Analyzing the
Amount of Gold of a Team
in a League of Legends Match

STATISTICS 101A
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LEAGUE OF LEGENDS

AN OVERVIEW

- One of the most popular multiplayer games in the world
- Blue and red team fight each other
- Gold and experience are awarded
- **Main objective:** team that destroys the enemy base (Nexus) first wins

SUMMONER'S RIFT WORK IN PROGRESS

Red Nexus

Top Lane

Jungle

Three Inhibitors

Turret

Turret

Jungle

Turret

Mid Lane

Jungle

Turret

Turret

Turret

Three Inhibitors

Jungle

Turret

Bottom Lane

Blue Nexus

Turret

Turret

SECONDARY OBJECTIVES

Killing Dragons

Champions get a specific bonus such as more experience and power.

Gaining Experience

The higher the champion's experience, the easier it is to defeat other champions.

Destroy Towers

Towers defend a team's base. A team gains the enemy's territory by taking towers down.

Gold Bonus

Gold is used to buy better weapons for a champion, thereby making the champion stronger.

SAGEFOX

PROCESS

Clean Data

Use the given data set and perform necessary steps to eliminate unnecessary or unreasonable variables.

01

Identify best model

Fit the best model using various techniques to identify the best model for this set of data.

02

Verify model

Use proper diagnostics to conclude that the identified model is indeed the best model.

03

Recommendation

Teams can get acquire more gold to buy things to get stronger, in turn, destroying the enemy's nexus and **winning the game.**

04

SAGEFOX

Methodology

Modeling Process

Step 1: Data Cleaning

- **Remove four columns containing all zero**
  - ○ **destroyedMidBaseTurret**
  - ○ **destroyedTopBaseTurret**
  - ○ **lostMidBaseTurret**
  - ○ **lostTopBaseTurret**

- **Disregard gameDuration**
  - ○ **results in gold yield for both teams**

Step 1: Make new data frame without gameID, gameDuriation, and variables containing all zero

```
is.zero <- function(x){
  all(x == 0)
}
is.zero <- function(x){
  all(x == 0)
}
zero_ind <- apply(lol_games, 2, is.zero)
new_lol_games <- lol_games[,!zero_ind]
new_lol_games <- new_lol_games[, -c(1,2)]
```

