             nan     0.0100 3208.1880
##    180  1309547.1107             nan     0.0100 2072.8539
##    200  1271779.4471             nan     0.0100 1715.5541
##    220  1241436.6871             nan     0.0100 1331.1440
##    240  1217245.7004             nan     0.0100 1001.2774
```

```
##    260  1197620.0220           nan     0.0100  540.0279
##    280  1182251.0723           nan     0.0100  717.1334
##    300  1169734.2801           nan     0.0100  373.5334
##    320  1160356.7951           nan     0.0100  355.7394
##    340  1152493.4951           nan     0.0100  122.6126
##    360  1145587.1676           nan     0.0100    7.4927
##    380  1140075.7292           nan     0.0100  116.5325
##    400  1135239.5266           nan     0.0100  139.7706
##    420  1130948.1695           nan     0.0100  -49.7886
##    440  1127463.5808           nan     0.0100   44.2410
##    460  1124339.2927           nan     0.0100  -16.8070
##    480  1121644.3634           nan     0.0100   30.2578
##    500  1119251.6728           nan     0.0100   16.2891
##    520  1117132.9733           nan     0.0100   45.1268
##    540  1115430.7471           nan     0.0100  -85.4339
##    560  1113623.4198           nan     0.0100 -107.9672
##    580  1112063.6952           nan     0.0100 -195.2550
##    600  1110544.7916           nan     0.0100  -38.9086
##    620  1108928.2558           nan     0.0100  -33.9531
##    640  1107349.7274           nan     0.0100  -61.4725
##    660  1105855.7866           nan     0.0100 -105.4519
##    680  1104673.7445           nan     0.0100   -3.2488
##    700  1103356.6551           nan     0.0100  -33.9781
##    720  1101907.9200           nan     0.0100 -209.1297
##    740  1100405.7107           nan     0.0100   -3.7175
##    760  1099071.3633           nan     0.0100  -81.0011
##    780  1097760.8939           nan     0.0100  -43.0761
##    800  1096710.7105           nan     0.0100  -12.0104
##    820  1095426.2570           nan     0.0100   -6.0233
##    840  1094283.3745           nan     0.0100 -123.4865
##    860  1093022.9177           nan     0.0100  -96.2362
##    880  1091864.6596           nan     0.0100 -125.5700
##    900  1090775.8810           nan     0.0100  -46.5944
##    920  1089222.5081           nan     0.0100  -54.9668
##    940  1088165.6442           nan     0.0100  -48.8856
##    960  1086942.1026           nan     0.0100 -228.0690
##    980  1085752.2080           nan     0.0100  -52.5033
##   1000  1084672.6546           nan     0.0100  -99.4585
##   1020  1083693.6657           nan     0.0100  -55.8104
##   1040  1082626.3908           nan     0.0100  -46.1395
##   1060  1081405.7804           nan     0.0100  -78.0506
##   1080  1080239.5520           nan     0.0100   -0.7021
##   1100  1079294.2912           nan     0.0100  -38.7938
##   1120  1078182.9250           nan     0.0100 -106.7422
##   1140  1077119.0578           nan     0.0100  -30.7732
##   1160  1075839.2500           nan     0.0100 -174.2047
##   1180  1074916.0160           nan     0.0100  -87.2970
##   1200  1073890.4339           nan     0.0100 -118.0821
##   1220  1072751.7036           nan     0.0100 -226.1540
##   1240  1071621.5808           nan     0.0100  -58.4154
##   1260  1070746.6790           nan     0.0100  -20.2888
##   1280  1069643.6976           nan     0.0100 -132.1394
##   1300  1068670.0611           nan     0.0100 -141.3853
##   1320  1067723.7276           nan     0.0100  -21.8876
```

```
##   1340  1066797.2912           nan     0.0100  -71.9162
##   1360  1065903.3711           nan     0.0100 -143.3432
##   1380  1065129.9944           nan     0.0100 -144.1237
##   1400  1064046.5975           nan     0.0100 -104.8027
##   1420  1063261.0978           nan     0.0100  -73.7181
##   1440  1062427.4809           nan     0.0100  -59.6834
##   1460  1061400.5101           nan     0.0100 -102.9856
##   1480  1060517.9694           nan     0.0100 -130.6193
##   1500  1059487.3276           nan     0.0100  -33.3134
##   1520  1058516.3301           nan     0.0100 -105.2511
##   1540  1057653.1896           nan     0.0100 -148.0880
##   1560  1056719.6802           nan     0.0100  -30.9027
##   1580  1055706.3117           nan     0.0100   33.1641
##   1600  1054900.4535           nan     0.0100  -95.7650
##   1620  1054096.9721           nan     0.0100  -53.4544
##   1640  1053262.2606           nan     0.0100  -87.5816
##   1660  1052306.5539           nan     0.0100  -40.5900
##   1680  1051385.3106           nan     0.0100 -129.6607
##   1700  1050495.2112           nan     0.0100 -116.0918
##   1720  1049573.1109           nan     0.0100  -93.3944
##   1740  1048836.0790           nan     0.0100  -52.2917
##   1760  1047968.2731           nan     0.0100 -137.0643
##   1780  1047052.5226           nan     0.0100 -161.6725
##   1800  1046295.4984           nan     0.0100  -74.8398
##   1820  1045423.5924           nan     0.0100  -51.7929
##   1840  1044583.8625           nan     0.0100  -33.5185
##   1860  1043718.9970           nan     0.0100 -111.3559
##   1880  1042846.0395           nan     0.0100  -80.9748
##   1900  1042074.3601           nan     0.0100  -73.3819
##   1920  1041257.6413           nan     0.0100 -108.5413
##   1940  1040275.0778           nan     0.0100 -114.6212
##   1960  1039245.3032           nan     0.0100  -58.8944
##   1980  1038470.3177           nan     0.0100 -153.1631
##   2000  1037600.1370           nan     0.0100 -102.0201
##   2020  1036751.6739           nan     0.0100 -110.9013
##   2040  1036052.6532           nan     0.0100  -95.6193
##   2060  1035166.3960           nan     0.0100  -32.0585
##   2080  1034405.4007           nan     0.0100  -64.3136
##   2100  1033657.3698           nan     0.0100  -59.7754
##   2120  1032966.7753           nan     0.0100 -111.8388
##   2140  1032305.1382           nan     0.0100 -103.9526
##   2160  1031614.2231           nan     0.0100 -194.5038
##   2180  1030766.9272           nan     0.0100  -96.4679
##   2200  1029908.7702           nan     0.0100  -54.7224
##   2220  1029194.9985           nan     0.0100  -61.3945
##   2240  1028521.1782           nan     0.0100  -91.7291
##   2260  1027822.1554           nan     0.0100  -42.0536
##   2280  1026974.0325           nan     0.0100  -99.7221
##   2300  1026273.3198           nan     0.0100  -56.5573
##   2320  1025571.4046           nan     0.0100  -83.8480
##   2340  1024704.2225           nan     0.0100 -173.1198
##   2360  1024073.4107           nan     0.0100  -94.1839
##   2380  1023219.1476           nan     0.0100  -71.3067
##   2400  1022461.1368           nan     0.0100  -91.9031
```

```
##   2420  1021619.4666             nan     0.0100  -62.7301
##   2440  1020808.4858             nan     0.0100  -75.1434
##   2460  1019950.3546             nan     0.0100  -75.0850
##   2480  1019036.9771             nan     0.0100  -40.4347
##   2500  1018461.9878             nan     0.0100  -65.4921
##   2520  1017803.8183             nan     0.0100  -32.4264
##   2540  1016947.1324             nan     0.0100 -115.7327
##   2560  1016213.1000             nan     0.0100 -168.6491
##   2580  1015499.7435             nan     0.0100 -200.9970
##   2600  1014859.9411             nan     0.0100 -129.3973
##   2620  1014247.4104             nan     0.0100 -197.4752
##   2640  1013565.2584             nan     0.0100  -95.9772
##   2660  1012893.8458             nan     0.0100 -101.4107
##   2680  1012190.7683             nan     0.0100  -46.3866
##   2700  1011563.5653             nan     0.0100   -7.3379
##   2720  1010770.4532             nan     0.0100  -97.1571
##   2740  1010200.9960             nan     0.0100 -131.3944
##   2760  1009563.6314             nan     0.0100  -79.6350
##   2780  1008737.6076             nan     0.0100 -119.2567
##   2800  1008108.4608             nan     0.0100  -59.5072
##   2820  1007595.2880             nan     0.0100 -142.2029
##   2840  1006959.4796             nan     0.0100  -60.6728
##   2860  1006293.6951             nan     0.0100  -30.8236
##   2880  1005677.2929             nan     0.0100  -77.9381
##   2900  1004927.6478             nan     0.0100  -76.9793
##   2920  1004313.5938             nan     0.0100  -57.1112
##   2940  1003700.9036             nan     0.0100  -96.5218
##   2960  1003006.2784             nan     0.0100 -189.7030
##   2980  1002341.3866             nan     0.0100  -84.4994
##   3000  1001690.5000             nan     0.0100 -108.3308
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2869135.9508             nan     0.0100 26854.9735
##      2  2842407.9384             nan     0.0100 25927.1929
##      3  2817185.6066             nan     0.0100 25521.2480
##      4  2793765.8075             nan     0.0100 23309.4372
##      5  2768994.9530             nan     0.0100 24658.2180
##      6  2745466.0989             nan     0.0100 24317.0236
##      7  2721617.9203             nan     0.0100 23082.1322
##      8  2698897.1828             nan     0.0100 22709.2384
##      9  2677417.0580             nan     0.0100 21063.0055
##     10  2654959.6393             nan     0.0100 21862.9751
##     20  2455634.2615             nan     0.0100 17630.2640
##     40  2141596.1020             nan     0.0100 12731.5247
##     60  1911584.3634             nan     0.0100 9180.4090
##     80  1737164.9418             nan     0.0100 6797.2017
##    100  1605906.1496             nan     0.0100 5355.5726
##    120  1503048.5428             nan     0.0100 4895.2248
##    140  1423536.5463             nan     0.0100 3040.7186
##    160  1359972.2267             nan     0.0100 2336.9314
##    180  1309983.7720             nan     0.0100 2056.6560
##    200  1270951.0164             nan     0.0100 1241.0372
##    220  1239944.1471             nan     0.0100 1043.7044
```

