# Billboard Top 10

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# Question

## What makes a song successful?

- For over 80 years Billboard has released a weekly Top 100 list to indicate which songs are most popular. What are the features that indicate popular songs on the chart?

# Data

- Our data is obtained from data.world
  - https://data.world/kcmillersean/billboard-hot-100-1958-2017
- There are two datasets:
  - Billboard Top 100 ratings from 1958 to 2020
  - Song information
- Join these two tables together to achieve a Billboard ranking and general information for 327,895 records.
- 18% of our records do not have song information
  - Impute the missing values with the median value of the songs respective decade.

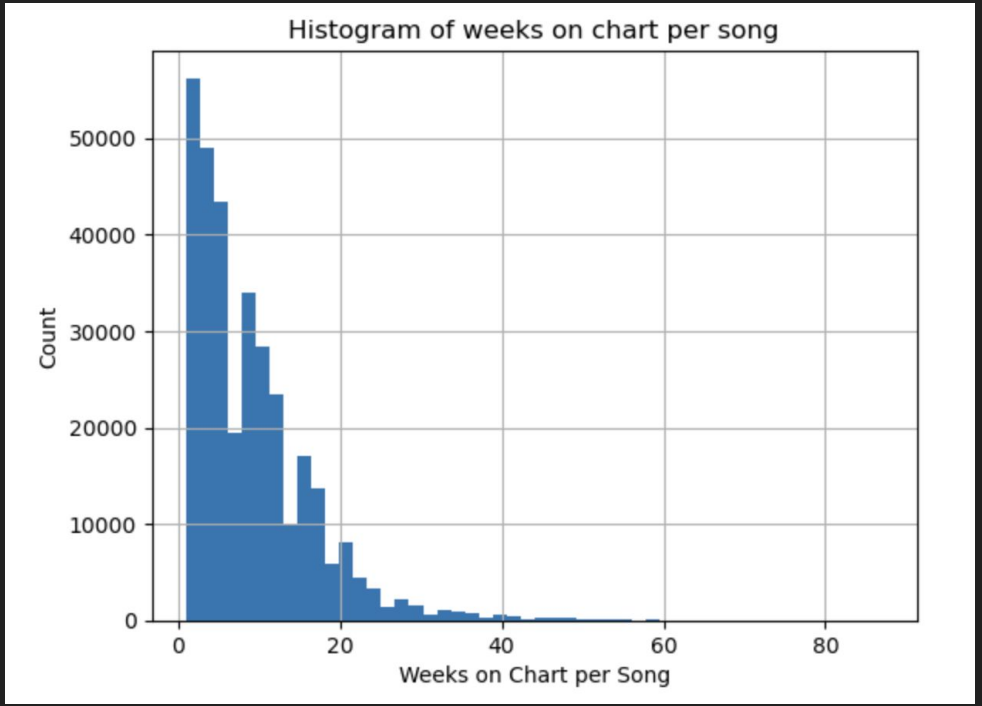
# Variable Creation

- **Success Indicator:** if the song was in the top 10 that week.
- **Artist Count Total**: total times an artist appeared on the Billboard 100.
- **Artist Count Year**: times an artist appeared on the Billboard 100 that year.
  - (year prior also calculated)
- **Artist Count Week**: times an artist appeared on the Billboard 100 that week.
  - (week prior also calculated)
- **Emotional Indicators**: did the song score in the 80th percentile of a certain emotion score.

# Weeks on Chart Distribution

- Most songs only appear on the chart once.
- Very few make it above 20 weeks.
- The song with the most weeks on the chart: Radioactive by Imagine Dragons, 87 weeks.*

*Note: our data only runs through 2020; as of 2022, the new record is held by Heat Waves, by Glass Animals reaching 91 weeks.



