

SHORT-TERM PRICE PREDICTION IN INITIAL PUBLIC OFFERINGS USING XGBOOST: BİST TECHNOLOGY SECTOR EXAMPLE*

XGBoost ile İlk Halka Arzlarda Kısa Vadeli Fiyat Tahmini: BİST Teknoloji Sektörü Örneđi

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Abstract

The aim of the study is to predict the closing price of the next trading day's stocks, of the initial public offering firms in the short term (between 5 and 10 days). For this purpose, firstly, the companies that went public in BIST in 2022, 2023, and 2024 are listed. Among these sectors, the decision was made to conduct the research in the technology sector, which experienced the highest number of initial public offerings in 2024. Using the model created with the XGBoost algorithm, price prediction for the Borsa Istanbul technology sector was made. The data to be used in the analyses consist of the daily closing stock prices of FORTE, which was the first IPO in 2023 and operates in the technology sector, from 15.06.2023 to 28.06.2024. It also includes the daily closing values of the BIST TECHNOLOGY and BIST IPO indices, and the first four-day closing stock prices of the technology sector companies (ODINE, PATEK, and ALTNY) that were the first IPOs in 2024. As a result of the coding steps performed using Python, it was found that the difference between the predicted prices and the actual prices gradually decreased from the fifth to the tenth day after the IPO.

Keywords:

Initial Public Offering,
Stock Price Prediction,
XGboost Algorithm

JEL Codes:

E27, E44, O16

Öz

Çalışmanın amacı, ilk halka arz edilen firmaların hisse senetlerinin kısa vadeli olarak (5 ile 10 gün arasındaki) bir sonraki işlem gününün kapanış fiyatının tahmin edilmesidir. Bu amaçla öncelikle 2022, 2023 ve 2024 yıllarında BİST'te halka arz edilen şirketler listelenmiştir. Bu sektörler arasında 2024 yılında en fazla ilk halka arzın gerçekleştiđi teknoloji sektöründe araştırmanın yapılması tercih edilmiştir. Bu sebeple Borsa İstanbul teknoloji sektörü özelinde, XGBoost algoritmasıyla oluşturulan model yardımıyla fiyat tahmini yapılmıştır. Analizlerde kullanılacak veriler, 2023 yılında ilk halka arz olan ve teknoloji sektöründe faaliyet gösteren FORTE firmasının 15.06.2023 ile 28.06.2024 tarihleri arasındaki günlük hisse senedi kapanış fiyatlarından, BİST TEKNOLOJİ ve BİST HALKA ARZ endekslerinin günlük kapanış değerlerinden ve 2024 yılında ilk halka arz olan teknoloji sektörü firmalarının (ODINE, PATEK ve ALTNY) ilk dört günlük hisse senedi kapanış fiyatlarından oluşmaktadır. Python programlama dili kullanılarak gerçekleştirilen kodlama adımlarının sonucunda, halka arzdan sonraki beşinci günden onuncu güne kadar hesaplanan tahmini fiyatlar ile gerçek fiyatlar arasındaki farkın giderek azaldığı belirlenmiştir.

Anahtar Kelimeler:

İlk Halka Arz,
Hisse Senedi Fiyat
Tahmini,
XGBoost Algoritması

JEL Kodları:

E27, E44, O16

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1. Introduction

Going public is one of the most important financial decisions made in the history of the firm. There may be many reasons that lead firms to this initial public offering. Firms sometimes decide to go public in order to finance their growth, to increase their credibility with financial institutions to increase their recognition to compete with firms that are financially stronger than themselves. The initial public offering process is made possible by the fulfillment of certain prerequisites. For firms that fulfill these conditions, there are many advantages, disadvantages, and some obligations that come with becoming a publicly traded company.

There are many studies on initial public offerings (IPOs), one of the most interesting topics in finance literature related to the stock market. The first study on the subject in the Scopus database is by Dawson (1987). Dawson (1987) analyzed the performance of IPOs in the secondary market for the years 1978-1984 in Hong Kong, Singapore, and Malaysia. Subsequent studies on the subject are generally related to post-IPO performance, abnormal returns, underpricing, and anomalies. The studies of Jindal et al. (2024), Bakırhan and Sayılğan (2023), Gupta et al. (2023), Haque et al. (2023), Mangala and Dhanda (2022), Jamaani and Abdullahi (2021), Yıldırım and Dursun (2016), Kıymaz (1997) are related to the performance of stocks after IPOs. In addition, the studies of Cai and Lee (2013), Tong and Ahmad (2015), Usanmaz and Söylemez (2021) deal with abnormal returns, while the studies of Yıldırım and Dursun (2016), Yılmaz and Abdioğlu (2023) deal anomalies.