```
##    240  1215187.0019           nan     0.0100  891.1534
##    260  1196343.1330           nan     0.0100  705.5350
##    280  1181384.7060           nan     0.0100  691.6557
##    300  1169466.7351           nan     0.0100  454.3736
##    320  1159945.4742           nan     0.0100  178.3405
##    340  1152327.0214           nan     0.0100  244.3823
##    360  1145458.2835           nan     0.0100  198.4171
##    380  1139839.7733           nan     0.0100  186.2295
##    400  1135195.6632           nan     0.0100   38.3468
##    420  1131349.9636           nan     0.0100  123.7659
##    440  1127752.7117           nan     0.0100  -45.0843
##    460  1124780.8159           nan     0.0100  -32.0243
##    480  1122048.0281           nan     0.0100 -123.2512
##    500  1119756.0257           nan     0.0100  -86.5957
##    520  1117540.4286           nan     0.0100  -16.0553
##    540  1115671.2426           nan     0.0100  -78.2477
##    560  1113974.1119           nan     0.0100  -39.3890
##    580  1112235.7193           nan     0.0100  -74.3128
##    600  1110686.1325           nan     0.0100 -173.9603
##    620  1109154.2385           nan     0.0100  -60.1460
##    640  1107710.6259           nan     0.0100   -4.5972
##    660  1106438.1033           nan     0.0100  -71.8064
##    680  1105100.3604           nan     0.0100 -119.8819
##    700  1104007.9715           nan     0.0100  -71.3985
##    720  1102727.8041           nan     0.0100 -105.4683
##    740  1101199.3459           nan     0.0100 -134.9254
##    760  1099902.7609           nan     0.0100  -24.5835
##    780  1098587.0193           nan     0.0100 -120.6304
##    800  1097186.1505           nan     0.0100  -43.5430
##    820  1095823.9113           nan     0.0100  -98.7419
##    840  1094549.8347           nan     0.0100  -19.2591
##    860  1093140.7450           nan     0.0100  -53.9501
##    880  1092254.9358           nan     0.0100   -7.6979
##    900  1091097.2895           nan     0.0100  -67.5964
##    920  1089933.5976           nan     0.0100 -134.9468
##    940  1088711.1749           nan     0.0100  -74.4267
##    960  1087471.3013           nan     0.0100 -115.9227
##    980  1086449.8919           nan     0.0100  -44.3169
##   1000  1085384.6759           nan     0.0100  -67.8730
##   1020  1084256.7306           nan     0.0100  -79.1245
##   1040  1083158.5333           nan     0.0100  -44.5348
##   1060  1082050.2735           nan     0.0100  -76.5915
##   1080  1080895.0500           nan     0.0100 -118.9136
##   1100  1079764.9010           nan     0.0100  -40.2822
##   1120  1078829.5242           nan     0.0100 -103.7330
##   1140  1077648.1137           nan     0.0100 -103.3174
##   1160  1076521.4449           nan     0.0100  -60.7036
##   1180  1075584.1806           nan     0.0100  -33.2771
##   1200  1074476.4134           nan     0.0100 -110.2486
##   1220  1073429.9657           nan     0.0100 -106.7883
##   1240  1072476.1272           nan     0.0100  -36.9018
##   1260  1071426.9328           nan     0.0100  -79.3919
##   1280  1070692.4846           nan     0.0100 -150.1219
##   1300  1069448.4538           nan     0.0100 -132.1718
```

```
##   1320  1068573.6154            nan     0.0100 -111.2737
##   1340  1067629.7174            nan     0.0100  -81.1876
##   1360  1066645.1903            nan     0.0100 -107.7905
##   1380  1065686.3419            nan     0.0100  -89.7368
##   1400  1064908.9315            nan     0.0100  -43.4522
##   1420  1063912.4694            nan     0.0100 -153.3525
##   1440  1062783.8351            nan     0.0100  -27.1805
##   1460  1061985.2160            nan     0.0100 -177.8519
##   1480  1060848.0758            nan     0.0100 -129.1808
##   1500  1059873.3198            nan     0.0100 -108.7868
##   1520  1059023.1072            nan     0.0100  -99.2621
##   1540  1058196.4632            nan     0.0100  -93.4364
##   1560  1057348.1802            nan     0.0100  -42.8154
##   1580  1056383.3495            nan     0.0100  -75.0918
##   1600  1055270.4613            nan     0.0100  -36.9213
##   1620  1054297.6328            nan     0.0100  -75.3613
##   1640  1053515.9112            nan     0.0100  -65.7816
##   1660  1052654.3304            nan     0.0100  -69.7831
##   1680  1051933.5008            nan     0.0100  -87.4925
##   1700  1050943.6724            nan     0.0100  -55.5546
##   1720  1050099.6075            nan     0.0100  -36.6518
##   1740  1049118.8415            nan     0.0100  -96.6994
##   1760  1048330.9437            nan     0.0100  -94.8157
##   1780  1047352.4801            nan     0.0100 -177.6679
##   1800  1046499.2231            nan     0.0100   -9.9226
##   1820  1045647.8828            nan     0.0100 -106.1086
##   1840  1044819.3396            nan     0.0100  -56.6765
##   1860  1044028.0373            nan     0.0100 -198.9979
##   1880  1043257.8125            nan     0.0100 -110.5008
##   1900  1042476.6570            nan     0.0100  -77.5574
##   1920  1041573.2441            nan     0.0100  -68.1361
##   1940  1040825.6352            nan     0.0100  -64.3096
##   1960  1039925.4638            nan     0.0100  -46.6292
##   1980  1038941.8993            nan     0.0100  -30.9127
##   2000  1038130.3253            nan     0.0100  -65.7640
##   2020  1037364.5203            nan     0.0100 -112.9933
##   2040  1036574.9983            nan     0.0100 -176.5561
##   2060  1035722.6317            nan     0.0100  -55.6784
##   2080  1035071.0703            nan     0.0100  -72.5637
##   2100  1034385.1275            nan     0.0100  -77.5453
##   2120  1033733.4442            nan     0.0100 -108.4496
##   2140  1032915.8177            nan     0.0100  -40.4588
##   2160  1032154.0586            nan     0.0100 -102.5155
##   2180  1031312.8500            nan     0.0100 -108.9451
##   2200  1030605.8154            nan     0.0100  -32.1247
##   2220  1029836.2615            nan     0.0100  -94.7647
##   2240  1028881.7038            nan     0.0100  -84.0321
##   2260  1028170.7225            nan     0.0100  -64.4734
##   2280  1027460.6688            nan     0.0100  -95.4901
##   2300  1026780.7345            nan     0.0100  -85.2124
##   2320  1025940.7374            nan     0.0100 -134.7538
##   2340  1025122.5251            nan     0.0100 -128.9093
##   2360  1024340.3132            nan     0.0100 -106.8766
##   2380  1023491.8781            nan     0.0100  -80.9099
```