Step 2: Full Model Building & VIF Testing

- **Running the full model with remaining 49 variables:**
  - **Insignificant variables**
  - **Too many predictors**
  - **VIF of some variables are greater than 5 ⇒ collinearity**

```
Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)              -8.521e+02  4.638e+02  -1.837 0.066189 .
expDiff                   2.450e-01  5.505e-03  44.508  < 2e-16 ***
champLevelDiff            1.469e+03  3.794e+01  38.707  < 2e-16 ***
isFirstTower              1.377e+03  4.853e+01  28.381  < 2e-16 ***
isFirstBlood              3.136e+02  4.647e+02   0.675 0.499783
killedFireDrake          -4.336e-01  2.523e+01  -0.017 0.986288
killedWaterDrake          8.299e+00  2.515e+01   0.330 0.741400
killedAirDrake            3.560e+01  2.532e+01   1.406 0.159691
killedEarthDrake         -7.013e+00  2.523e+01  -0.278 0.781065
killedElderDrake          2.673e+02  7.549e+01   3.542 0.000399 ***
lostFireDrake            -4.536e+01  2.519e+01  -1.801 0.071747 .
lostWaterDrake            1.837e+01  2.522e+01   0.728 0.466441
lostAirDrake             -2.261e+01  2.524e+01  -0.896 0.370359
lostEarthDrake            3.532e+00  2.510e+01   0.141 0.888115
lostElderDrake           -2.529e+02  7.461e+01  -3.389 0.000702 ***
killedBaronNashor         1.359e+02  3.003e+01   4.526 6.05e-06 ***
lostBaronNashor          -2.533e+02  3.008e+01  -8.421  < 2e-16 ***
killedRiftHerald          2.736e+02  2.595e+01  10.546  < 2e-16 ***
lostRiftHerald           -2.556e+02  2.564e+01  -9.967  < 2e-16 ***
destroyedTopInhibitor     2.576e+02  4.805e+01   5.361 8.37e-08 ***
destroyedMidInhibitor     4.283e+02  3.558e+01  12.038  < 2e-16 ***
destroyedBotInhibitor     1.373e+02  2.942e+01   4.667 3.07e-06 ***
lostTopInhibitor         -2.109e+02  4.887e+01  -4.316 1.59e-05 ***
lostMidInhibitor         -3.861e+02  3.550e+01 -10.877  < 2e-16 ***
lostBotInhibitor         -5.222e+01  3.057e+01  -1.708 0.087658 .
destroyedTopNexusTurret   3.399e+02  4.822e+01   7.048 1.86e-12 ***
destroyedBotNexusTurret   3.126e+02  3.546e+01   8.816  < 2e-16 ***
lostTopNexusTurret       -3.273e+02  4.911e+01  -6.665 2.69e-11 ***
lostBotNexusTurret       -3.771e+02  3.592e+01 -10.498  < 2e-16 ***
destroyedBotBaseTurret    2.735e+02  2.014e+01  13.583  < 2e-16 ***
lostBotBaseTurret        -2.545e+02  2.019e+01 -12.607  < 2e-16 ***
destroyedTopInnerTurret   6.902e+02  3.103e+01  22.242  < 2e-16 ***
destroyedMidInnerTurret   7.386e+02  3.056e+01  24.171  < 2e-16 ***
destroyedBotInnerTurret   4.628e+02  3.085e+01  14.998  < 2e-16 ***
lostTopInnerTurret       -7.629e+02  3.175e+01 -24.026  < 2e-16 ***
lostMidInnerTurret       -7.454e+02  3.071e+01 -24.269  < 2e-16 ***
lostBotInnerTurret       -4.575e+02  3.124e+01 -14.645  < 2e-16 ***
destroyedTopOuterTurret   3.845e+02  2.744e+01  14.012  < 2e-16 ***
destroyedMidOuterTurret   3.987e+02  2.759e+01  14.448  < 2e-16 ***
destroyedBotOuterTurret   3.523e+02  2.891e+01  12.185  < 2e-16 ***
lostTopOuterTurret       -6.492e+02  2.613e+01 -24.848  < 2e-16 ***
