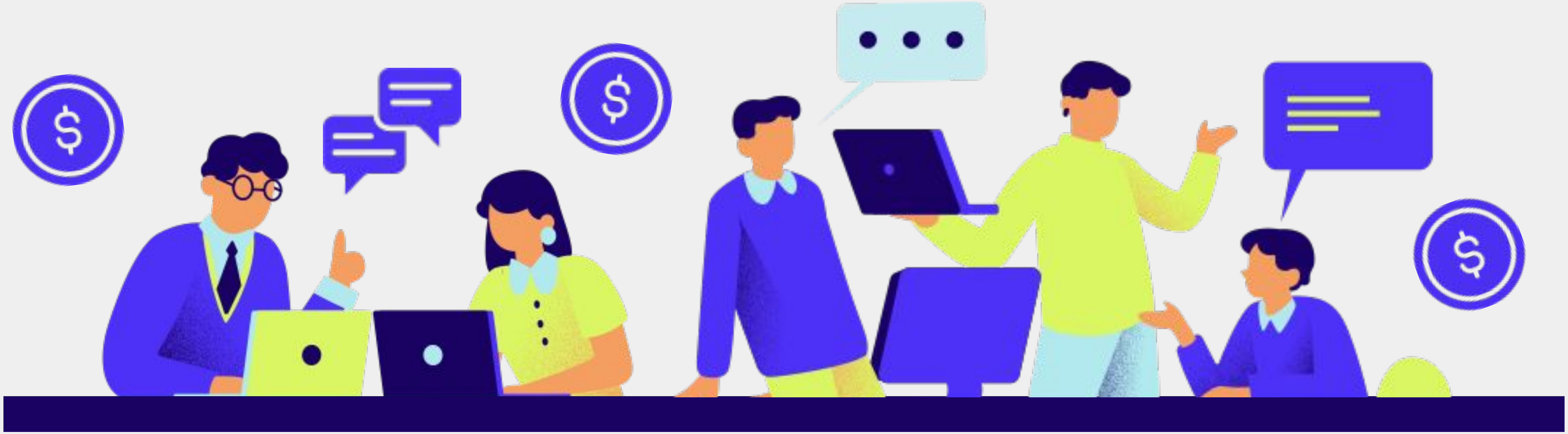
DSO 530 - 16275. Team 6: Linh Chu, Nhi Dang, Linh Pham, Cong Minh Tran

Introducing our

Call Option Valuation & Pricing



Agenda

1. Problem Statement
2. Exploratory Data Analysis
3. Feature Engineering
4. Value Prediction Model
5. BS Prediction Model
6. Considerations

Which one predicts better?