```
##   2400  1022904.4998             nan     0.0100  -86.7548
##   2420  1022138.6450             nan     0.0100  -22.2672
##   2440  1021354.8359             nan     0.0100 -113.2561
##   2460  1020555.7430             nan     0.0100  -78.5012
##   2480  1019717.8512             nan     0.0100  -98.0329
##   2500  1019066.0419             nan     0.0100  -87.3579
##   2520  1018362.1540             nan     0.0100 -173.4218
##   2540  1017726.1491             nan     0.0100  -17.3155
##   2560  1017087.8996             nan     0.0100 -100.3217
##   2580  1016476.4214             nan     0.0100 -105.5918
##   2600  1015786.1713             nan     0.0100  -63.1919
##   2620  1014885.1108             nan     0.0100 -192.6296
##   2640  1014260.7786             nan     0.0100  -58.9358
##   2660  1013547.1699             nan     0.0100 -144.4235
##   2680  1012721.9159             nan     0.0100  -34.4239
##   2700  1012031.0716             nan     0.0100  -28.9445
##   2720  1011249.5751             nan     0.0100  -51.0536
##   2740  1010601.2689             nan     0.0100  -79.0893
##   2760  1009940.4149             nan     0.0100 -115.8271
##   2780  1009350.1112             nan     0.0100  -29.8725
##   2800  1008596.4214             nan     0.0100  -94.2147
##   2820  1008020.6382             nan     0.0100  -99.4684
##   2840  1007411.0077             nan     0.0100  -50.1924
##   2860  1006686.4963             nan     0.0100  -57.8888
##   2880  1005870.4094             nan     0.0100   14.4906
##   2900  1005348.6756             nan     0.0100  -53.5338
##   2920  1004658.0263             nan     0.0100  -94.2891
##   2940  1004039.9673             nan     0.0100  -43.0926
##   2960  1003525.7549             nan     0.0100  -35.4613
##   2980  1002931.2685             nan     0.0100  -58.0072
##   3000  1002415.4786             nan     0.0100  -98.7272
##   3020  1001801.4743             nan     0.0100  -83.8182
##   3040  1001097.6111             nan     0.0100  -47.7580
##   3060  1000443.3677             nan     0.0100  -83.8866
##   3080   999813.2308             nan     0.0100 -136.5687
##   3100   999234.2822             nan     0.0100 -149.6679
##   3120   998539.1609             nan     0.0100 -105.8461
##   3140   997960.5844             nan     0.0100  -75.8808
##   3160   997238.2432             nan     0.0100  -69.9238
##   3180   996667.9536             nan     0.0100 -112.2829
##   3200   995958.3739             nan     0.0100  -79.3671
##   3220   995410.0270             nan     0.0100  -72.0118
##   3240   994800.8616             nan     0.0100 -148.3826
##   3250   994432.5247             nan     0.0100  -76.6233
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868557.1390             nan     0.0100 26190.9180
##      2  2843047.0495             nan     0.0100 25688.6516
##      3  2818189.8473             nan     0.0100 23668.5023
##      4  2792674.5806             nan     0.0100 24756.4424
##      5  2769078.4573             nan     0.0100 23192.3564
##      6  2745016.5360             nan     0.0100 24283.0446
##      7  2721362.6276             nan     0.0100 23238.4336
```

```
##      8  2697997.3786           nan     0.0100 22568.8841
##      9  2676205.3149           nan     0.0100 22390.3366
##     10  2654135.7891           nan     0.0100 22106.9699
##     20  2454306.3938           nan     0.0100 16265.6650
##     40  2137826.4279           nan     0.0100 12346.6454
##     60  1909756.0667           nan     0.0100 9416.1655
##     80  1736201.6516           nan     0.0100 6625.4717
##    100  1602178.1918           nan     0.0100 6119.2166
##    120  1501876.0837           nan     0.0100 4323.9290
##    140  1422227.5296           nan     0.0100 3942.5465
##    160  1358676.1178           nan     0.0100 2647.6373
##    180  1308681.9113           nan     0.0100 2452.2051
##    200  1270332.3825           nan     0.0100 1485.7832
##    220  1239313.0784           nan     0.0100 1160.1568
##    240  1215271.1974           nan     0.0100 1047.0839
##    260  1196644.8287           nan     0.0100  955.0549
##    280  1181584.9856           nan     0.0100  541.9347
##    300  1169317.2769           nan     0.0100  288.1989
##    320  1159727.7442           nan     0.0100  466.6970
##    340  1151537.0392           nan     0.0100  359.9164
##    360  1145235.8437           nan     0.0100  208.7510
##    380  1139581.6497           nan     0.0100 -117.7275
##    400  1135130.6508           nan     0.0100  133.5982
##    420  1131253.2917           nan     0.0100   68.4892
##    440  1127623.6112           nan     0.0100  157.3011
##    460  1124565.6767           nan     0.0100   51.1154
##    480  1121983.1884           nan     0.0100   -1.6084
##    500  1119657.9163           nan     0.0100   41.4147
##    520  1117709.2315           nan     0.0100 -122.3979
##    540  1115470.7890           nan     0.0100  -70.1188
##    560  1113629.8415           nan     0.0100   -9.0270
##    580  1111803.4956           nan     0.0100  -77.1523
##    600  1110144.6692           nan     0.0100  -41.7548
##    620  1108639.2673           nan     0.0100  -28.2591
##    640  1107030.5773           nan     0.0100  -40.1238
##    660  1105722.7973           nan     0.0100  -51.4672
##    680  1104377.3866           nan     0.0100  -26.7139
##    700  1102945.7449           nan     0.0100  -43.1495
##    720  1101630.0486           nan     0.0100  -35.6259
##    740  1100287.0797           nan     0.0100   -6.1025
##    760  1099078.4689           nan     0.0100  -39.1069
##    780  1098023.3971           nan     0.0100  -17.5571
##    800  1096509.2282           nan     0.0100  -33.3987
##    820  1095264.0806           nan     0.0100 -165.8134
##    840  1093961.9419           nan     0.0100  -28.3591
##    860  1092691.3096           nan     0.0100  -74.1411
##    880  1091242.1381           nan     0.0100  -37.6037
##    900  1090235.7558           nan     0.0100 -171.0203
##    920  1089002.2267           nan     0.0100  -92.7285
##    940  1087897.0206           nan     0.0100  -76.4323
##    960  1086626.3023           nan     0.0100  -13.3661
##    980  1085351.0647           nan     0.0100 -198.7852
##   1000  1084452.7575           nan     0.0100 -139.6385
##   1020  1083284.1875           nan     0.0100  -86.1161
```

```
##   1040  1082015.4163           nan     0.0100  -45.5712
##   1060  1080898.2237           nan     0.0100  -43.6959
##   1080  1079735.2593           nan     0.0100  -55.4965
##   1100  1078558.1642           nan     0.0100  -35.3538
##   1120  1077679.7260           nan     0.0100 -111.4671
##   1140  1076750.8036           nan     0.0100  -87.9169
##   1160  1075788.5942           nan     0.0100  -46.1397
##   1180  1074639.2358           nan     0.0100  -91.9542
##   1200  1073408.1851           nan     0.0100  -28.3881
##   1220  1072577.3555           nan     0.0100  -69.0913
##   1240  1071599.3380           nan     0.0100  -93.5517
##   1260  1070649.1727           nan     0.0100 -158.7040
##   1280  1069641.2877           nan     0.0100  -75.2871
##   1300  1068511.8546           nan     0.0100  -73.0053
##   1320  1067603.9880           nan     0.0100  -82.0247
##   1340  1066639.2291           nan     0.0100  -56.1682
##   1360  1065704.1535           nan     0.0100  -47.0909
##   1380  1064688.9604           nan     0.0100  -55.0164
##   1400  1063920.5109           nan     0.0100  -62.1432
##   1420  1063066.2327           nan     0.0100 -137.3071
##   1440  1061902.9896           nan     0.0100  -68.4410
##   1460  1061049.9220           nan     0.0100 -158.7104
##   1480  1060147.9052           nan     0.0100 -142.6503
##   1500  1059306.1825           nan     0.0100 -106.2190
##   1520  1058429.8656           nan     0.0100  -25.8766
##   1540  1057546.6619           nan     0.0100 -107.2680
##   1560  1056685.9259           nan     0.0100  -29.4225
##   1580  1055657.6462           nan     0.0100 -124.5549
##   1600  1054767.4307           nan     0.0100  -53.1802
##   1620  1053704.5333           nan     0.0100  -71.2248
##   1640  1052715.3442           nan     0.0100  -60.1755
##   1660  1051917.3575           nan     0.0100  -12.1411
##   1680  1050951.8836           nan     0.0100  -77.2783
##   1700  1050266.3856           nan     0.0100 -146.1197
##   1720  1049358.7815           nan     0.0100  -72.6907
##   1740  1048463.9184           nan     0.0100  -70.9819
##   1760  1047790.6902           nan     0.0100  -91.8967
##   1780  1047003.2004           nan     0.0100   -4.2235
##   1800  1046171.8947           nan     0.0100  -53.6607
##   1820  1045265.0169           nan     0.0100  -84.7425
##   1840  1044556.2737           nan     0.0100  -41.4135
##   1860  1043798.1226           nan     0.0100 -115.8269
##   1880  1042892.3155           nan     0.0100  -68.5872
##   1900  1042221.3474           nan     0.0100 -135.8648
##   1920  1041593.0814           nan     0.0100  -70.4672
##   1940  1040853.1428           nan     0.0100  -42.9524
##   1960  1039977.6622           nan     0.0100 -104.9089
##   1980  1039245.3146           nan     0.0100  -75.2991
##   2000  1038570.5841           nan     0.0100  -22.6447
##   2020  1037957.8825           nan     0.0100  -50.1752
##   2040  1037426.9044           nan     0.0100 -123.5231
##   2060  1036485.1423           nan     0.0100  -97.2090
##   2080  1035738.9765           nan     0.0100  -21.7706
##   2100  1035059.5117           nan     0.0100  -25.7460
```