In recent years, in the post-Covid-19 period, participation in IPOs has gradually increased, indicating a rising trend on the investor front. According to the reports published by the Central Registry Agency (CRA), the total number of investors participating in IPOs was recorded as approximately 9 million (8,713,686) in 2022. This number increased 13.5-fold, reaching approximately 124 million (123,881,239) in 2023. In 2024, the total number of investors participating in IPOs was 23,382,697 at the end of the first quarter and 52,609,000 at the end of the second quarter, and is predicted to be around 150 million by the end of the year.

Although the number of long-term investors in IPOs is very low, there are a large number of investors who want to make high gains in the short term, recently. Scientific studies also indicate that IPOs exhibit high performance in the short term due to low pricing (Savaşkan, 2005; Bakırhan and Sayılğan, 2023; Haque et al., 2023). Therefore, the most important issue investors who want to make high gains in the short term should know is the short-term price course of IPOs. It is extremely important for investors participating in IPOs to know on which day they can make the highest profit by disposing of their stocks, thanks to accurate price forecasts to be made in the short term. There are many studies in the literature that generally examine the short term in five, ten, and fifteen-day periods (Chi and Padgett, 2005; Orhan, 2006; Tunçay, 2019; Yetim and Koy, 2022)

This study aims to predict the closing stock prices of IPOs on the next trading day in the short term. For this purpose, the companies that went public in 2022, 2023, and 2024 were listed, and the sectors in which these companies operate were determined (Table 2). The technology sector, which is one of the sectors with the highest number of IPOs in these three years, was chosen as the focus of this research. For price prediction, a model was created using the XGBoost algorithm, a popular machine learning algorithm. The BIST IPO index, BIST Technology index, and the data of a technology firm that went public in 2023 were used as model variables to predict the market prices of three firms with IPOs in the technology sector on their fifth trading day in

2024. The reason for the fifth day price estimation within the scope of the study is both because the five-day period is mostly preferred as a short-term period in the literature, and the finding of Yetim and Koy (2022) that the index volatility is affected in the five and ten-day periods after the IPO date.

2. Methodology

2.1. Method

The aim of the study is to predict in the short run the closing stock prices of the firms that are offered to the public for the first time on the next trading day. For this purpose, the XGBoost (Extreme Gradient Boosting) algorithm is used to create a model. The XGBoost algorithm, which is effectively used in classification and regression problems, was developed in the paper "XGBoost: A Scalable Tree Boosting System" by Chen and Guestrin (2016). XGBoost is an ensemble learning algorithm based on decision trees and uses the Boosting technique, where weak learners come together to form a strong predictor. In this study, a data set of approximately one year is used. In the literature, studies by authors such as İmece (2019) and Ülker (2023) also used the XGBoost algorithm in short-term forecasts and stated that the model is appropriate.

Ensemble learning refers to a process where decision trees from multiple machine learning models are combined to reduce errors and improve prediction, compared to a single machine learning model (Malik et al., 2020: 7). In the XGBoost algorithm, normalization is used in the objective function to reduce model complexity, prevent overfitting, and make the learning process faster (Jabeur et al., 2024: 688). Since normalization usually helps the model to generalize better, a normal distribution of the training data or compression to a certain range, can make the model more consistent and accurate on the test data. Therefore, it is a widely preferred method in machine learning and optimization problems.

In XGBoost, various parameters need to be adjusted to optimize model performance and avoid overloading issues. This process, called hyperparameterization, can significantly improve the performance of the model when done correctly. Therefore, hyperparameter tuning is an essential step in the design of machine learning models. Various techniques are used to find the optimal parameter combination (Jabeur et al., 2024: 688). For hyperparameter tuning methods, there are approaches such as manual search, grid search, random search, Bayesian optimization, genetic algorithms, and particle swarm optimization (Emeç and Özcanhan, 2023: 81). In this study, grid search with 5-fold cross validation for time series was used for hyperparameter adjustment. Since the classical cross-validation method cannot be used, due to the sequential nature of time series, the TimeSeriesSplit function in the scikit-learn model_selection library, which is designed to split time series data sequentially, was run in GridSearchCV as a cross-validation method. The list of hyper-parameters to be adjusted, the search ranges and the optimal values obtained from the grid search are presented in Table 1.