S
Current Asset Value

K
Strike Price of Option

r
Annual Interest Rate

tau
Time to Maturity

Machine Learning
vs.
Black-Scholes Formula

Value
Current Option Value

BS
Black-Scholes Formula Prediction

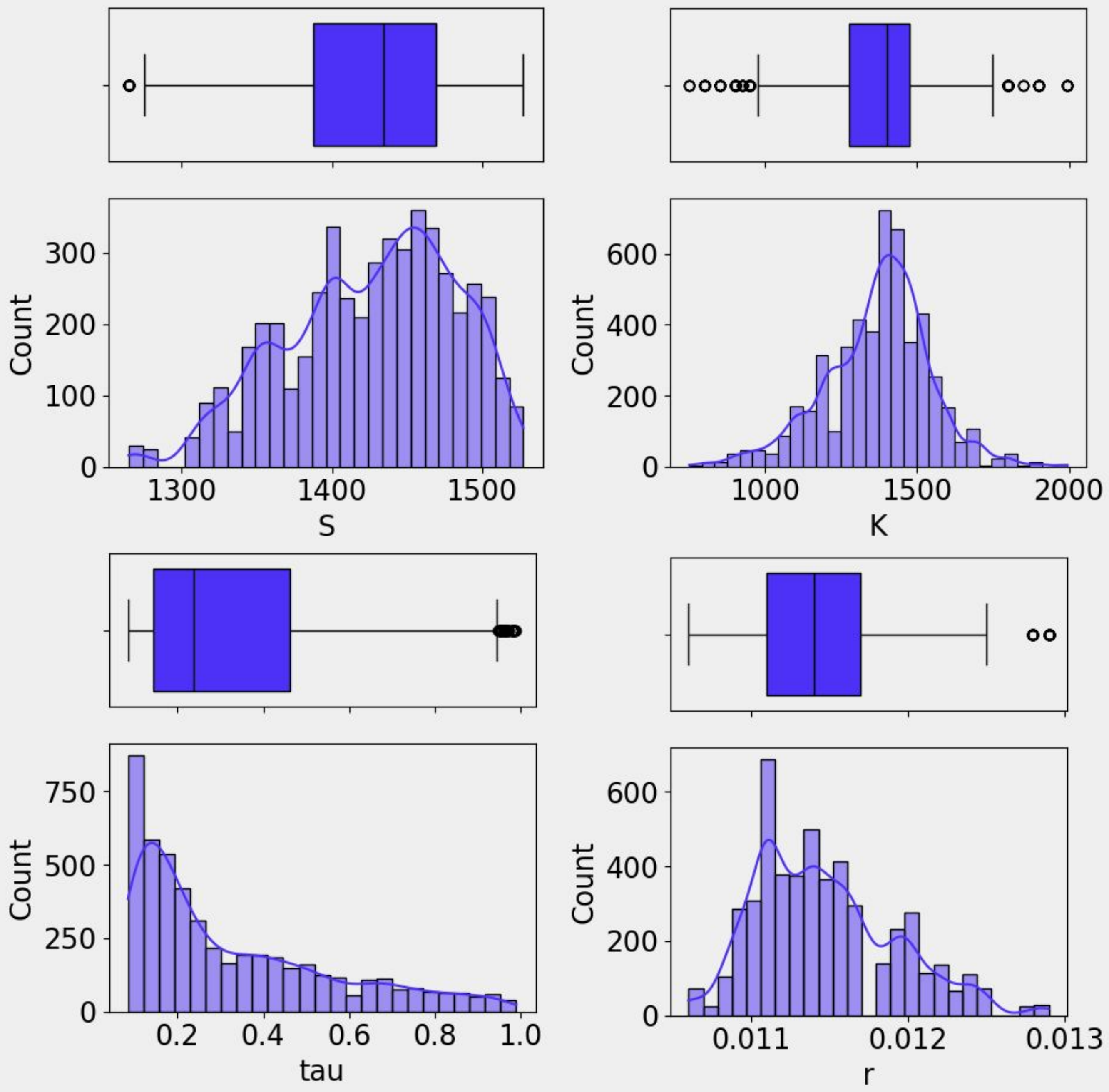
