# **Model Results**

## **Model Evaluation**

The model was evaluated using the ML.EVALUATE function in BigQuery. The key performance metrics are:

* **Mean Absolute Error (MAE):** 281.34
* **Mean Squared Error (MSE):** 503,209.06
* **Mean Squared Log Error (MSLE):** 3.47
* **Median Absolute Error:** 114.93
* **R² Score:** 0.675
* **Explained Variance:** 0.676

The **R² score of approximately 0.68** indicates that the model explains about 68% of the variance in daily store-family-level sales, which reflects a strong relationship between the features (including family) and sales. This is a substantial improvement over previous models without the family feature.

The **mean absolute error of $281.34** means that on average, the model's predictions deviate from actual sales by about $281 per store per product family per day. This is a reasonable error margin for operational forecasting and indicates the model can support category-level decision making.

The relatively low **median absolute error (115)** suggests that half of the daily predictions are within $115 of the actual sales, highlighting consistent predictive performance across most observations.

## **Prediction Results**

Sure! Here’s a polished **Prediction Results** section based on your model and the prediction query you ran:

## **Prediction Results**

The model was used to predict daily sales for each store and product family during the period **August 1–15, 2017**. Predictions were generated using the following query:

SELECT \*  
FROM ML.PREDICT(  
 MODEL `focal-furnace-465023-g3.assignment\_dataflow.store\_family\_sales\_model`,  
 (  
 SELECT  
 store\_nbr,  
 family,  
 type,  
 cluster,  
 EXTRACT(DAYOFWEEK FROM date) AS day\_of\_week,  
 EXTRACT(DAY FROM date) AS day\_of\_month,  
 onpromotion  
 FROM `focal-furnace-465023-g3.assignment\_dataflow.store\_family\_sales\_features`  
 WHERE date BETWEEN DATE '2017-08-01' AND DATE '2017-08-15'  
 )  
);

### **Key Insights**

* **Granular Forecasts:** By including family, the model predicts sales at a granular level—by product category, store, and day—allowing for more precise inventory and marketing planning.
* **Improved Accuracy:** The model’s predictive accuracy is reflected in a mean absolute error of approximately $281 per store-family-day, significantly improving over previous aggregated models.
* **Operational Usefulness:** These predictions support store managers and planners in anticipating demand fluctuations for different product families on a daily basis, enabling better resource allocation.
* **Areas for Further Improvement:** Although the model performs well overall, unexplained variation remains that could be addressed by incorporating additional factors such as holidays, local events, weather conditions, or more advanced time-series modeling techniques.

### **Implications**

Here’s a detailed **Implications** section comparing your previous aggregated store-level model with the new store-family-level model including family as a feature:

## **Implications**

The introduction of the family feature and modeling at the store-family-day level has led to significant improvements compared to the previous aggregated store-level model.

|  |  |  |
| --- | --- | --- |
| **Metric** | **Previous Model (Store-Level)** | **New Model (Store+Family-Level)** |
| Mean Absolute Error | 5,537 | 281 |
| Mean Squared Error | 64,125,200 | 503,209 |
| Median Absolute Error | 3,807 | 115 |
| R² Score | 0.35 | 0.68 |
| Explained Variance | 0.35 | 0.68 |

### **Key Takeaways:**

* **Substantial Error Reduction:** The mean absolute error dropped dramatically from over $5,500 to approximately $281. This indicates that predicting sales at the aggregated store level without differentiating product families results in very coarse, less accurate forecasts.
* **Improved Variance Explanation:** The R² score nearly doubled (from 0.35 to 0.68), demonstrating that incorporating product family as a categorical feature captures much more of the variability in sales data.
* **Better Median Error:** The median absolute error also fell significantly, suggesting that the new model’s predictions are more consistently accurate across typical daily observations.
* **Greater Granularity Enables More Actionable Insights:** Modeling at the product family level provides actionable insights for category-specific inventory management, promotions, and resource allocation — capabilities that were limited or impossible in the aggregated model.
* **Remaining Challenges:** Despite these gains, about 32% of the variation in sales remains unexplained. This points to opportunities for further enhancement by including additional data such as:
  + Seasonality and holidays
  + Local events or weather conditions
  + Lagged sales trends and time-series effects
  + Store-specific factors like foot traffic or competitor actions

### **Conclusion**

The comparison clearly shows that **including product family in the sales prediction model is critical to significantly improving forecast accuracy and usefulness.** This approach better supports operational planning and strategic decision-making in retail environments.