Table 1. XGBoost Hyper Parameters for which Appropriate Values are Searched by the Grid Method

Hyper Parameter Name	Search Set	Appropriate Value
Maximum Tree Depth (max_depth)	[3,4,5,6, 7,8,9]	5
Learning Coefficient (learning_rate)	[0.05, 0.01, 0.5, 0.1, 0.2]	0.05
Number of Trees (n_estimators)	[50, 100,150, 200,250,300,350]	150

Grid search is the scanning of the search space by systematically trying all possible parameter value combinations to determine the best combination within a given hyperparameter search set. For this study, 7x7x5 different combinations were run with 5-fold cross-validation, and the maximum tree depth was set to 5, the learning coefficient was set to 0.05, and the number of trees, i.e., estimators, was set to 150 as the optimal values.

2.2. Data Set

For the purpose of the study the companies that went public on BIST in 2022, 2023, and 2024 are listed. As seen in Table 2, the sectors with the highest number of IPOs are technology, electricity, gas and water, metal goods, machinery, electrical appliances, transportation vehicles, and the basic metal industry in these years. Among these sectors, it was preferred to conduct the research in the technology sector, where the highest number of IPOs was realized in 2024. For this reason, the sample of the study consists of companies in the technology sector, whose IPOs were realized in 2024.

Table 2. Sectoral Information on IPOs by Year

Sectors	2022	2023	2024
Technology	4	2	3
Chemical, Pharmaceutical, Petroleum, Rubber and Plastic Products	4	3	-
Financial Institutions	7	13	-
Electricity, Gas and Water	5	6	2
Administrative and Support Service Activities	3	1	-
Agriculture Forestry and Fisheries	1	1	-
Metal Goods Machinery Electrical Equipment and Transportation Vehicles	4	6	2
Textiles, Clothing and Leather	3	-	1
Basic Metal Industry	4	2	3
Wholesale and Retail Trade	1	2	1
Transportation and Warehousing	1	1	2
Forest Products and Furniture	1	-	-
Construction and Public Works	1	-	-
Paper and Paper Products Printing	1	1	1
Food, Beverages and Tobacco	1	7	4
Stone and Soil Based	-	3	1
Real Estate Activities	-	-	1
Hotels and Restaurants	-	3	-
Education Health Sports and Entertainment Services	-	2	-
Mining and Quarrying	-	1	-
Total	41	54	21

Table 3 provides information on the firms in the technology sector that will have IPOs in 2024 and were selected as the sample.

Table 3. Information on the Firms Composing the Sample of the Study

Company Name	BIST Code	Initial Public Offering Date
Odine Solutions Teknoloji Tic. ve San. A.Ş.	ODINE	March 13-15, 2024
Pasifik Donanım ve Yazılım Bilgi Teknolojileri A.Ş.	PATEK	February 6-7, 2024
Altınay Savunma Teknolojileri A.Ş.	ALTNY	May 8-10, 2024

The data to be used in the analysis consists of the daily closing stock prices of FORTE (Forte Bilgi İletişim Teknolojileri ve Savunma Sanayi A.Ş.), which was the first public offering in 2023 and operates in the technology sector, between 15.06.2023 and 28.06.2024, the daily closing values of the BIST TECHNOLOGY and BIST PUBLIC OFFERING indices, and the first four-day closing stock prices of ODINE, PATEK and ALTNY, which were the first public offerings in 2024.