Exploratory Data Analysis

1. Descriptive Statistics

No missing value + no extreme outliers

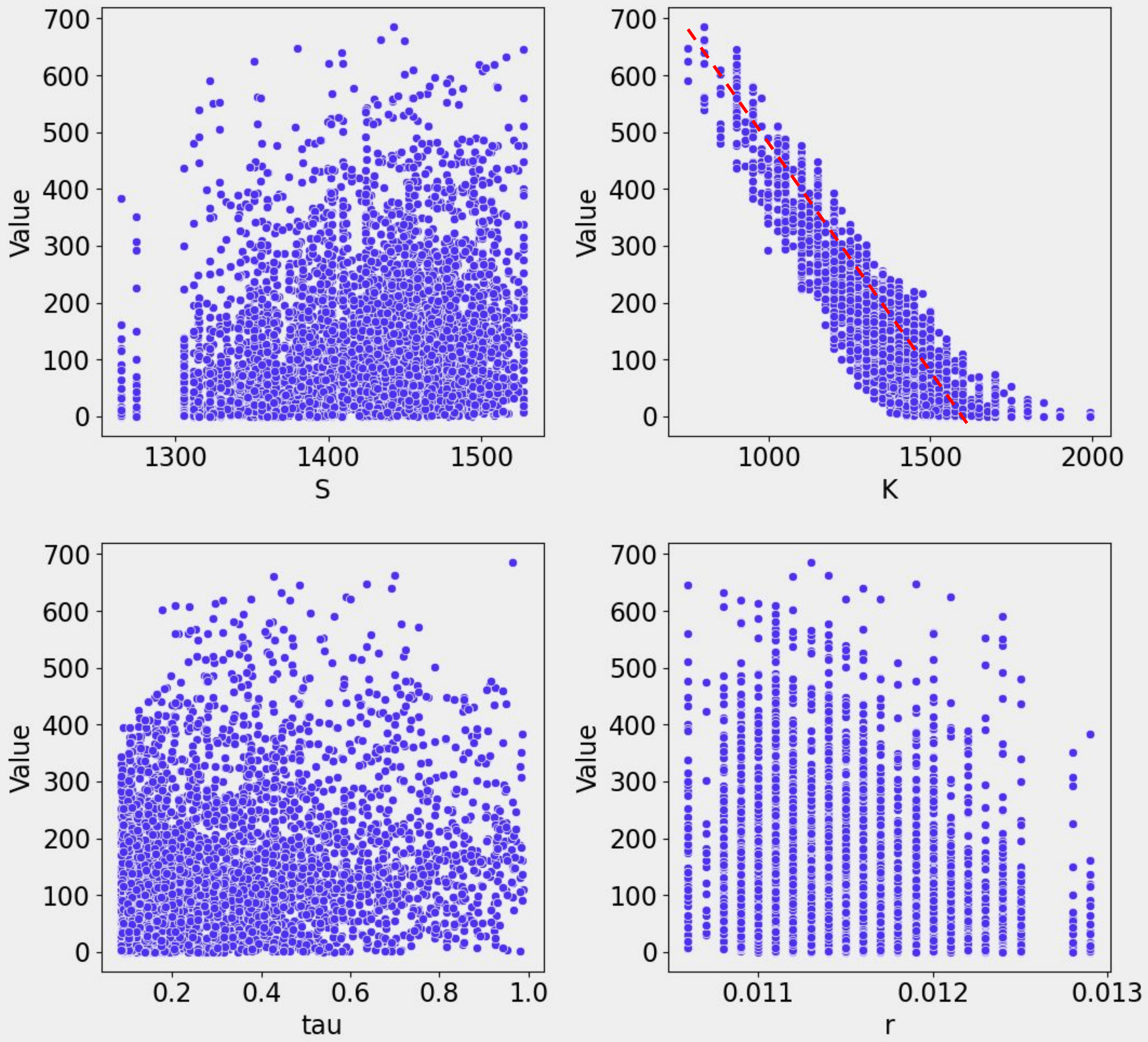
→ Keep all 5,000 rows

→ Standardize all features



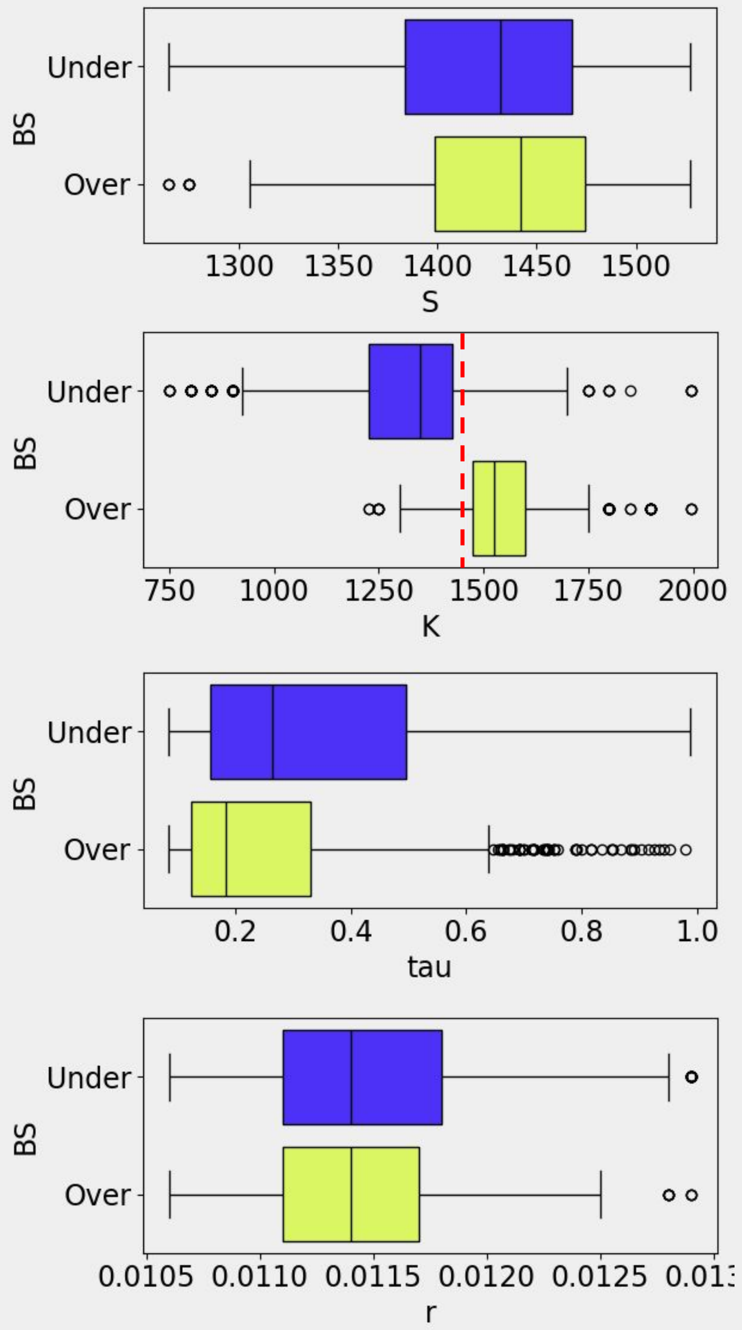
2. Correlation with 'Value'