```
##   2120  1034197.4631           nan     0.0100  -67.1067
##   2140  1033333.8770           nan     0.0100 -106.1858
##   2160  1032711.7261           nan     0.0100  -77.2517
##   2180  1031764.8287           nan     0.0100  -57.0646
##   2200  1031050.9401           nan     0.0100 -158.4176
##   2220  1030256.3570           nan     0.0100 -170.7558
##   2240  1029519.7850           nan     0.0100  -84.1144
##   2260  1028872.9772           nan     0.0100 -123.1098
##   2280  1028171.6314           nan     0.0100 -119.0786
##   2300  1027274.2946           nan     0.0100  -63.6356
##   2320  1026512.8284           nan     0.0100  -74.4450
##   2340  1025807.4137           nan     0.0100 -193.3119
##   2360  1025037.7781           nan     0.0100 -125.0112
##   2380  1024286.9027           nan     0.0100  -66.5761
##   2400  1023535.5311           nan     0.0100 -177.0346
##   2420  1022804.4699           nan     0.0100 -106.1826
##   2440  1022194.9337           nan     0.0100 -140.0232
##   2460  1021475.1916           nan     0.0100  -82.6112
##   2480  1020748.9908           nan     0.0100 -141.4567
##   2500  1019967.1487           nan     0.0100 -118.8018
##   2520  1019297.2077           nan     0.0100 -122.9923
##   2540  1018496.4016           nan     0.0100  -50.1653
##   2560  1017532.5836           nan     0.0100  -47.5275
##   2580  1016931.7588           nan     0.0100 -100.8131
##   2600  1016212.4140           nan     0.0100  -65.4000
##   2620  1015711.5808           nan     0.0100 -145.0590
##   2640  1015049.4909           nan     0.0100  -62.9201
##   2660  1014369.0963           nan     0.0100 -106.2960
##   2680  1013734.2321           nan     0.0100  -44.3183
##   2700  1013047.3413           nan     0.0100  -44.4470
##   2720  1012437.7332           nan     0.0100  -94.6408
##   2740  1011723.7665           nan     0.0100  -79.6974
##   2760  1011219.2704           nan     0.0100 -144.5024
##   2780  1010699.7963           nan     0.0100  -87.8542
##   2800  1010073.2237           nan     0.0100  -85.4161
##   2820  1009477.4315           nan     0.0100  -63.6443
##   2840  1008732.8634           nan     0.0100  -56.8570
##   2860  1008197.8801           nan     0.0100 -146.1070
##   2880  1007538.6504           nan     0.0100  -36.3798
##   2900  1006911.5245           nan     0.0100  -19.9931
##   2920  1006242.5129           nan     0.0100  -59.8125
##   2940  1005595.7574           nan     0.0100  -50.2768
##   2960  1005004.9269           nan     0.0100  -93.5282
##   2980  1004433.0432           nan     0.0100 -183.9283
##   3000  1003825.9244           nan     0.0100  -60.9465
##   3020  1003296.2308           nan     0.0100  -98.9171
##   3040  1002642.1289           nan     0.0100  -68.4569
##   3060  1001934.8748           nan     0.0100  -73.1892
##   3080  1001393.3307           nan     0.0100 -115.8830
##   3100  1000743.2911           nan     0.0100  -90.4688
##   3120  1000154.2127           nan     0.0100 -187.7325
##   3140   999588.9146           nan     0.0100  -57.1808
##   3160   998881.8716           nan     0.0100  -15.9005
##   3180   998166.1602           nan     0.0100  -41.3251
```

```
##   3200   997390.8406             nan     0.0100  -70.0165
##   3220   996617.5820             nan     0.0100  -27.2101
##   3240   995999.4500             nan     0.0100  -49.7421
##   3260   995427.8199             nan     0.0100  -37.1366
##   3280   994802.2976             nan     0.0100  -78.6289
##   3300   994295.3692             nan     0.0100  -64.1462
##   3320   993530.6713             nan     0.0100  -14.0196
##   3340   992926.7277             nan     0.0100  -69.6617
##   3360   992351.3680             nan     0.0100 -121.1715
##   3380   991708.6922             nan     0.0100  -90.2909
##   3400   991127.4989             nan     0.0100  -42.3163
##   3420   990411.2966             nan     0.0100 -107.0539
##   3440   989753.6503             nan     0.0100  -70.0561
##   3460   989166.5227             nan     0.0100  -83.7273
##   3480   988603.6472             nan     0.0100  -74.2817
##   3500   988020.6124             nan     0.0100  -21.1976
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868671.3539             nan     0.0100 26767.7894
##      2  2842184.7180             nan     0.0100 26146.8204
##      3  2816661.3329             nan     0.0100 25337.1563
##      4  2791503.2682             nan     0.0100 24527.1845
##      5  2766669.0327             nan     0.0100 24869.0711
##      6  2742400.2205             nan     0.0100 24052.3269
##      7  2718614.8023             nan     0.0100 23963.0686
##      8  2696087.3220             nan     0.0100 22620.0539
##      9  2673812.7545             nan     0.0100 22250.2141
##     10  2652647.0922             nan     0.0100 20739.7284
##     20  2455217.2192             nan     0.0100 18454.4710
##     40  2141075.5627             nan     0.0100 14345.9254
##     60  1914926.5446             nan     0.0100 8621.9695
##     80  1739212.6933             nan     0.0100 7537.3230
##    100  1607432.0887             nan     0.0100 5121.7396
##    120  1505678.3670             nan     0.0100 4691.2343
##    140  1424660.5612             nan     0.0100 3304.0105
##    160  1361927.1050             nan     0.0100 2759.4431
##    180  1311993.6320             nan     0.0100 2331.1124
##    200  1272661.9020             nan     0.0100 1776.4106
##    220  1241251.7378             nan     0.0100 1358.3868
##    240  1216761.7869             nan     0.0100 1074.8369
##    260  1197238.5249             nan     0.0100  767.0313
##    280  1181736.1795             nan     0.0100  723.5976
##    300  1169811.8844             nan     0.0100  391.3245
##    320  1159526.6159             nan     0.0100  260.7078
##    340  1151623.5738             nan     0.0100  116.8082
##    360  1144444.9064             nan     0.0100  350.6455
##    380  1138908.8642             nan     0.0100  143.0379
##    400  1134387.7249             nan     0.0100  243.0594
##    420  1130571.5964             nan     0.0100   84.7382
##    440  1127032.4855             nan     0.0100  -30.7176
##    460  1123944.0846             nan     0.0100   70.0607
##    480  1121261.0577             nan     0.0100    5.3368
##    500  1119086.3655             nan     0.0100   41.7006
```

```
##    520  1116984.2002           nan     0.0100   37.1730
##    540  1114993.0663           nan     0.0100  -72.1464
##    560  1112934.9030           nan     0.0100  -57.2431
##    580  1111002.5013           nan     0.0100  -57.2586
##    600  1109321.4210           nan     0.0100  -86.0907
##    620  1107777.4887           nan     0.0100  -69.5517
##    640  1106407.6012           nan     0.0100  -71.7261
##    660  1104931.3312           nan     0.0100    1.3961
##    680  1103574.0831           nan     0.0100  -32.1151
##    700  1102092.5252           nan     0.0100  -23.6531
##    720  1100872.6105           nan     0.0100 -103.1046
##    740  1099555.1945           nan     0.0100  -80.2422
##    760  1098168.1614           nan     0.0100   13.0863
##    780  1096879.6292           nan     0.0100 -119.8602
##    800  1095649.4302           nan     0.0100 -174.9996
##    820  1094613.1404           nan     0.0100  -66.5931
##    840  1093290.0070           nan     0.0100  -68.5716
##    860  1091926.0951           nan     0.0100  -27.0284
##    880  1090932.8751           nan     0.0100 -157.0145
##    900  1089809.3460           nan     0.0100 -102.3787
##    920  1088675.4577           nan     0.0100  -83.0435
##    940  1087325.2300           nan     0.0100 -119.2728
##    960  1086198.5253           nan     0.0100  -35.1144
##    980  1085139.9421           nan     0.0100 -121.5855
##   1000  1084306.8468           nan     0.0100  -85.1672
##   1020  1082924.9497           nan     0.0100  -87.4625
##   1040  1081648.1916           nan     0.0100 -129.0152
##   1060  1080488.0858           nan     0.0100  -54.5159
##   1080  1079353.7557           nan     0.0100 -168.7874
##   1100  1078265.4015           nan     0.0100  -74.1241
##   1120  1077149.5405           nan     0.0100  -69.6126
##   1140  1075908.6427           nan     0.0100  -90.3548
##   1160  1074794.3795           nan     0.0100  -77.1437
##   1180  1073742.8886           nan     0.0100  -67.5811
##   1200  1072536.5465           nan     0.0100  -62.3922
##   1220  1071562.2874           nan     0.0100  -13.1590
##   1240  1070308.9182           nan     0.0100  -25.6341
##   1260  1069460.5348           nan     0.0100 -144.4058
##   1280  1068522.5095           nan     0.0100   42.0219
##   1300  1067497.1525           nan     0.0100  -48.6599
##   1320  1066377.7718           nan     0.0100   -7.7060
##   1340  1065262.8606           nan     0.0100 -113.2490
##   1360  1064351.7283           nan     0.0100   10.5947
##   1380  1063497.0324           nan     0.0100  -29.5819
##   1400  1062549.7466           nan     0.0100  -58.6487
##   1420  1061227.5147           nan     0.0100  -90.3748
##   1440  1060364.5956           nan     0.0100  -65.6305
##   1460  1059489.9256           nan     0.0100 -129.3448
##   1480  1058357.9336           nan     0.0100 -112.3935
##   1500  1057531.8116           nan     0.0100  -67.7216
##   1520  1056579.6241           nan     0.0100  -80.1053
##   1540  1055898.9663           nan     0.0100  -38.8157
##   1560  1054885.2770           nan     0.0100 -194.5939
##   1580  1053720.7241           nan     0.0100  -87.7962
```