2.3. Analysis

In this study, which aims to predict the stock closing prices of the initial public offering firms in the next trading day in the short term, the XGBoost algorithm is preferred. Price prediction with XGBoost is coded using Python. The main libraries used in the study are Pandas, NumPy, XGBoost, and SciKit-Learn. The steps applied are as follows:

1. Data collection and preparation of the Training Dataset: The data were obtained from the Yahoo Finance (2024) and organized with the Pandas library. In the organization phase, the daily closing prices and dates to be used in the dataset were extracted as time series. The training set to train the XGBoost algorithm was created using the extracted data. For this purpose, the dataset was constructed using the daily stock closing prices of FORTE, a newly public company in the technology sector, between 15.06.2023 and 28.06.2024, along with the daily values of the BIST TECHNOLOGY and BIST PUBLIC OFFERING indices. This data formed the basis of the training set, where each record comprises the stock prices of the last four days as input and the stock price of the fifth day as output. The training set includes a total of approximately 265 daily records, spanning more than a year, which provides a sufficient volume of data to train a machine learning model such as XGBoost, known for its ability to learn from structured tabular data and relatively small datasets (Chen and Guestrin, 2016).

This study employs the sliding window approach to model the temporal dynamics of stock closing prices for companies following their IPOs. Given the inherently sequential and frequently volatile nature of stock price movements, particularly in the early post-IPO period, it is crucial to effectively capture short-term patterns and fluctuations. By using the closing prices from the first four trading days as input to predict the closing price on the fifth day, the sliding window method transforms raw time series data into a supervised learning framework. This transformation enables machine learning models to learn from recent temporal dependencies, thereby enhancing short-term forecasting performance. This approach is supported by existing literature which models time series forecasting as a sequence-to-one problem using sliding windows (Zhang et al., 1998; Brownlee, 2018; Hyndman et al., 2021).

An example of a nine-day record from the training dataset is presented in Table 4.

Table 4. Sample Records from Training Dataset

Date	BISTTEK	BISTHALK	INPUTS				OUTPUT
			t-3 (1st day)	t-2 (2nd day)	t-1 (3rd day)	t (4th day)	t+1 (5th day)
15.06.2023	47164,17	5354,74	14,66	16,12	17,73	19,5	21,44
16.06.2023	47443,39	5379,82	16,12	17,73	19,5	21,44	23,58
19.06.2023	46016,08	5175,5	17,73	19,5	21,44	23,58	25,92
20.06.2023	45158,12	5125,71	19,5	21,44	23,58	25,92	27,4
21.06.2023	44948,77	5106,98	21,44	23,58	25,92	27,4	28,2
22.06.2023	45988,89	5286,53	23,58	25,92	27,4	28,2	31,02
23.06.2023	47113,89	5422,69	25,92	27,4	28,2	31,02	34,12
26.06.2023	48417,39	5595,77	27,4	28,2	31,02	34,12	37,52
27.06.2023	49462,69	5598,89	28,2	31,02	34,12	37,52	41,26

2. *Data preprocessing:* The data in the training set were normalized using the MinMaxScaler class from the Preprocessing module of the SciKit-Learn library. The formula used in the calculation is given in equation 1.

$$X_{scaled} = \frac{X - X_{min}}{X_{max} - X_{min}} \quad (1)$$

3. *Preparing the Test Dataset:* In 2024, the closing prices of ODINE, PATEK and ALTNY, and the daily closing values of BIST TECHNOLOGY and BIST IPO indices from the day of IPO until July 2024 are used as test data. A separate test set is prepared for each firm. This testing approach simulates a real-world forecasting scenario in which a trained model is applied to previously unseen stocks to assess its generalization ability. The data for these companies were not included in the training process, ensuring a strict separation between training and testing phases.

In addition, this approach is aligned with similar studies such as Fischer and Krauss (2018) and Kim and Won (2018), which utilize sequential stock price data with windowed inputs to predict future values using machine learning models.

4. *Training and evaluation of the model:* The model was trained using the optimal combination of hyperparameters given in Table 1. The R^2 value of the trained model was 0.9324, and the MSE value was 6.0388.

5. *Model estimation and analysis:* The trained model is tested using the stock closing price data of 3 different firms with IPOs in 2024. Forecasts are obtained from the test data and compared with the realized end-of-day closing prices. The performance of the model for the test set is reported, and the related graphs are presented in Table 5 in the findings section.