lostMidOuterTurret       -6.459e+02  2.616e+01 -24.687  < 2e-16 ***
lostBotOuterTurret       -5.872e+02  2.792e+01 -21.032  < 2e-16 ***
kills                     2.230e+02  3.147e+00  70.869  < 2e-16 ***
deaths                   -2.007e+02  2.489e+00 -80.610  < 2e-16 ***
assists                  -1.680e+01  1.424e+00 -11.801  < 2e-16 ***
wardsPlaced              -1.784e-01  1.696e-01  -1.052 0.292831
wardsDestroyed            1.121e+01  1.619e+00   6.923 4.53e-12 ***
wardsLost                -1.436e+01  1.628e+00  -8.821  < 2e-16 ***
```

```
        expDiff              champLevelDiff               isFirstTower               isFirstBlood              killedFireDrake
      21.723151                 18.111688                   2.194040                   1.017240                   1.961691
 killedWaterDrake              killedAirDrake             killedEarthDrake           killedElderDrake             lostFireDrake
       1.997899                  1.996746                   2.028913                   1.158378                   2.018205
  lostWaterDrake               lostAirDrake               lostEarthDrake             lostElderDrake            killedBaronNashor
       2.052156                  2.047006                   2.104640                   1.185598                   2.473019
 lostBaronNashor             killedRiftHerald             lostRiftHerald          destroyedTopInhibitor      destroyedMidInhibitor
       2.714610                  2.638186                   2.636215                   1.727057                   1.298710
destroyedBotInhibitor         lostTopInhibitor            lostMidInhibitor           lostBotInhibitor       destroyedTopNexusTurret
       2.040117                  1.775596                   1.308951                   2.067727                   1.810247
destroyedBotNexusTurret      lostTopNexusTurret          lostBotNexusTurret       destroyedBotBaseTurret        lostBotBaseTurret
       2.145621                  1.854846                   2.148934                   1.490943                   1.508609
destroyedTopInnerTurret  destroyedMidInnerTurret     destroyedBotInnerTurret       lostTopInnerTurret         lostMidInnerTurret
       1.440276                  1.470148                   1.735118                   1.466584                   1.478674
 lostBotInnerTurret       destroyedTopOuterTurret    destroyedMidOuterTurret    destroyedBotOuterTurret       lostTopOuterTurret
       1.762369                  1.362065                   1.367926                   1.486993                   1.236563
 lostMidOuterTurret         lostBotOuterTurret                  kills                      deaths                     assists
       1.239027                  1.404580                   8.411366                   5.458555                   5.574798
    wardsPlaced              wardsDestroyed                 wardsLost
       1.157219                  1.980545                   2.028306
```
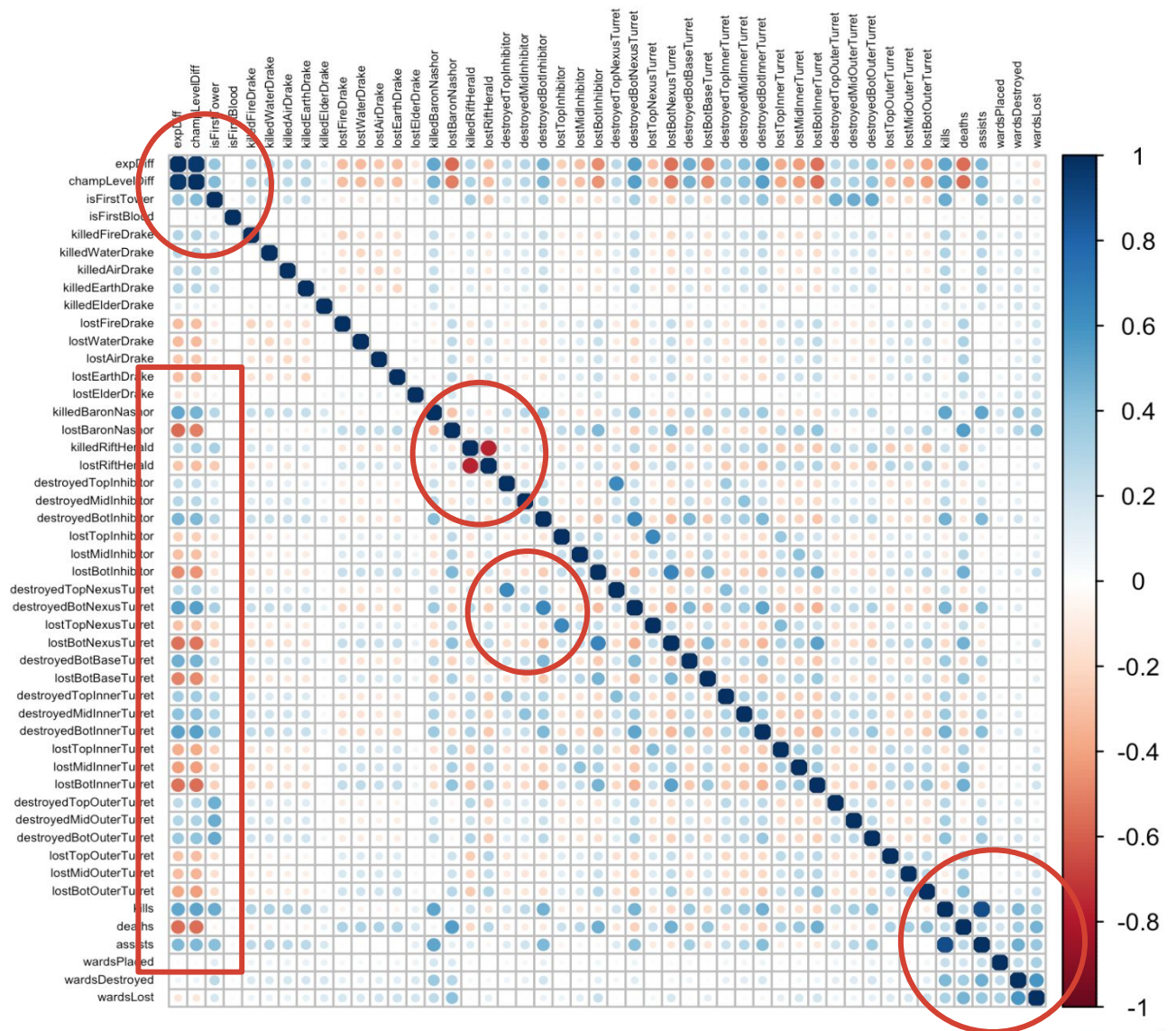
Modeling Process