```
##   1600  1052938.9157           nan     0.0100  -13.4596
##   1620  1052266.2778           nan     0.0100  -87.4039
##   1640  1051289.0170           nan     0.0100  -86.6299
##   1660  1050369.7355           nan     0.0100 -132.6854
##   1680  1049641.2610           nan     0.0100 -204.7972
##   1700  1048836.6477           nan     0.0100  -24.0114
##   1720  1047930.3901           nan     0.0100 -116.3982
##   1740  1047178.7488           nan     0.0100  -59.8050
##   1760  1046339.3927           nan     0.0100  -84.0040
##   1780  1045338.6735           nan     0.0100 -155.5939
##   1800  1044424.4123           nan     0.0100 -124.9140
##   1820  1043628.5137           nan     0.0100  -93.0199
##   1840  1042942.5835           nan     0.0100 -119.0665
##   1860  1042106.9403           nan     0.0100  -91.7754
##   1880  1041300.3614           nan     0.0100 -138.6975
##   1900  1040525.7739           nan     0.0100  -58.1809
##   1920  1039966.3418           nan     0.0100  -84.3757
##   1940  1039083.5131           nan     0.0100  -55.6088
##   1960  1038336.3131           nan     0.0100 -197.4898
##   1980  1037450.9395           nan     0.0100  -49.8751
##   2000  1036701.1724           nan     0.0100 -128.5629
##   2020  1035812.8147           nan     0.0100  -79.9076
##   2040  1034993.6086           nan     0.0100  -86.9281
##   2060  1034375.6408           nan     0.0100 -189.3636
##   2080  1033501.2941           nan     0.0100 -155.9477
##   2100  1032909.7039           nan     0.0100 -127.1534
##   2120  1032248.1726           nan     0.0100 -130.4973
##   2140  1031232.0916           nan     0.0100  -73.0495
##   2160  1030479.9461           nan     0.0100  -65.1559
##   2180  1029790.2634           nan     0.0100  -80.8133
##   2200  1029132.2619           nan     0.0100  -41.1847
##   2220  1028276.0534           nan     0.0100  -94.4913
##   2240  1027530.8204           nan     0.0100 -129.3436
##   2260  1026844.8241           nan     0.0100  -29.9644
##   2280  1026239.9357           nan     0.0100  -88.9753
##   2300  1025514.3777           nan     0.0100  -46.8296
##   2320  1024777.0739           nan     0.0100  -33.2918
##   2340  1024021.8415           nan     0.0100  -57.4859
##   2360  1023417.9403           nan     0.0100  -96.8768
##   2380  1022727.9634           nan     0.0100  -69.0240
##   2400  1021976.7123           nan     0.0100  -95.0056
##   2420  1021276.8009           nan     0.0100  -25.7010
##   2440  1020498.1295           nan     0.0100 -116.2927
##   2460  1019728.5816           nan     0.0100 -102.1120
##   2480  1019122.2748           nan     0.0100  -25.3190
##   2500  1018481.3069           nan     0.0100  -68.2613
##   2520  1017778.9288           nan     0.0100 -146.1581
##   2540  1016916.5065           nan     0.0100 -127.0462
##   2560  1016139.9022           nan     0.0100  -34.1418
##   2580  1015262.2171           nan     0.0100  -76.2515
##   2600  1014488.1543           nan     0.0100  -68.4606
##   2620  1013718.0776           nan     0.0100  -69.0261
##   2640  1013038.5099           nan     0.0100 -118.7544
##   2660  1012264.9901           nan     0.0100  -41.9892
```

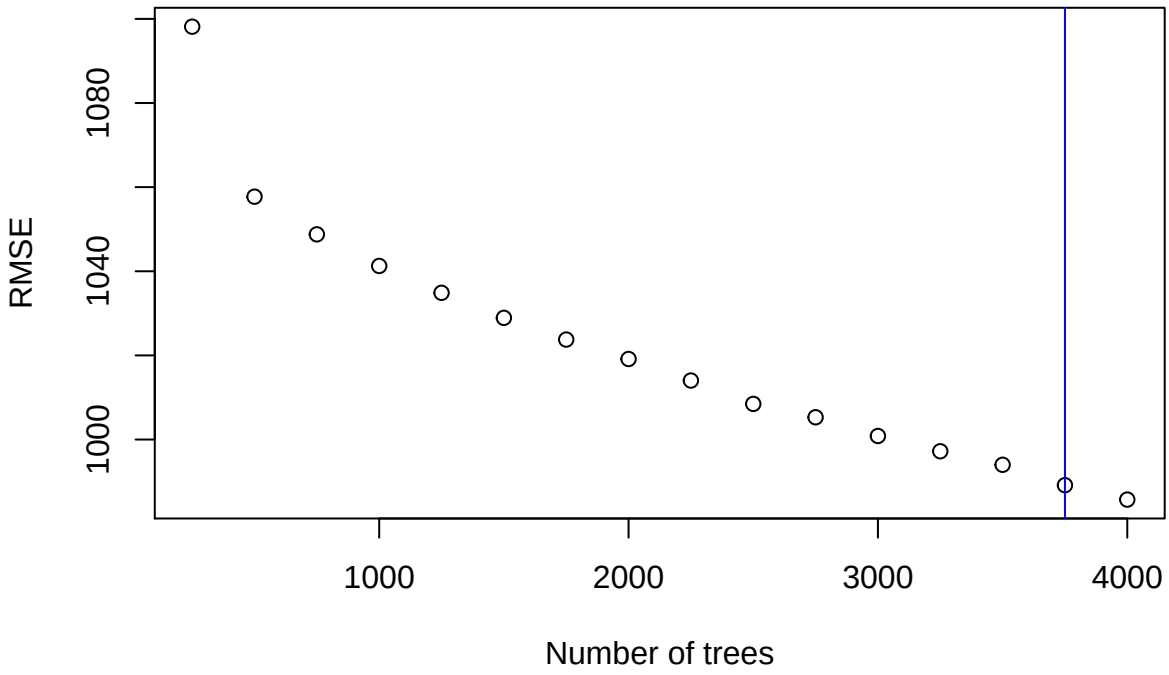
```
##   2680  1011551.1812           nan     0.0100  -79.4444
##   2700  1010810.2427           nan     0.0100  -54.2260
##   2720  1010032.6560           nan     0.0100 -172.4930
##   2740  1009391.6875           nan     0.0100 -147.7374
##   2760  1008617.0387           nan     0.0100  -89.1718
##   2780  1007775.0036           nan     0.0100 -126.6475
##   2800  1007201.4563           nan     0.0100 -122.6640
##   2820  1006627.1925           nan     0.0100  -57.3647
##   2840  1006103.6798           nan     0.0100  -79.7650
##   2860  1005293.0899           nan     0.0100 -151.6123
##   2880  1004680.3333           nan     0.0100 -115.2509
##   2900  1004145.4758           nan     0.0100 -107.4202
##   2920  1003608.5155           nan     0.0100 -143.7610
##   2940  1003057.7464           nan     0.0100 -102.2506
##   2960  1002328.9870           nan     0.0100  -90.6740
##   2980  1001655.2548           nan     0.0100   -1.0950
##   3000  1000990.8480           nan     0.0100  -42.3543
##   3020  1000374.7189           nan     0.0100 -107.0466
##   3040   999640.3798           nan     0.0100 -113.0870
##   3060   999126.6704           nan     0.0100  -80.0261
##   3080   998425.1282           nan     0.0100  -82.1047
##   3100   997737.3261           nan     0.0100  -88.6104
##   3120   997184.8788           nan     0.0100  -96.5641
##   3140   996606.2357           nan     0.0100  -77.1820
##   3160   996120.9905           nan     0.0100 -133.4127
##   3180   995467.3051           nan     0.0100 -221.0045
##   3200   994862.1830           nan     0.0100 -162.5851
##   3220   994148.1609           nan     0.0100 -134.8718
##   3240   993522.0548           nan     0.0100  -88.3058
##   3260   993046.2498           nan     0.0100  -18.5127
##   3280   992506.0674           nan     0.0100  -73.2899
##   3300   991776.4031           nan     0.0100  -29.0327
##   3320   991212.9561           nan     0.0100 -153.3948
##   3340   990590.2015           nan     0.0100  -74.6697
##   3360   989931.8810           nan     0.0100 -136.3674
##   3380   989387.7855           nan     0.0100 -113.3140
##   3400   988867.9229           nan     0.0100  -56.9285
##   3420   988280.6671           nan     0.0100  -73.2297
##   3440   987556.0520           nan     0.0100 -139.8443
##   3460   986955.4779           nan     0.0100  -80.1083
##   3480   986321.2801           nan     0.0100 -146.9413
##   3500   985759.8157           nan     0.0100  -88.7388
##   3520   985069.0299           nan     0.0100  -47.7808
##   3540   984501.4483           nan     0.0100 -115.1390
##   3560   983822.1711           nan     0.0100  -79.9195
##   3580   983262.2661           nan     0.0100 -151.7932
##   3600   982632.4479           nan     0.0100  -68.0965
##   3620   982117.7404           nan     0.0100  -18.2908
##   3640   981520.3934           nan     0.0100 -192.2283
##   3660   980962.6754           nan     0.0100  -72.9207
##   3680   980322.2901           nan     0.0100  -31.5699
##   3700   979811.0734           nan     0.0100  -49.2272
##   3720   979290.9742           nan     0.0100  -89.4116
##   3740   978695.8464           nan     0.0100 -142.3212
```