3. Findings

As a result of the steps in the analysis phase, the mean squared error (MSE), mean absolute error (MAE), root mean square error (RMSE), values were calculated to measure the performance of the trained XGBoost machine learning model and were presented in Table 5. MSE value is calculated in equation 2, MAE value in equation 3, RMSE value in equation 4, and R^2 value in equation 5. In these equations, N = number of registrations, y_i = actual closing price of the

stock, $\hat{y}_i$ = stock closing price predicted by the XGBoost model, $\bar{y}$ = average of actual closing prices of the stock.

$$MSE = \frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2 \quad (2)$$

$$MAE = \frac{\sum_{i=1}^N |y_i - \hat{y}_i|}{N} \quad (3)$$

$$RMSE = \sqrt{MSE} \quad (4)$$

$$R^2 = 1 - \frac{\sum_{i=1}^N (y_i - \hat{y}_i)^2}{\sum_{i=1}^N (y_i - \bar{y})^2} \quad (5)$$

Table 5. Error Metrics of the XGBoost Model

Company Name	Error Metrics			
	MSE	MAE	RMSE	R ²
ODINE	6,2659	1,2288	2,5031	0,9565
PATEK	87,29436	6,026003	9,343145	0,9226
ALTNY	6,7358	0,9918	0,9919	0,9667

When the error metric values of the models established with the XGBoost algorithm are examined, it is evident that the company with the least difference between the predicted and actual values is ALTNY. However, the difference between the predicted value and the actual value was ± 2.5 for ODINE and ± 9.3 for PATEK. When R² values are analyzed, it is determined that the data fit the model with high coefficients of determination of 95.65%, 92.26%, and 96.67%. To identify periods in which the differences between the actual values and the predicted values deviate and to interpret which factors are responsible for these deviations, the graphical representation of these values is shown below for each firm.

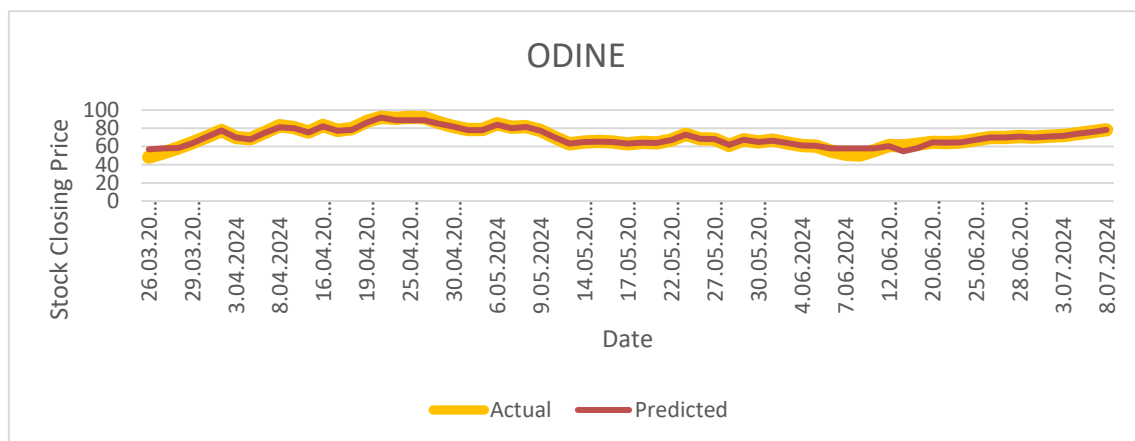


Figure 1. ODINE Stock Closing Price Prediction Graph with XGBoost Algorithm

Figure 1 shows the stock closing price prediction graph for ODINE. In Figure 1, the yellow line shows the actual daily closing prices of the firm, while the orange line shows the daily closing

prices predicted by the XGBoost algorithm. As seen in Figure 1, it is noteworthy that there is a deviation between the actual and predicted closing prices of the firm on March 26, 2024, and June 4-11, 2024. Before evaluating the reasons for these deviations, it would be useful to know some information about the firm and its initial public offering. This information has been compiled from the company's prospectus and the halkarz.com website and is listed below:

- The public offering price of the company, whose IPO dates are March 13-14-15, is 30 TL,
- Form of public offering is capital increase and joint sale,
- Public offering method is to collect demand with fixed price and equal distribution
- The brokerage method is best-effort brokerage,
- The number of shares offered to the public is TL 44,200,000,
- Consortium leaders TSKB / Yatırım Finansman Menkul Değerler A.Ş.,
- Free float is 40%,
- The funds raised through the IPO will be used 52.5%-62.5% for overseas investments, 30%-40% for working capital, and 5%-10% for financing new products and solutions,
- The date of commencement of operations of the company is reported as 30.12.1999.