Step 3: Handling variable correlation

- **Creating correlation map**
- **Checking multicollinearity**
- **Remove 8 predictors which are highly correlated to other predictors.**

❏ assists
❏ champLevelDiff
❏ lostRiftHerald
❏ destroyedTopNexusTurret
❏ destroyedBotNexusTurret
❏ lostBotNexusTurret
❏ lostTopNexusTurret
❏ expDiff

Modeling Process

**Step 4: Run the second model without collinearity**

- Contains 41 predictors without any serious correlation issue.

- Conduct t.test to test the contribution of each variable to the model.

- Construct residuals analysis
  ⇒ The conditions meet, but too many variables are not significant.

```
Coefficients:
                          Estimate Std. Error  t value Pr(>|t|)
(Intercept)             -3.433e+03  6.156e+02   -5.576 2.48e-08 ***
isFirstTower             2.030e+03  6.398e+01   31.733  < 2e-16 ***
isFirstBlood             2.705e+03  6.171e+02    4.383 1.17e-05 ***
killedFireDrake          3.794e+01  3.335e+01    1.138 0.255273
killedWaterDrake         1.869e+01  3.324e+01    0.562 0.574016
killedAirDrake           6.158e+00  3.348e+01    0.184 0.854076
killedEarthDrake         1.552e+01  3.332e+01    0.466 0.641509
killedElderDrake         1.455e+03  9.852e+01   14.773  < 2e-16 ***
lostFireDrake           -2.473e+02  3.313e+01   -7.464 8.68e-14 ***
lostWaterDrake          -1.805e+02  3.313e+01   -5.449 5.12e-08 ***
lostAirDrake            -1.341e+02  3.327e+01   -4.030 5.58e-05 ***
lostEarthDrake          -1.478e+02  3.306e+01   -4.471 7.84e-06 ***
lostElderDrake          -1.460e+03  9.675e+01  -15.085  < 2e-16 ***
killedBaronNashor        1.329e+03  3.757e+01   35.371  < 2e-16 ***
lostBaronNashor         -1.471e+03  3.757e+01  -39.162  < 2e-16 ***
killedRiftHerald         2.430e+02  2.425e+01   10.021  < 2e-16 ***
destroyedTopInhibitor    1.838e+02  5.366e+01    3.425 0.000617 ***
destroyedMidInhibitor    1.556e+02  4.728e+01    3.290 0.001002 **
destroyedBotInhibitor   -6.804e+01  3.547e+01   -1.918 0.055132 .
lostTopInhibitor         1.603e+01  5.417e+01    0.296 0.767377
lostMidInhibitor        -6.423e+01  4.718e+01   -1.361 0.173370
lostBotInhibitor         8.459e+01  3.667e+01    2.307 0.021065 *
destroyedBotBaseTurret   7.466e+02  2.618e+01   28.518  < 2e-16 ***
lostBotBaseTurret       -7.315e+02  2.635e+01  -27.755  < 2e-16 ***
destroyedTopInnerTurret  8.115e+02  4.028e+01   20.147  < 2e-16 ***
destroyedMidInnerTurret  8.331e+02  4.061e+01   20.514  < 2e-16 ***
destroyedBotInnerTurret  8.073e+02  4.031e+01   20.030  < 2e-16 ***
lostTopInnerTurret      -8.476e+02  4.131e+01  -20.519  < 2e-16 ***
lostMidInnerTurret      -7.818e+02  4.089e+01  -19.122  < 2e-16 ***
lostBotInnerTurret      -8.218e+02  4.078e+01  -20.153  < 2e-16 ***
destroyedTopOuterTurret  3.898e+02  3.649e+01   10.682  < 2e-16 ***
destroyedMidOuterTurret  2.861e+02  3.674e+01    7.789 6.99e-15 ***
destroyedBotOuterTurret  4.725e+02  3.847e+01   12.283  < 2e-16 ***
lostTopOuterTurret      -8.564e+02  3.462e+01  -24.741  < 2e-16 ***
lostMidOuterTurret      -7.445e+02  3.471e+01  -21.453  < 2e-16 ***
lostBotOuterTurret      -8.000e+02  3.692e+01  -21.671  < 2e-16 ***
kills                    4.104e+02  2.591e+00  158.381  < 2e-16 ***
deaths                  -4.141e+02  2.577e+00 -160.717  < 2e-16 ***
wardsPlaced             -5.474e-02  2.259e-01   -0.242 0.808565
wardsDestroyed           1.136e+01  2.155e+00    5.271 1.37e-07 ***
wardsLost               -1.925e+01  2.166e+00   -8.889  < 2e-16 ***
```
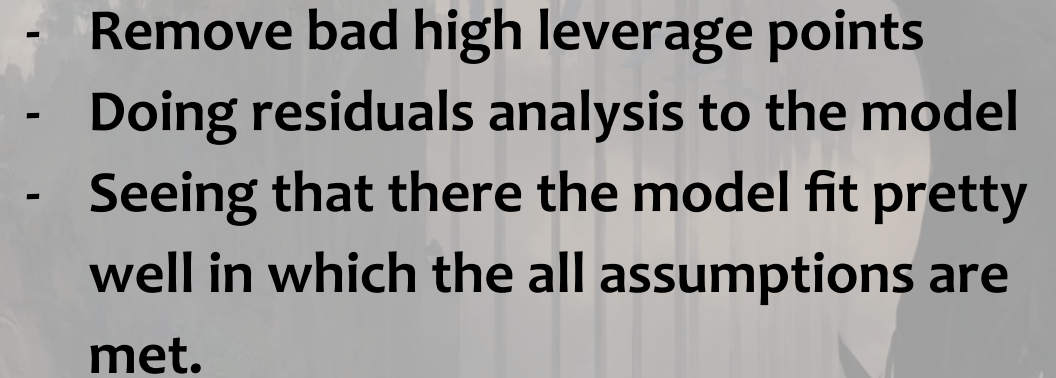
Modeling Process