```
##   3750   978403.2155             nan     0.0100  -84.0733
##
## Distribution not specified, assuming gaussian ...
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1  2868962.2425             nan     0.0100 26868.5872
##      2  2842768.0811             nan     0.0100 25440.0949
##      3  2817745.0738             nan     0.0100 25606.5623
##      4  2794055.5836             nan     0.0100 23586.8737
##      5  2769542.2604             nan     0.0100 23287.9421
##      6  2745306.0556             nan     0.0100 24309.6789
##      7  2722730.5454             nan     0.0100 22667.1018
##      8  2699409.1607             nan     0.0100 23322.6767
##      9  2676120.9551             nan     0.0100 22544.1538
##     10  2653713.2144             nan     0.0100 22140.0190
##     20  2454470.3029             nan     0.0100 19419.6025
##     40  2139381.1276             nan     0.0100 13587.4181
##     60  1911601.5124             nan     0.0100 10656.2453
##     80  1740289.4718             nan     0.0100 6950.2096
##    100  1607960.8327             nan     0.0100 4908.0779
##    120  1504402.0150             nan     0.0100 4462.9463
##    140  1424065.3942             nan     0.0100 3148.0804
##    160  1360324.4294             nan     0.0100 2228.0660
##    180  1310409.1129             nan     0.0100 2279.3631
##    200  1270374.4597             nan     0.0100 1778.3804
##    220  1239391.4252             nan     0.0100 1086.4703
##    240  1215488.6413             nan     0.0100  790.7066
##    260  1196684.2774             nan     0.0100  724.1678
##    280  1181935.3383             nan     0.0100  707.2370
##    300  1169563.6121             nan     0.0100  439.2639
##    320  1159931.6144             nan     0.0100  386.9324
##    340  1152078.5022             nan     0.0100  144.3802
##    360  1145159.2322             nan     0.0100  257.6520
##    380  1139801.2927             nan     0.0100  164.4861
##    400  1135085.1493             nan     0.0100  179.1667
##    420  1130674.6907             nan     0.0100   50.6540
##    440  1127367.7280             nan     0.0100   75.2198
##    460  1124444.8507             nan     0.0100  -82.6993
##    480  1122156.2829             nan     0.0100   75.8384
##    500  1119944.3773             nan     0.0100  -28.3429
##    520  1117471.6547             nan     0.0100  -41.2964
##    540  1115451.2650             nan     0.0100   25.6282
##    560  1113480.4018             nan     0.0100   12.4780
##    580  1111656.8772             nan     0.0100  -31.6267
##    600  1109923.3468             nan     0.0100   -3.8397
##    620  1108443.2827             nan     0.0100  -32.4073
##    640  1106833.6776             nan     0.0100 -134.5708
##    660  1105435.6945             nan     0.0100  -17.7427
##    680  1103888.3185             nan     0.0100  -19.5865
##    700  1102620.0022             nan     0.0100 -128.2245
##    720  1101073.2389             nan     0.0100 -104.7532
##    740  1099806.1073             nan     0.0100  -74.9221
##    760  1098417.7741             nan     0.0100  -17.1967
##    780  1097246.9013             nan     0.0100  -12.0261
##    800  1096146.5331             nan     0.0100  -70.0900
```

```
##    820  1094617.1306           nan     0.0100 -135.2752
##    840  1093538.8919           nan     0.0100  -98.8514
##    860  1092447.5234           nan     0.0100 -137.7181
##    880  1091296.1820           nan     0.0100  -63.5990
##    900  1090028.1689           nan     0.0100  -82.6585
##    920  1088791.5955           nan     0.0100 -202.5265
##    940  1087735.0952           nan     0.0100 -104.2892
##    960  1086526.6708           nan     0.0100 -124.0874
##    980  1085396.5924           nan     0.0100  -98.6603
##   1000  1084342.5233           nan     0.0100  -88.7718
##   1020  1083304.3131           nan     0.0100  -87.2396
##   1040  1082313.5980           nan     0.0100  -51.9221
##   1060  1081298.6815           nan     0.0100 -144.0854
##   1080  1080342.9378           nan     0.0100 -113.2920
##   1100  1079491.9338           nan     0.0100  -83.3731
##   1120  1078507.8942           nan     0.0100  -95.3747
##   1140  1077313.7506           nan     0.0100  -69.0197
##   1160  1076203.2524           nan     0.0100 -101.3104
##   1180  1075047.0112           nan     0.0100  -14.2425
##   1200  1073845.0270           nan     0.0100  -59.5572
##   1220  1072872.7076           nan     0.0100 -155.0989
##   1240  1071987.8837           nan     0.0100  -67.9892
##   1260  1071021.0749           nan     0.0100  -53.6729
##   1280  1070169.8138           nan     0.0100  -55.7939
##   1300  1069081.6093           nan     0.0100 -164.1058
##   1320  1068141.9331           nan     0.0100 -113.0622
##   1340  1067175.7205           nan     0.0100  -56.4619
##   1360  1066314.6286           nan     0.0100  -37.8605
##   1380  1065324.7604           nan     0.0100  -93.6969
##   1400  1064560.2184           nan     0.0100 -100.9454
##   1420  1063685.8576           nan     0.0100  -95.6174
##   1440  1062741.9090           nan     0.0100  -85.7349
##   1460  1061925.4284           nan     0.0100 -125.0846
##   1480  1060953.2774           nan     0.0100   -3.3659
##   1500  1060206.2757           nan     0.0100  -66.7058
##   1520  1059278.1018           nan     0.0100  -40.7386
##   1540  1058345.6127           nan     0.0100 -150.7014
##   1560  1057454.9949           nan     0.0100 -176.6041
##   1580  1056579.0363           nan     0.0100  -44.1799
##   1600  1055577.6271           nan     0.0100 -105.5076
##   1620  1054675.5234           nan     0.0100  -60.6818
##   1640  1053710.3237           nan     0.0100   11.0855
##   1660  1052786.9679           nan     0.0100 -104.0594
##   1680  1051897.2018           nan     0.0100 -172.3657
##   1700  1051117.4287           nan     0.0100  -62.1540
##   1720  1050254.4749           nan     0.0100  -99.7283
##   1740  1049425.1665           nan     0.0100  -62.4078
##   1760  1048734.1808           nan     0.0100 -115.9437
##   1780  1047666.6895           nan     0.0100  -70.4330
##   1800  1046497.4994           nan     0.0100 -103.6584
##   1820  1045766.6386           nan     0.0100 -183.5018
##   1840  1044919.7493           nan     0.0100  -94.8459
##   1860  1043992.8559           nan     0.0100 -206.1503
##   1880  1043142.8180           nan     0.0100  -64.4153
```