- K seems negatively correlated
- No clear linear correlation with other features



3. 'BS' differences

K can separate the majority of 2 classes

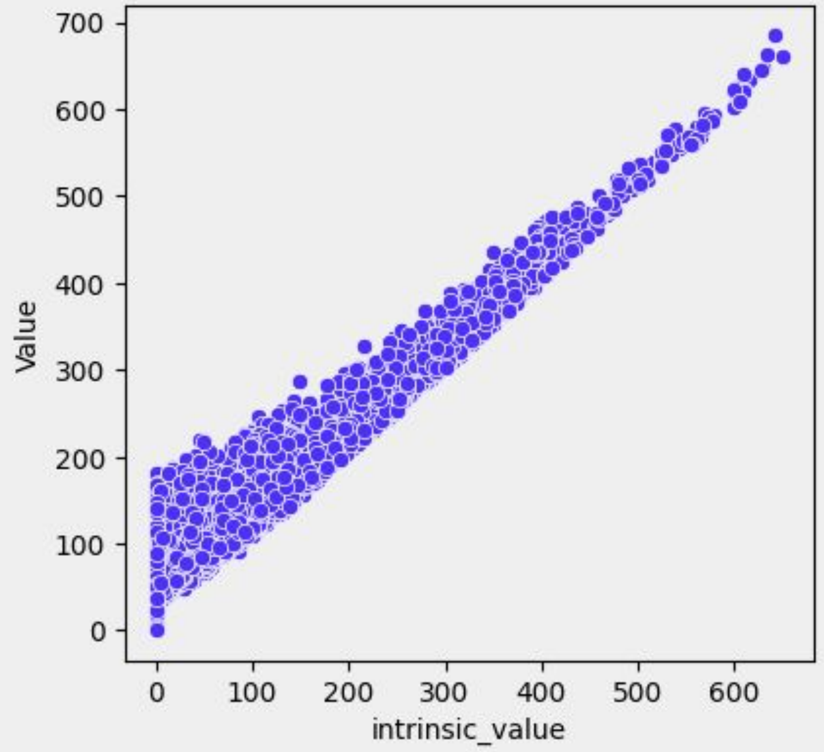


Feature Engineering

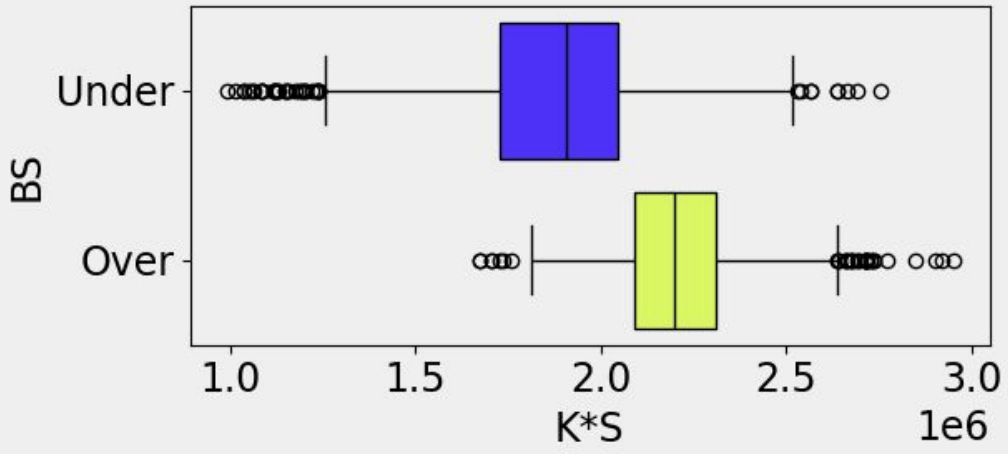
Creating new features based on options terminologies

Features	Definitions
S/K	Moneyness - Indicator for in-the-money (ITM), at-the-money (ATM), or out-of-the-money (OTM) options
max(S-K,0)	Capture intrinsic value, enhancing the interpretability of the model by incorporating a clear and intuitive measure of option value
abs(S-K)	A direct measure of the distance between the current asset price S and the strike price K - assess the potential impact of asset price fluctuations on option values
tau_days	Offer additional granularity and capture more nuanced temporal information
K*S	Monetary value of the underlying asset relative to the strike price

→ **max(S-K,0)** has **a strong linear relationship** with option value



→ **K*S** can **partially separate** BS value



Modeling Approach

Regression
(Criteria: R^2)

- Linear Regression
- Decision Tree
- Gradient Boosting
- XGBoost
- Random Forest