# Superlatives (through 2020)

**Most sad song:** “Sad, Sad Girl” by Barbara Mason

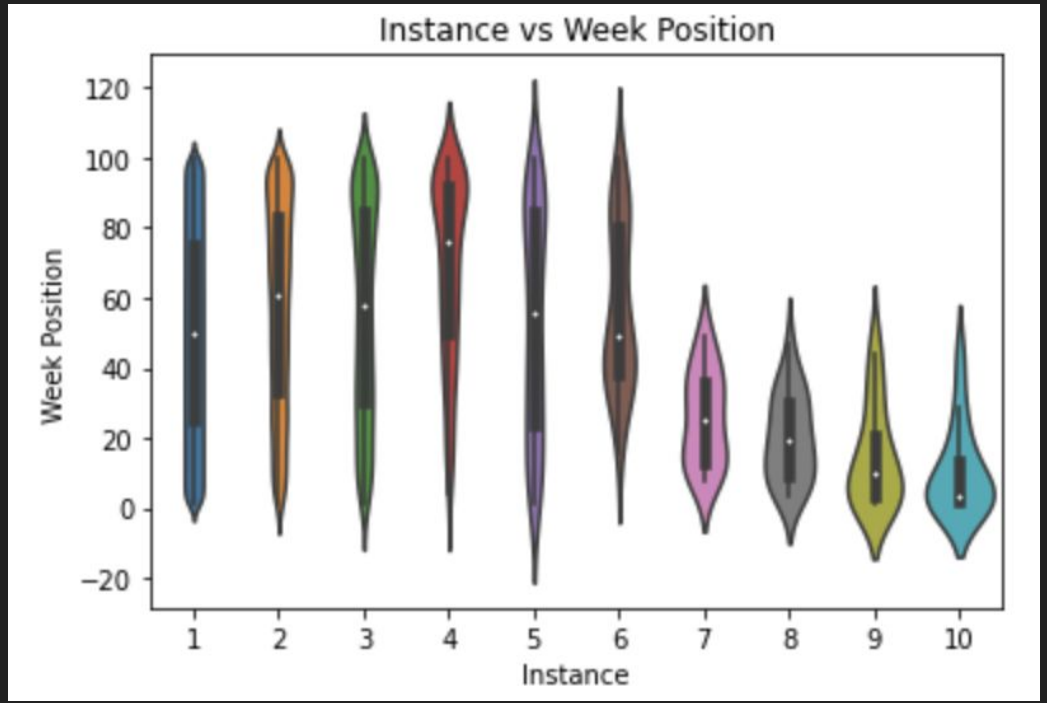
**Most joyful song:** “I’m in Love” by Aretha Franklin

**Most words:** “Duckworth” by Kendrick Lamar

**Most times on chart (artist):** Drake (1,093 counts)

# Interesting Relationships

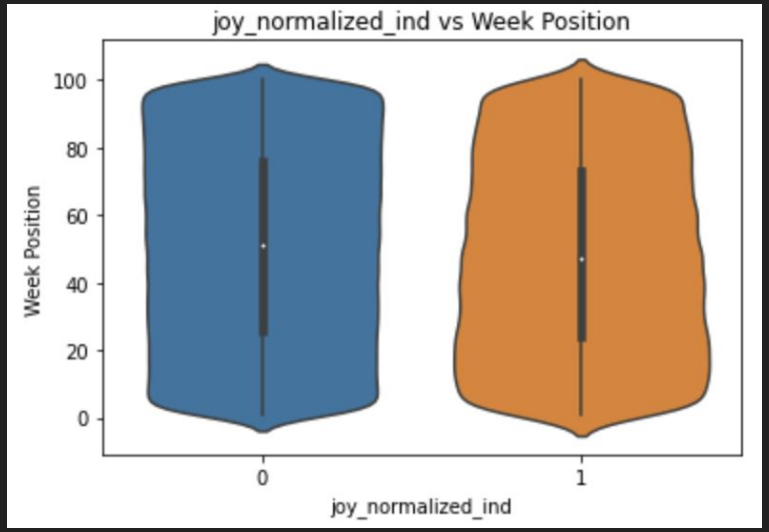
- Instance by Week Position: instance refers to the amount of times a song has previously entered and exited the Billboard 100. After a song enters its 7th time on the chart, it is almost guaranteed a higher ranking.



# Interesting Relationships

- Our “joy” indicator ever slightly appears to be associated with higher ranking songs.

- Weeks on chart as a song stays on the chart longer, the song ranks higher.



# Response Selection

- Options
  - Success Indicator: Indicates if a song is in the top 10 that week.
  - Peak Position: The highest ranking a song achieves.
  - Weeks on Chart: The amount of weeks a song remains on the chart.
  - Week Position: The actual ranking of a song.
- Analysis:
  - Using PPS Predictor Analysis, we find that Week Position contains the most predictive factors.
- Response selection : Week Position

# Model Comparison

**PyCaret** iterates model production through our dataset to determine which regression algorithms produce best performing metrics. We find CatBoost, LightGBM, Random Forest, and Extra Trees Regressor to be top performers.