```
##   1900  1042325.6469           nan     0.0100   -6.9273
##   1920  1041536.5682           nan     0.0100  -25.3172
##   1940  1040817.8291           nan     0.0100  -61.2011
##   1960  1039962.5289           nan     0.0100  -88.4219
##   1980  1039223.3360           nan     0.0100 -220.1464
##   2000  1038332.9687           nan     0.0100  -12.4237
##   2020  1037498.6407           nan     0.0100 -112.6255
##   2040  1036691.4465           nan     0.0100  -66.3475
##   2060  1036092.9479           nan     0.0100  -96.7620
##   2080  1035152.5242           nan     0.0100  -90.4469
##   2100  1034406.9382           nan     0.0100  -82.1214
##   2120  1033647.6418           nan     0.0100  -88.0183
##   2140  1032885.1706           nan     0.0100  -76.9132
##   2160  1031890.4114           nan     0.0100 -110.5436
##   2180  1031236.8742           nan     0.0100  -22.2985
##   2200  1030318.9693           nan     0.0100  -59.3410
##   2220  1029672.8743           nan     0.0100  -19.6401
##   2240  1028954.3684           nan     0.0100 -128.2062
##   2260  1028239.4714           nan     0.0100 -112.4110
##   2280  1027367.3356           nan     0.0100 -111.8338
##   2300  1026772.7353           nan     0.0100  -71.1086
##   2320  1026207.4309           nan     0.0100  -28.6773
##   2340  1025551.9670           nan     0.0100  -95.7445
##   2360  1024726.6128           nan     0.0100  -47.6186
##   2380  1023764.7517           nan     0.0100  -44.3085
##   2400  1023098.7213           nan     0.0100  -72.9140
##   2420  1022236.1432           nan     0.0100  -42.9885
##   2440  1021606.0504           nan     0.0100  -57.5336
##   2460  1020866.3566           nan     0.0100  -47.1723
##   2480  1020144.8402           nan     0.0100 -143.6609
##   2500  1019361.0445           nan     0.0100  -62.0188
##   2520  1018628.6773           nan     0.0100  -37.0985
##   2540  1018058.0985           nan     0.0100  -31.7088
##   2560  1017401.0332           nan     0.0100  -80.7644
##   2580  1016765.2908           nan     0.0100 -120.1440
##   2600  1015995.6922           nan     0.0100  -52.6942
##   2620  1015256.3665           nan     0.0100 -100.0290
##   2640  1014496.8710           nan     0.0100  -61.2359
##   2660  1013820.9616           nan     0.0100  -62.0002
##   2680  1013125.0860           nan     0.0100 -108.8162
##   2700  1012538.7207           nan     0.0100 -117.3186
##   2720  1011830.0717           nan     0.0100 -122.3377
##   2740  1011156.5117           nan     0.0100 -122.0076
##   2760  1010544.3649           nan     0.0100 -129.4387
##   2780  1009919.2972           nan     0.0100  -72.6403
##   2800  1009217.6872           nan     0.0100  -96.2400
##   2820  1008552.0191           nan     0.0100  -50.3599
##   2840  1007911.5821           nan     0.0100 -146.4102
##   2860  1007233.2583           nan     0.0100  -43.7417
##   2880  1006590.1000           nan     0.0100 -120.2859
##   2900  1005924.6168           nan     0.0100  -62.5009
##   2920  1005216.4609           nan     0.0100  -96.7619
##   2940  1004545.6816           nan     0.0100  -74.2270
##   2960  1003884.4608           nan     0.0100  -73.4107
```

```
##   2980  1003141.6057           nan     0.0100 -121.3223
##   3000  1002389.0276           nan     0.0100 -113.5508
##   3020  1001548.8641           nan     0.0100  -52.1308
##   3040  1000968.5736           nan     0.0100  -65.2566
##   3060  1000265.5947           nan     0.0100 -107.6803
##   3080   999740.6240           nan     0.0100  -50.8793
##   3100   999065.2629           nan     0.0100 -103.1205
##   3120   998409.3644           nan     0.0100  -26.5184
##   3140   997815.5045           nan     0.0100  -96.0597
##   3160   997235.1151           nan     0.0100  -11.7649
##   3180   996614.5345           nan     0.0100 -142.9136
##   3200   995970.9189           nan     0.0100  -44.6515
##   3220   995388.2021           nan     0.0100  -93.3873
##   3240   994718.1789           nan     0.0100  -50.2079
##   3260   993782.6307           nan     0.0100 -152.4025
##   3280   993196.2187           nan     0.0100  -95.0761
##   3300   992598.0635           nan     0.0100 -130.1213
##   3320   991903.3419           nan     0.0100  -81.3006
##   3340   991370.0974           nan     0.0100  -72.9929
##   3360   990749.1389           nan     0.0100 -101.0125
##   3380   990221.1675           nan     0.0100  -25.4578
##   3400   989701.4529           nan     0.0100  -68.5679
##   3420   989104.7549           nan     0.0100  -78.3929
##   3440   988380.7555           nan     0.0100 -101.5169
##   3460   987759.9694           nan     0.0100 -112.5574
##   3480   987011.2220           nan     0.0100  -16.8212
##   3500   986422.4519           nan     0.0100  -73.0810
##   3520   985845.9200           nan     0.0100 -101.7502
##   3540   985233.9658           nan     0.0100  -29.4500
##   3560   984570.9799           nan     0.0100 -113.2149
##   3580   983951.7079           nan     0.0100  -94.5131
##   3600   983390.7203           nan     0.0100 -125.5831
##   3620   982898.3702           nan     0.0100 -138.4462
##   3640   982294.2912           nan     0.0100  -39.3976
##   3660   981640.1378           nan     0.0100  -51.3587
##   3680   980942.1569           nan     0.0100  -46.6268
##   3700   980376.5657           nan     0.0100 -106.4492
##   3720   979696.4948           nan     0.0100  -53.3318
##   3740   979137.1100           nan     0.0100  -99.2489
##   3760   978560.9119           nan     0.0100  -33.6885
##   3780   978007.5371           nan     0.0100 -110.3336
##   3800   977507.4914           nan     0.0100 -116.2710
##   3820   976970.0994           nan     0.0100 -157.8983
##   3840   976393.7705           nan     0.0100  -64.9763
##   3860   975819.5430           nan     0.0100 -124.5307
##   3880   975216.6280           nan     0.0100  -75.5133
##   3900   974581.0502           nan     0.0100  -43.3569
##   3920   973860.1626           nan     0.0100 -101.0484
##   3940   973304.3521           nan     0.0100 -128.8308
##   3960   972653.7266           nan     0.0100  -61.5053
##   3980   972148.3032           nan     0.0100  -65.9312
##   4000   971652.4056           nan     0.0100  -54.0945
```




```
## integer(0)
```

```
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
## Distribution not specified, assuming gaussian ...
```

```
## Boosting RMSE:  1083.932
```

XGBoost

eXtreme Gradient Boosting

Xgboost is a parallelized boosting algorithm that implements dropout regularization (dropping trees that tend to overfit data) to prevent overfitting. Boosting techniques suffer from over fitting since at each step they try to minimize the error from the previous step thus tend to overly adapt to the data.

We do cross validation for searching the best parameters over 100 iterations. Evaluation criterion is `rmse`.

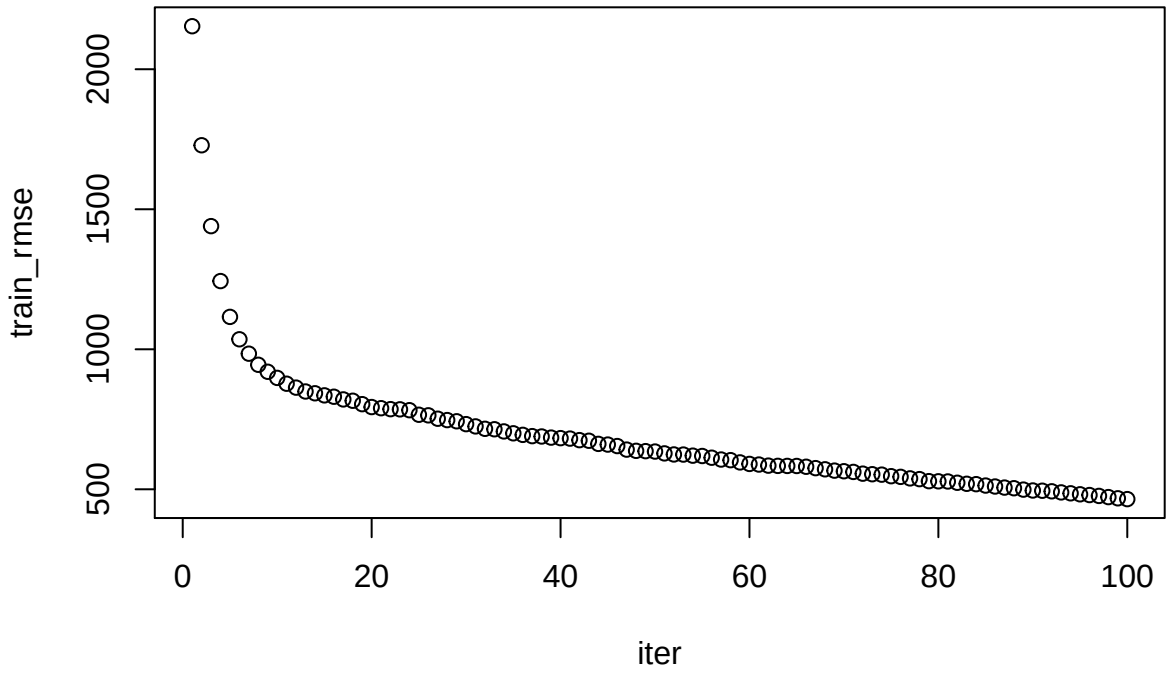
```
##
## Attaching package: 'xgboost'
```