Classification
(Criteria: Classification Error)

- Logistic Regression
- K-NN
- Decision Tree
- Random Forest
- XGBoost
- SVM

Cross validation 10-folds + **Hyperparameter Tuning**

Model selection based on **best mean CV score**

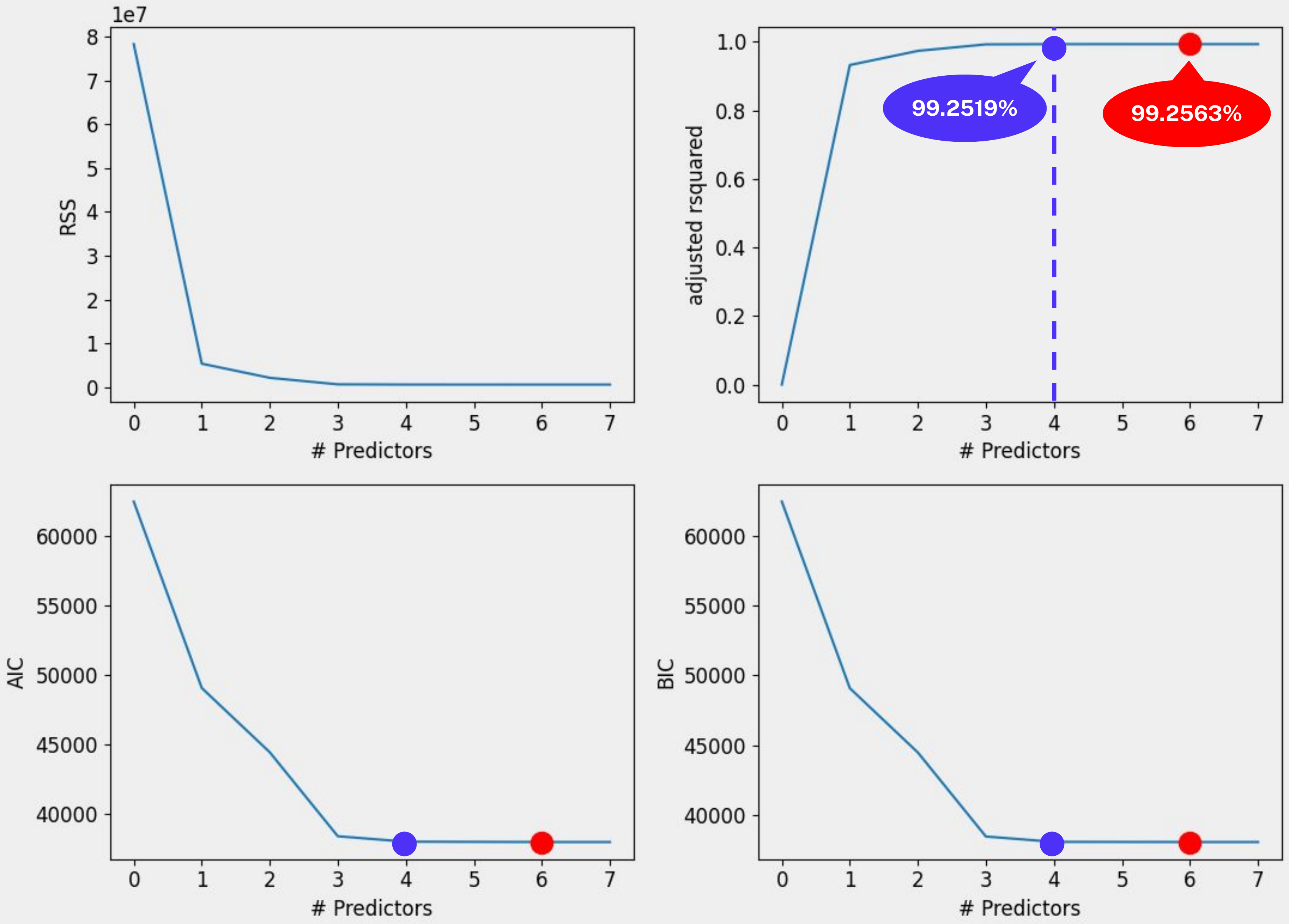
Regression

Model	Features	Mean CV R-squared
Linear Regression w/ Best Subset Selection	tau, S/K, |S-K|, intrinsic value	99.25

Linear Regression with Best Subset Selection

Adjusted R squared does not increase significantly for 5+ predictors

→ stop at 4 best predictors: **tau, S/K, |S-K|, intrinsic_value** for better model interpretability



	coef	std err	t	P>|t|	[0.025	0.975]
const	-130.5409	7.821	-16.691	0.000	-145.874	-115.208
tau	122.4174	0.678	180.551	0.000	121.088	123.747
S/K	160.3511	7.946	20.179	0.000	144.773	175.930
S-K_abs	-0.1724	0.005	-37.137	0.000	-0.182	-0.163
intrinsic_value	0.8795	0.012	72.230	0.000	0.856	0.903

