# Model Evaluation Summary

## 1. Train-Test Split Results

| Model | RMSE | MAE | $R^2$ |
|---|---|---|---|
| XGBoost (No Outlier) | 10.94 | 2.07 | 0.96 |
| XGBoost (With Outlier) | 63.73 | 3.56 | -0.29 |
| Random Forest (No Outlier) | 13.75 | 3.40 | 0.93 |
| Random Forest (With Outlier) | 16.70 | 3.67 | 0.91 |
| Gradient Boosting (No Outlier) | 10.68 | 2.06 | 0.96 |
| Gradient Boosting (With Outlier) | 43.47 | 4.06 | 0.40 |

### Best Model: Train-Test Split (No Outlier)
- **Model**: Gradient Boosting (No Outlier)
- **Performance**: RMSE = 10.68, MAE = 2.06, $R^2$ = 0.96
- **Explanation**:
  - This model has the lowest RMSE and highest $R^2$, indicating that it explains 96% of the variance and has minimal prediction error.

### Best Model: Train-Test Split (With Outlier)
- **Model**: Random Forest (With Outlier)
- **Performance**: RMSE = 16.70, MAE = 3.67, $R^2$ = 0.91
- **Explanation**:
  - Even with outliers, this model maintains a high $R^2$ of 0.91, meaning it explains 91% of the variance. The RMSE value indicates some error, likely due to the outliers, but it performs best compared to other models with outliers.

## 2. Cross-Validation Results

| Model | Mean RMSE | Std RMSE | Mean $R^2$ | Mean MAE |
|---|---|---|---|---|
| XGBoost (No Outlier) | 10.50 | 1.44 | 0.95 | 2.04 |
| XGBoost (With Outlier) | 33.01 | 36.41 | 0.76 | 2.76 |
| Random Forest (No Outlier) | 14.19 | 3.98 | 0.91 | 3.36 |
| Random Forest (With Outlier) | 35.34 | 37.47 | 0.74 | 4.05 |
| Gradient Boosting (No Outlier) | 10.26 | 1.39 | 0.96 | 1.88 |
| Gradient Boosting (With Outlier) | 29.60 | 39.34 | 0.80 | 2.51 |

### Best Model: Cross-Validation (No Outlier)
- **Model**: Gradient Boosting (No Outlier)
- **Performance**: Mean RMSE = 10.26, Mean MAE = 1.88, Mean $R^2$ = 0.96
- **Explanation**:
  - This model shows consistent performance across folds with the lowest mean RMSE and the highest mean $R^2$, suggesting it is the most reliable and accurate model.

### Best Model: Cross-Validation (With Outlier)

- **Model**: XGBoost (With Outlier)
- **Performance**: Mean RMSE = 33.01, Mean MAE = 2.76, Mean $R^2$ = 0.76
- **Explanation**:
  - Despite the presence of outliers, this model achieves the highest $R^2$ (0.76) and the lowest RMSE among models tested with outliers.

## 3. Results Without the Feature `agent_avg_revenue`

### Train-Test Split Results Without `agent_avg_revenue`

| Model | RMSE | MAE | $R^2$ |
|---|---|---|---|
| XGBoost (No Outlier) | 16.17 | 3.92 | 0.91 |
| XGBoost (With Outlier) | 87.72 | 6.44 | -1.44 |
| Random Forest (No Outlier) | 20.77 | 5.96 | 0.85 |
| Random Forest (With Outlier) | 45.30 | 8.05 | 0.35 |
| Gradient Boosting (No Outlier) | 12.54 | 3.09 | 0.94 |
| Gradient Boosting (With Outlier) | 43.47 | 4.06 | 0.40 |

### Best Model: Train-Test Split (No Outlier) Without `agent_avg_revenue`
- **Model**: Gradient Boosting (No Outlier)
- **Performance**: RMSE = 12.54, MAE = 3.09, $R^2$ = 0.94
- **Explanation**:
  - Even without the feature, this model still explains 94% of the variance, showing robustness. However, the RMSE is higher than when the feature is included.

### Best Model: Train-Test Split (With Outlier) Without `agent_avg_revenue`
- **Model**: Gradient Boosting (With Outlier)
- **Performance**: RMSE = 43.47, MAE = 4.06, $R^2$ = 0.40
- **Explanation**:
  - With outliers and the removal of the feature, the model's $R^2$ drops to 0.40, showing that `agent_avg_revenue` is an important feature for improving model performance.

### Cross-Validation Results Without `agent_avg_revenue`

| Model | Mean RMSE | Std RMSE | Mean $R^2$ | Mean MAE |
|---|---|---|---|---|
| XGBoost (No Outlier) | 16.91 | 1.79 | 0.88 | 4.09 |
| XGBoost (With Outlier) | 39.00 | 37.01 | 0.67 | 4.91 |
| Random Forest (No Outlier) | 21.41 | 3.29 | 0.81 | 5.98 |
| Random Forest (With Outlier) | 51.03 | 32.90 | 0.35 | 7.62 |
| Gradient Boosting (No Outlier) | 14.12 | 1.87 | 0.91 | 3.03 |
| Gradient Boosting (With Outlier) | 55.45 | 36.64 | -0.02 | 4.57 |

### Best Model: Cross-Validation (No Outlier) Without `agent_avg_revenue`
- **Model**: Gradient Boosting (No Outlier)
- **Performance**: Mean RMSE = 14.12, Mean MAE = 3.03, Mean $R^2$ = 0.91

- **Explanation**:
  - This model has the best performance among models without `agent_avg_revenue` in cross-validation, although its metrics indicate some loss of predictive power compared to when the feature is included.

### Best Model: Cross-Validation (With Outlier) Without `agent_avg_revenue`
- **Model**: XGBoost (With Outlier)
- **Performance**: Mean RMSE = 39.00, Mean MAE = 4.91, Mean $R^2$ = 0.67
- **Explanation**:
  - Even with outliers and without the feature, this model performs best in cross-validation. However, the performance metrics clearly show the importance of retaining the feature.

## Conclusion
- **Gradient Boosting (No Outlier)** consistently shows the best performance across scenarios, indicating its robustness and reliability.
- The removal of the feature `agent_avg_revenue` significantly impacts performance, highlighting its importance in predictive accuracy.