Step 5: Regsubsets using forward method
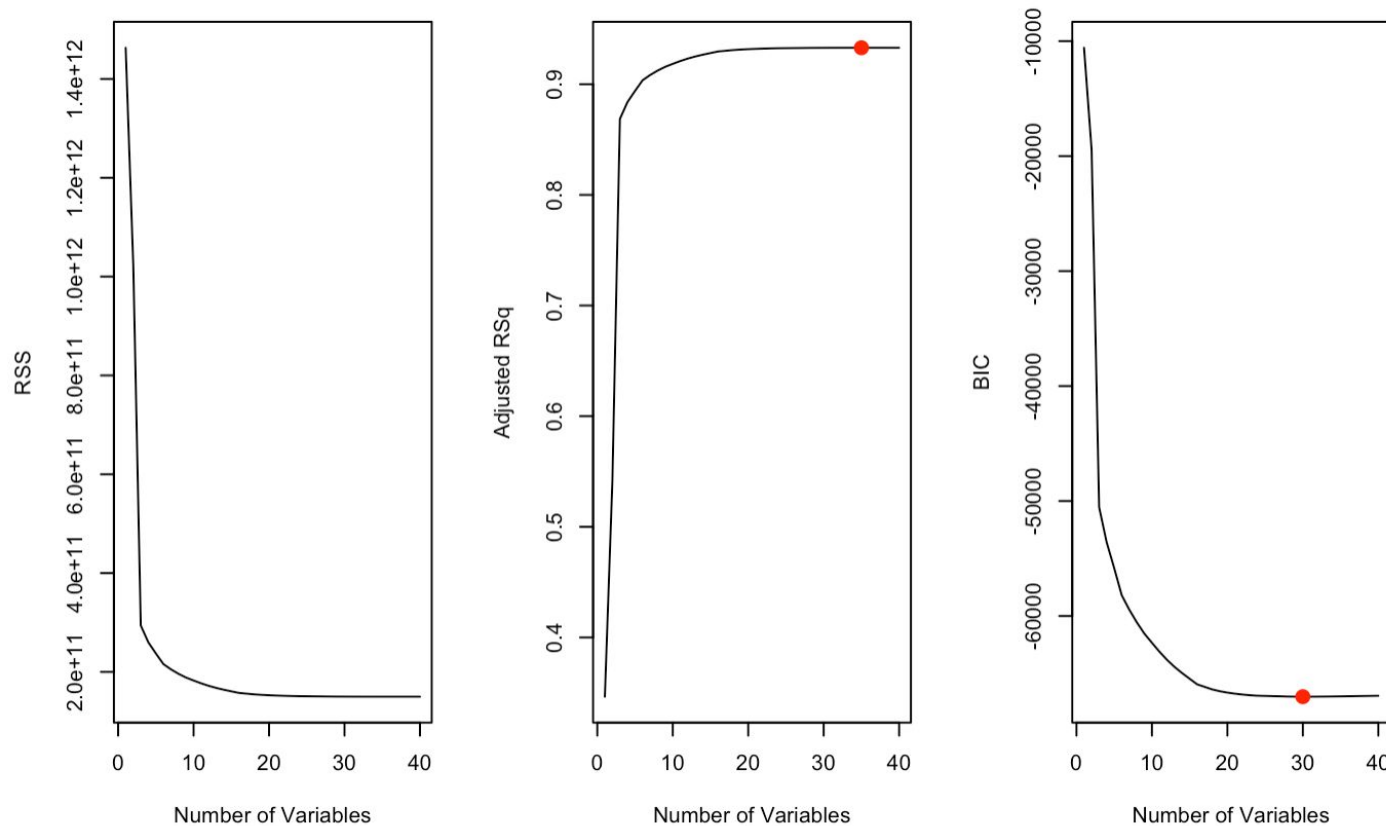
- Select the overall best model