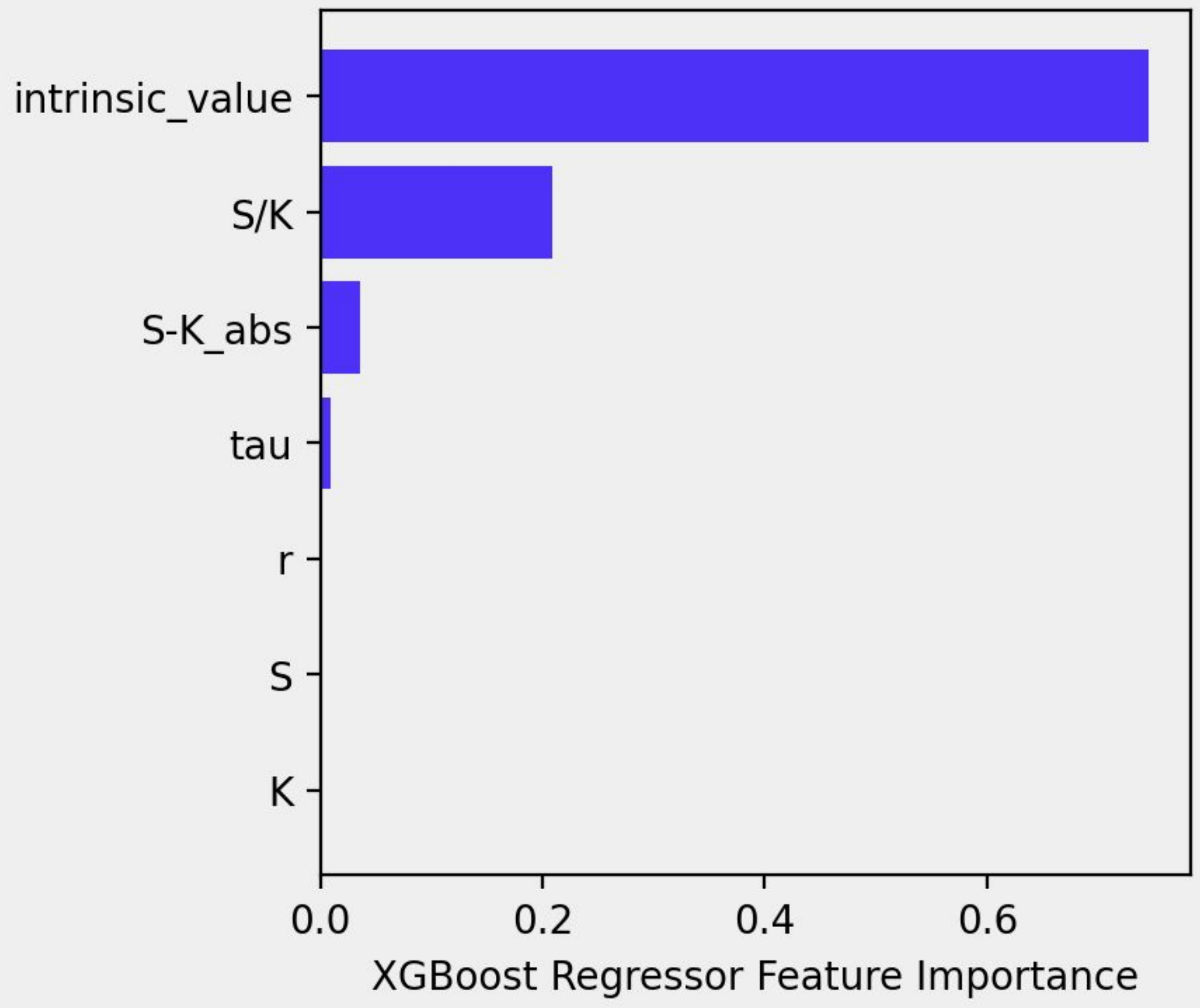
Regression

Model	Features	Mean CV R-squared
Linear Regression w/ Best Subset Selection	tau, S/K, |S-K|, intrinsic value	99.25
Decision Tree	S, K, tau, r, S/K, |S-K|, intrinsic value	99.58
Random Forest		99.77
Gradient Boosting		99.81
XGBoost		99.87

→ **XGBoost** is our final choice for the best **prediction accuracy**
→ **Linear Regression** can also be considered for **model interpretability**