- PyCaret Analysis:
  - All Factors

| | Model | MAE | MSE | RMSE | R2 | RMSLE | MAPE | TT (Sec) |
|---|---|---|---|---|---|---|---|---|
| **catboost** | CatBoost Regressor | 5.7055 | 76.8578 | 8.7667 | 0.9079 | 0.2413 | 0.2027 | 7.5700 |
| **lightgbm** | Light Gradient Boosting Machine | 5.7869 | 78.7547 | 8.8743 | 0.9056 | 0.2406 | 0.2064 | 1.3560 |
| **rf** | Random Forest Regressor | 5.9214 | 82.1829 | 9.0654 | 0.9015 | 0.2434 | 0.2038 | 54.5460 |
| **et** | Extra Trees Regressor | 6.0936 | 86.1485 | 9.2816 | 0.8967 | 0.2490 | 0.2075 | 66.0480 |
| **gbr** | Gradient Boosting Regressor | 6.1121 | 87.5695 | 9.3577 | 0.8950 | 0.2565 | 0.2267 | 14.6020 |

  - Controllable Factors:

| | Model | MAE | MSE | RMSE | R2 | RMSLE | MAPE | TT (Sec) |
|---|---|---|---|---|---|---|---|---|
| **et** | Extra Trees Regressor | 18.1790 | 523.5849 | 22.8819 | 0.3712 | 0.7147 | 1.1297 | 9.3220 |
| **rf** | Random Forest Regressor | 18.2429 | 523.7808 | 22.8862 | 0.3710 | 0.7144 | 1.1314 | 18.1480 |
| **dt** | Decision Tree Regressor | 18.2369 | 530.7099 | 23.0370 | 0.3626 | 0.7173 | 1.1306 | 1.3360 |
| **knn** | K Neighbors Regressor | 19.4559 | 607.4218 | 24.6449 | 0.2705 | 0.7427 | 1.1601 | 641.5360 |
| **catboost** | CatBoost Regressor | 22.3702 | 689.6900 | 26.2619 | 0.1717 | 0.8279 | 1.6403 | 5.0860 |

# Model Comparison

- Having familiarity with LightGBM and Random Forest Regression, these two algorithms are selected for our analysis.
- We use 5-Fold Cross Validation Random Search to tune our model hyper-parameters. LightGBM shows best performance.

LightGBM:
- r-square: 0.9015
- n_leaves: 1815
- n_estimators: 147
- max_depth: 3
- learning_rate: .82
- time_to_run: 1 h 10 m

Random Forest:
- r-square: 0.888
- n_estimators: 400
- max_depth: 7
- time_to_run: 10+ h

# Model Results

- Recall, we are interested in most influential features (feature importances).
- LightGBM feature importance:
  - Previous Week Position
  - Weeks on Chart
  - Artist Count Year
  - Artist Count Total
  - Artist Count Week
- Random Forest feature importance:
  - Previous Week Position
  - Instance
- All of these features are not necessarily controllable.

# Model Reconstruction - Controllable Factors

- Using LightGBM we re-construct our model using only controllable factors.
- Again we use 5-Fold Cross Validation Random Search to tune our model hyper-parameters.

LightGBM:
- r-square: 0.369
- n_leaves: 666
- n_estimators: 88
- max_depth: 16
- learning_rate: .77
- time_to_run: 7 m

# Model Comparison - Part 2

- Our top controllable factors are MTLD, Sentiment Score, Word Count, TTR, Emotion Score, and CTTR.
- Notice our metrics, our model with controllable factors does not perform as well as the model with all factors.
- Recall our question - which factors contribute to a song's success?

LightGBM Full Metrics:
MAE: 5.8958
MSE: 79.4554
RMSE: 8.9138
R_Sqr: 0.9044

LightGBM Controllable Metrics:
MAE: 17.9598
MSE: 513.9297
RMSE: 22.67
R_Sqr: 0.382

# Recommendations

- A song’s position is mostly impacted by uncontrollable factors:
  - The number of times an artist has been and stayed on the chart.
- Looking at controllable factors:
  - Include lyrics with shorter sentences. (MTLD)
  - Create songs with a positive sentiment. (Sentiment Score)
  - Include more words in the song. (Word count)
  - Use repetitive lyrics - less unique words. (TTR)

# Future Improvements

- Include additional data in the analysis:
  - External ratings
  - Streaming data
  - Most recent data only (e.g. 2010 and beyond)
- Include additional controllable variables.
  - Song length
  - Marketing information
- Run analysis on all songs, not just those on the chart.

# Appendix

- All work can be found on my GitHub:
  - https://github.com/chase-weber/Billboard-Top-10-Prediction