- Pick the best model based on the smallest BIC value, which contains 30 predictors.

Modeling Process

Final step : Reaching the best model

- Remove bad high leverage points
- Doing residuals analysis to the model
- Seeing that there the model fit pretty well in which the all assumptions are met.

Verifying our Model

Regression Diagnostics

Scale-Location

❏ There is no pattern ⇒ model is not incorrect
❏ Equal dispersion ⇒ constant variance assumption is satisfied

Normal Q-Q

❏ Most of the data lies on the line, indicating the data is normally distributed

Residuals vs. Leverage

❏ There are some high leverage points, but this is expected of such a large dataset
❏ Bad high leverage points have been removed
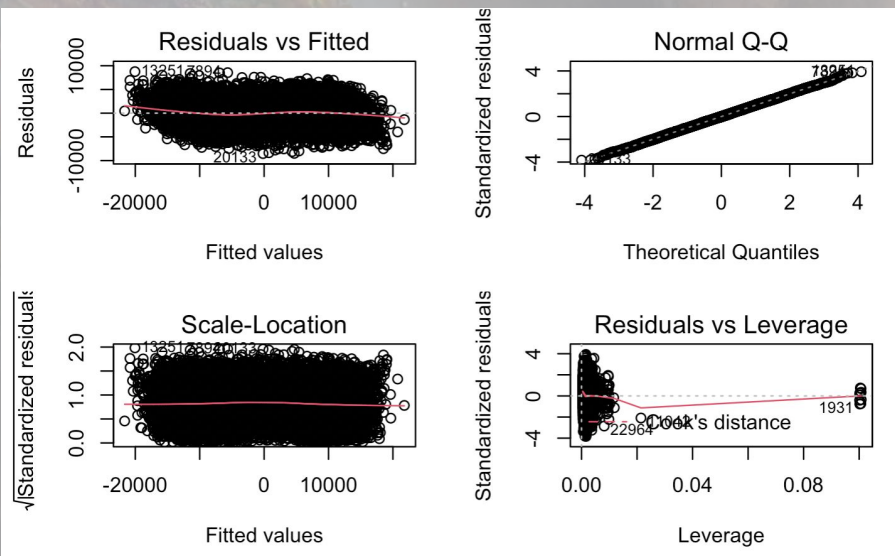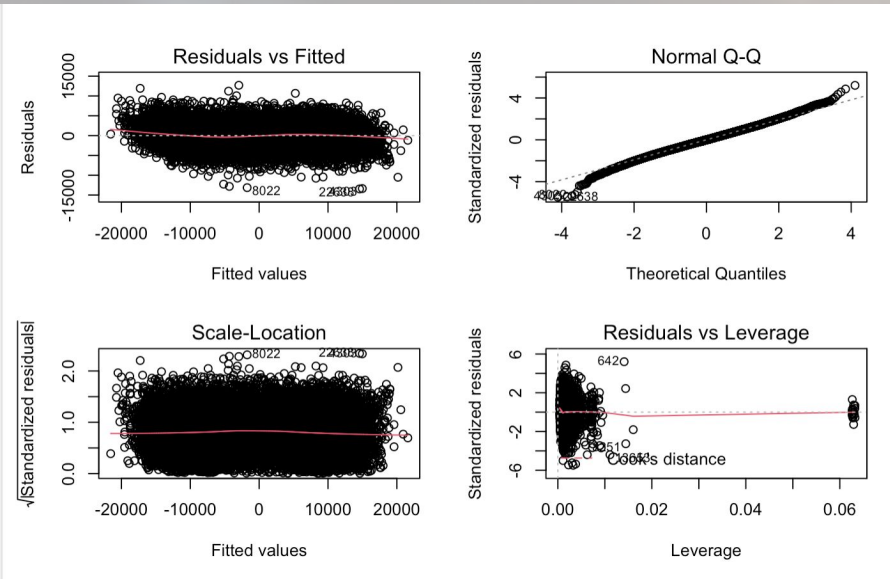
Modeling Process

At the level of alpha = 0.05, all predictors are significant, and having high adjusted R^2 value.

⇒ **No need for any further transformations**

```
Coefficients:
                          Estimate Std. Error  t value Pr(>|t|)
(Intercept)              -3437.592    615.680   -5.583 2.38e-08 ***
isFirstTower              2031.963     63.792   31.853  < 2e-16 ***
isFirstBlood              2727.091    617.082    4.419 9.94e-06 ***
killedElderDrake          1442.883     97.206   14.844  < 2e-16 ***
lostFireDrake             -261.286     26.528   -9.850  < 2e-16 ***
lostWaterDrake            -193.670     26.496   -7.310 2.76e-13 ***
lostAirDrake              -146.433     26.364   -5.554 2.81e-08 ***
lostEarthDrake            -160.449     26.126   -6.141 8.31e-10 ***
lostElderDrake           -1467.946     94.932  -15.463  < 2e-16 ***
killedBaronNashor         1340.306     35.558   37.693  < 2e-16 ***