XGBoost Regressor

- Out of tree-based models, XGBoost gave the highest R-squared
- 4 most important features in XGBoost match with 4 features selected in Linear Regression



Hyperparameter	Value
gamma	0.1
learning_rate	0.1
max_depth	7
n_estimators	300
subsample	0.8

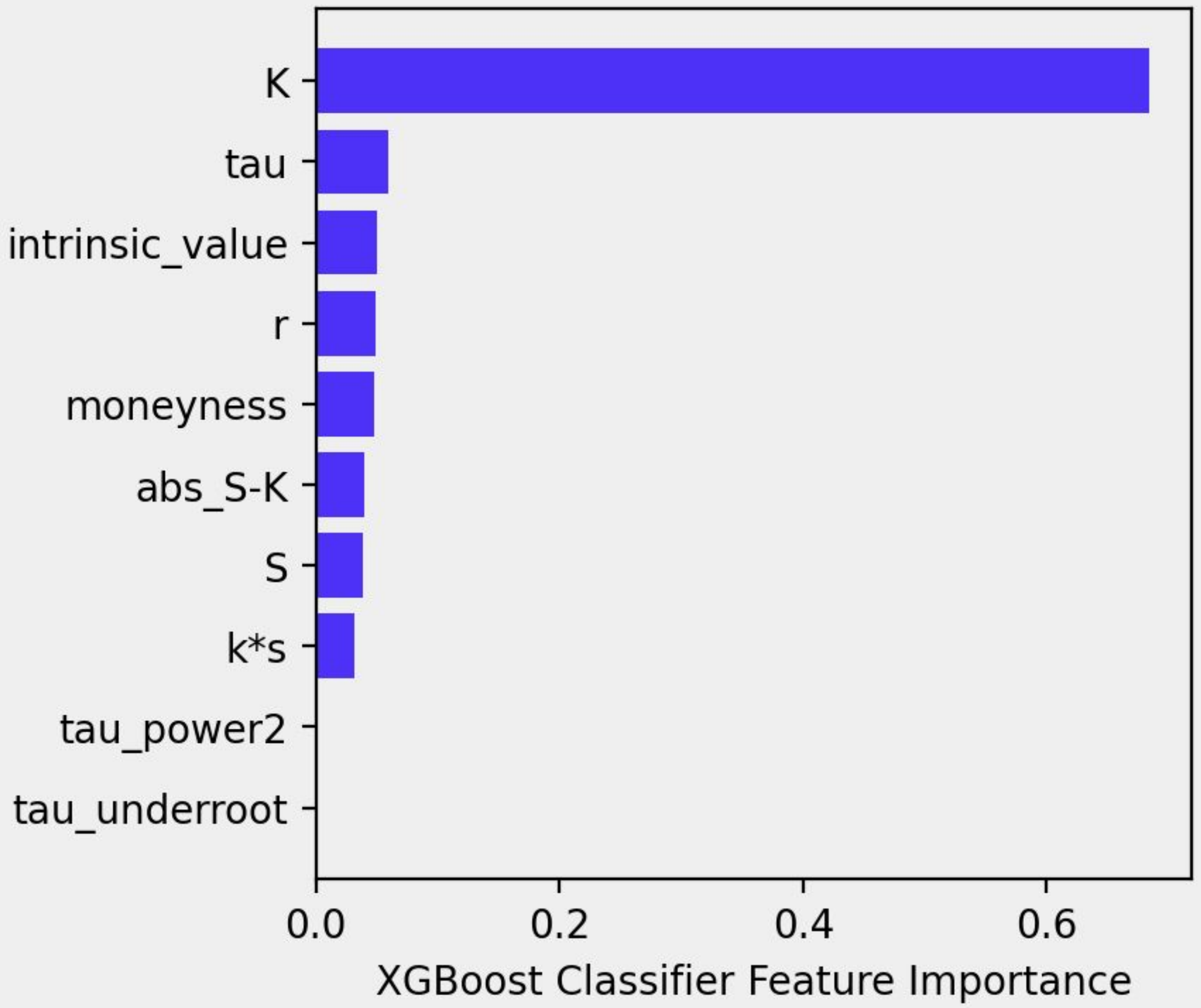
Classification

Model	Features	Mean CV Classification Error
Logistic Regression	K, tau, r, S/K, |S-K|, intrinsic value, tau^2	10.36
SVM	K, r, |S-K|, tau_underroot	9.16
KNN	S, K, r, S/K, intrinsic value, $\sqrt{tau}$, K*S	8.38
Decision Tree	S, K, tau, r, $\sqrt{tau}$, tau^2	9.28
Random Forest	all	6.46
XGBoost	all	5.58