```
## The following object is masked from 'package:dplyr':
##
##     slice
```

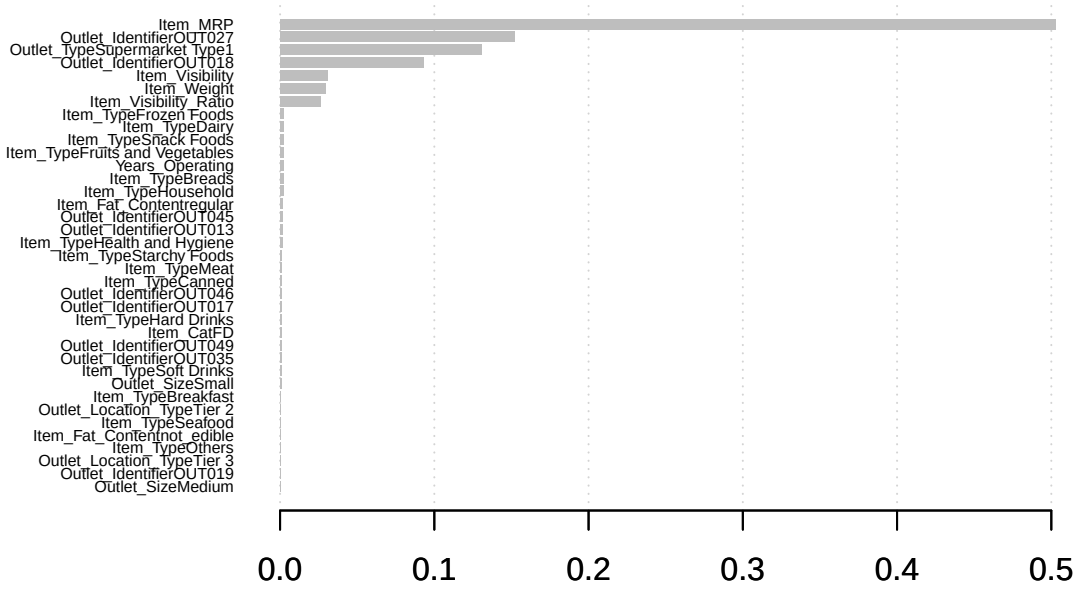
Now we plot the `rmse` against the number of trees to see the knee in the curve. We don't want to overfit. From the plot below that 15 is the number of trees after which the error does not drop significantly.

```
## best_param:
```

```
## $objective
## [1] "reg:linear"
##
## $eval_metric
## [1] "rmse"
##
## $max_depth
## [1] 8
##
## $eta
## [1] 0.2657478

## best_rmse:

## [1] 1124.704

## best_rounds:

## 100
```




```
##    iter train_rmse
## 1:   15   835.3906
```



The plot above explains the variable importance where we can clearly see that `MRP` is the most significant feature.

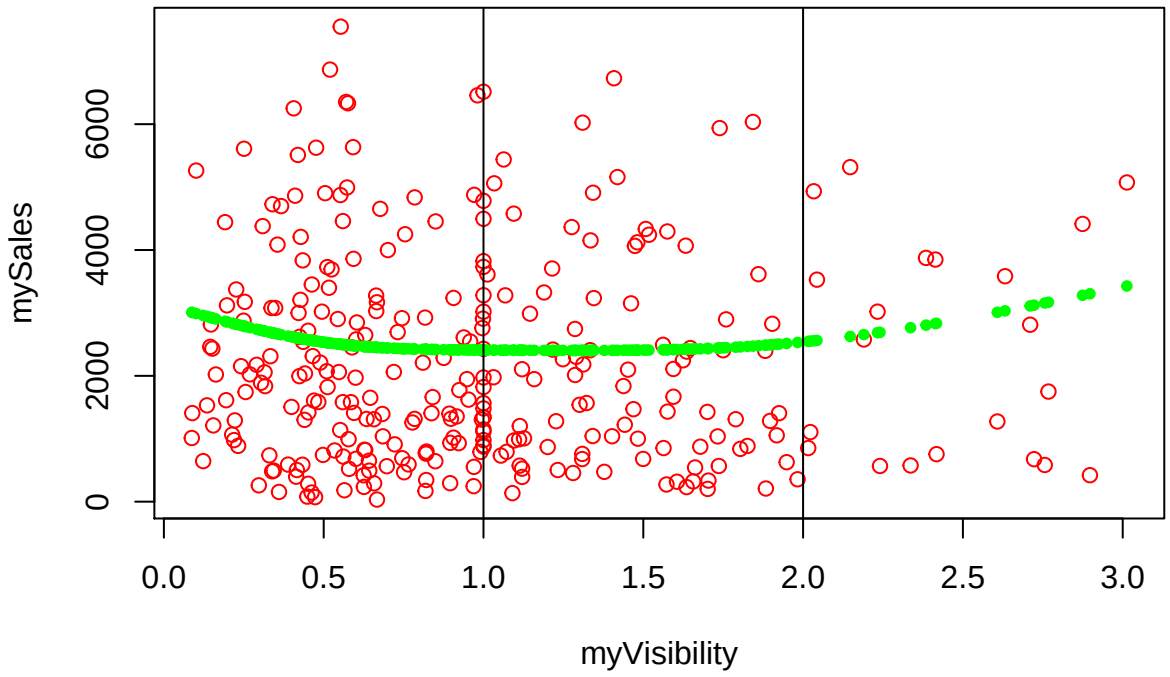
Bagging (Random forest)

In this section we now implement a random Forrest on the Training Data and run a 10-fold cross validation. Looking at the error plots vs. number of trees we decided each Forrest having 50 trees is sufficient in order to get a approximation of our Training RMSE. Additionally, by default within a given Forrest each tree is built on a random sample of 2/3 with 1/3 of the predictors. Through this approach we obtain a training RMSE of about 1185 which is a little better than the Tree RMSE of 1276.

Natural Splines

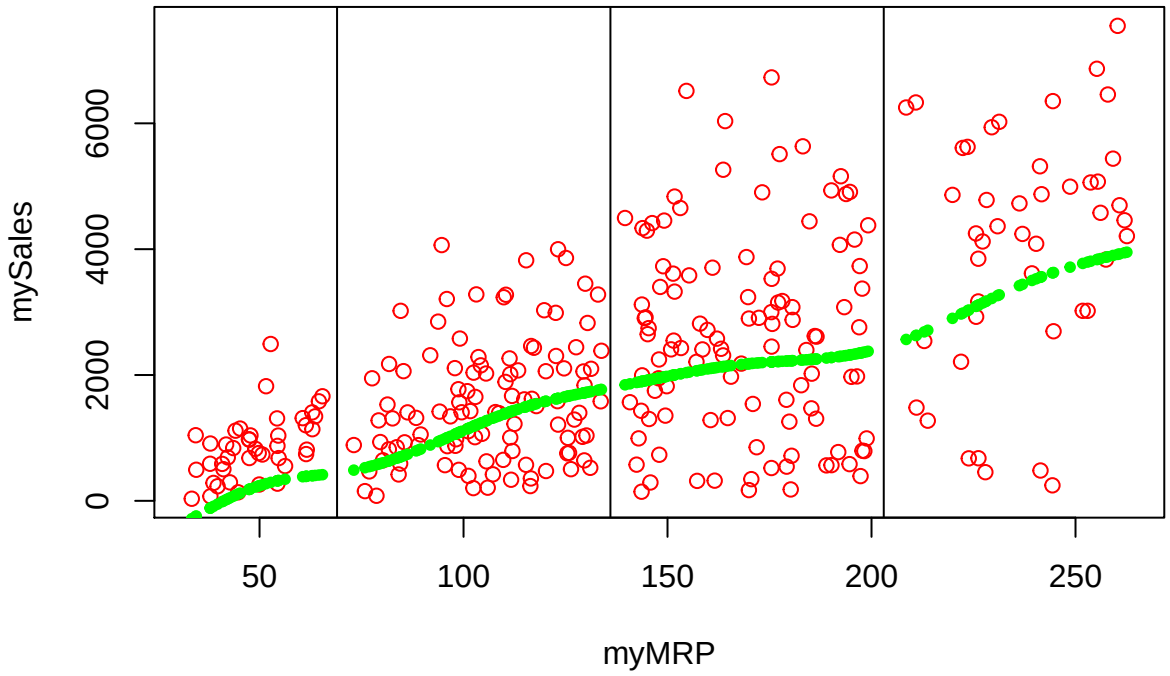
As we observed above in the `Item_Outlet_Sales` vs. `Item_MRP` plot that the `Item_MRP` presents three different seperation between the data. These separations could be interpreted as knots where the underlying function could have changed. On the other side, we know that `Item_MRP` is a predictor of high importance according to the previous experiments. In order to investigate this further, we tried to fit our model with a natural spline with three knots corresponding to the above-mentionned values.

We noticed also during the experiments that a natural spline could be fitted (better than other predictors but still poor) to `Item_Visibility_Ratio`.



1-1.bb

```
## integer(0)
```



1-2.bb

```
## integer(0)
```

We can observe that the model is poorly fitted for `Item_Visibility_Ratio`, however, it presents a slightly better fit for `Item_MRP`.

After multiple experiments, the best fitting spline to the sample of data that we picked corresponds to the predicted value `-3` times the standard error as shown above. Now we fit our model on the whole training data and calculate the RMSE.

```
## Natural Spline RMSE(Item_MRP:  1397.221
```

We can see that the model above is not performing well since its RMSE is around 1397.588 which is higher than the previous models.

We can conclude that this is due to a poor fit of the underlying function since it's based on only one predictor.

Conclusion