lostBaronNashor          -1456.986     35.504  -41.037  < 2e-16 ***
killedRiftHerald           245.450     24.204   10.141  < 2e-16 ***
destroyedTopInhibitor      190.664     53.337    3.575 0.000351 ***
destroyedBotBaseTurret     738.505     25.357   29.125  < 2e-16 ***
lostBotBaseTurret         -719.508     25.348  -28.385  < 2e-16 ***
destroyedTopInnerTurret    814.762     40.194   20.271  < 2e-16 ***
destroyedMidInnerTurret    867.084     38.965   22.253  < 2e-16 ***
destroyedBotInnerTurret    795.521     39.865   19.955  < 2e-16 ***
lostTopInnerTurret        -843.389     39.891  -21.142  < 2e-16 ***
lostMidInnerTurret        -794.706     39.377  -20.182  < 2e-16 ***
lostBotInnerTurret        -804.335     40.202  -20.008  < 2e-16 ***
destroyedTopOuterTurret    389.933     36.481   10.689  < 2e-16 ***
destroyedMidOuterTurret    287.878     36.718    7.840 4.68e-15 ***
destroyedBotOuterTurret    471.817     38.441   12.274  < 2e-16 ***
lostTopOuterTurret        -854.576     34.552  -24.733  < 2e-16 ***
lostMidOuterTurret        -747.919     34.677  -21.568  < 2e-16 ***
lostBotOuterTurret        -799.892     36.856  -21.703  < 2e-16 ***
kills                      410.258      2.476  165.680  < 2e-16 ***
                          -413.155      2.550 -162.041  < 2e-16 ***
                            11.834      2.079    5.693 1.26e-08 ***
                           -19.156      2.077   -9.222  < 2e-16 ***
                         0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2456 on 24881 degrees of freedom
Multiple R-squared:  0.933,      Adjusted R-squared:  0.9329
F-statistic: 1.155e+04 on 30 and 24881 DF,  p-value: < 2.2e-16
```