→ **XGBoost** is our final choice for the best **prediction accuracy**

XGBoost Classifier

- K is the most important feature in XGBoost Classification



Hyperparameter	Value
colsample_bytree	1.0
gamma	0.1
learning_rate	0.1
max_depth	7
n_estimators	300
subsample	0.8

CONSIDERATIONS

Model complexity vs. prediction accuracy

- Hyperparameters & features lead to better performance
- Linear regression model has lower accuracy but higher interpretability

Inclusion of all four variables

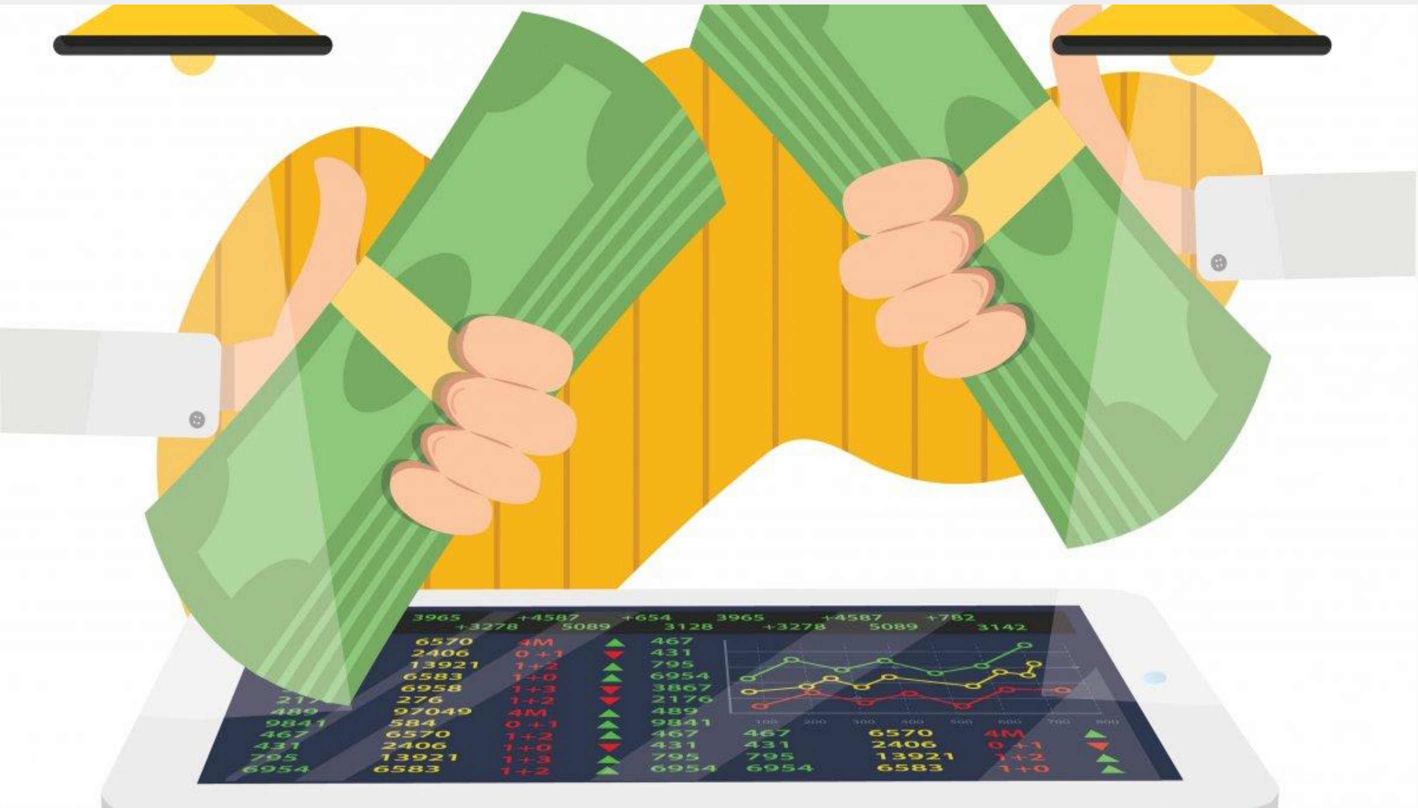
- Not all variables are equally important
- Redundant predictors increase model complexity

Application on Tesla stocks

- Can't directly be applied to Tesla stocks
- Application depends on diverse set of stocks/industries/time period & external factors

CONCLUSION

Best Model	Value Prediction (Regression) Mean CV R-squared	BS Prediction (Classification) Mean CV Classification Error
XGBoost	**99.87**	**5.58**



Thank you!

Problem Statement

Are there any Statistical/Machine Learning Models giving better prediction values on option pricing than the Black-Scholes Model?