all predictors are significant

```
Residual standard error: 2456 on 24881 degrees of freedom
Multiple R-squared:  0.933,      Adjusted R-squared:  0.9329
F-statistic: 1.155e+04 on 30 and 24881 DF,  p-value: < 2.2e-16
```

Thus, this is our best model.

CONCLUSION

Coefficients of Our Best Model
Interpretation

isFirstBlood	isFirstTower	killedElderDrake
2727.09089	2031.96283	1442.88326
killedBaronNashor	destroyedMidInnerTurret	destroyedTopInnerTurret
1340.30564	867.08398	814.76188
destroyedBotInnerTurret	destroyedBotBaseTurret	destroyedBotOuterTurret
795.52129	738.50495	471.81709
kills	destroyedTopOuterTurret	destroyedMidOuterTurret
410.25821	389.93333	287.87764
killedRiftHerald	destroyedTopInhibitor	wardsDestroyed
245.44994	190.66431	11.83433
wardsLost	lostAirDrake	lostEarthDrake
-19.15633	-146.43283	-160.44895
lostWaterDrake	lostFireDrake	deaths
-193.67005	-261.28574	-413.15548
lostBotBaseTurret	lostMidOuterTurret	lostMidInnerTurret
-719.50773	-747.91910	-794.70591
lostBotOuterTurret	lostBotInnerTurret	lostTopInnerTurret
-799.89244	-804.33545	-843.38946
lostTopOuterTurret	lostBaronNashor	lostElderDrake
-854.57597	-1456.98577	-1467.94557
(Intercept)		
-3437.59248		

Important Variables

- **First Blood, First Tower**
- **Drake, Baron, Herald**
- **Inner Turret**
- **Kills**
- **Top Inhibitor**
- **Wards**

Gold Bonus

- **First Blood: 400**
- **First Tower: 400**
- **Drake: 250/+100**
- **Baron: 300/+25**
- **Rift Herald: 100**
- **Inner Turret: 300/550 (Local Gold)**
- **Outer Turret: 250**
- **Kills: 100-1000+**
- **Inhibitor: minions get stronger**
- **Wards: obtain map vision**

IMPORTANT PREDICTORS

From our summary chart, the important predictors are:

- **First Blood**

- **First Tower**

- **Elder Drake**

- **Baron Nashor**

- **Inner Turret**

- **Kills**

- **Inhibitors**

RECOMMENDATIONS

- **For higher gold yield:**
  - **Kill the rival's champion first**
  - **Destroy the rival's tower first**
  - **Kill Baron Nashor and Elder Drake**
  - **Destroy Inner Turrets**

- **To prevent opposing team from gaining more gold against your team:**
  - **Protect Turrets**
  - **Try to not be killed**

STRENGTHS

- **Data is cleaned**

- **Multicollinearity is resolved by removing collinear variables**

- **Regression diagnostics are satisfied through Residual plots.**

- **High adjusted R-squared values**

- **All predictors are now significant**

THANK YOU