There are numerous factors affecting the market price in IPOs, and these factors have been evaluated in various studies. The reason for evaluating these factors is to determine investors' confidence in the firm and their appetite for investment. Asset size, company age, total IPO amount, market return, IPOs ratio, and IPOs method are among the antecedent factors affecting the price in initial IPOs (Savaşkan, 2005: 15). Firms' high age and sectoral experience are seen as a reassuring factor for investors. Ritter (1991), Rosenboom (2012), Elma (2017) found a strong negative relationship between firm age and underpricing.

When ODINE is evaluated within the framework of these factors, it reveals that the age of the company is almost 25 years. Investors who see that the firm has been operating in the sector for a long time may expect that it will not be underpriced in the initial public offering, since they will face less uncertainty. According to Beatty and Ritter (1986), Rock (1986), Dongwei and Fleisher (1999), underpricing is often associated with future uncertainty. More than half of the funds provided by the firm as a result of the IPO will be used for investments, while 30-40% will be allocated to working capital. Investors mostly prefer that firms use the funds obtained from IPOs in new investments. An adverse situation may give negative signals to investors. Kirkulak and Davis (2005) argue that the pricing level in IPOs is largely determined by investor demand. In ODINE, although the ratio of funds to be used for new investments is relatively high, the amount to be kept as working capital is also substantial. This may have created a negative signaling effect for investors. Another noteworthy aspect of the firm's data is its 40% public float rate. It is still a high percentage, even if it is less than half, which may cause investors to feel a sense of ownership and belonging almost as much as the main shareholders. Therefore, this situation which reduces uncertainty may be perceived as a sign that the firm will not be underpriced. As a result, the possible reasons for the deviation between the predicted and realized stock prices in the first days of the firm's IPO can be interpreted.

When the possible reasons for the deviations between the actual and predicted prices between March 26 and June 4-11 are evaluated on a firm-by-firm basis and on the basis of financial developments in the country/world in Figure 1, the following situations stand out:

On March 21, 2024, ODINE's first trading day on BIST, ODINE disclosed its "Company General Information Form" to the Public Disclosure Platform (KAP, 2024) on March 26. In addition, as stated by Tacirler (2024), the price stabilization period for ODINE is 15 days after the shares start trading on BIST (<https://www.kap.org.tr/tr/sirket-bildirimleri/5941-odine-solutions-teknoloji-ticaret-ve-sanayi-a-s>; <https://www.kap.org.tr/tr/Bildirim/1296193>; <https://tacirler.com.tr/odine-solutions-teknoloji-ticaret-ve-san-as-odine>).

On May 29, June 7, June 10, and June 12, the company notified PDP that the circuit breaker application started during the transaction (<https://www.kap.org.tr/tr/sirket-bilgileri/ozet/5941-odine-solutions-teknoloji-ticaret-ve-sanayi-a-s>).

Although not specific to ODINE, the CRA announced that it has set June 11, 2024, as the date for the publication of the 2024 interim and annual financial reports of companies traded on the Istanbul Stock Exchange on the PDP, in line with the Capital Markets Board (CMB) announcements (<https://www.kap.org.tr/tr/sirket-bilgileri/ozet/5941-odine-solutions-teknoloji-ticaret-ve-sanayi-a-s>).

At its meeting held on May 23, CBRT kept the policy rate unchanged in line with expectations. On May 17, public austerity measures were announced. In May, MSCI world and emerging markets indices posted increases. The downturn in the US stock markets reversed on the back of the continued positive performance of technology companies, and the indices hit historic highs at the close of the month. The inflation rate increased in May, reaching its highest annual inflation level since November 7, 2022. In line with the accelerated portfolio investments in Turkey in May, domestic markets also followed a positive course and BIST-100 closed May with a 3.5% premium. Moreover, the 5-year CDS risk premium ended May at its lowest level since January 10, 2020 (Isbank, 2024).

All the developments listed above may have given some negative or positive signals to investors. As can be seen in Figure 1, there is a downward trend in the actual closing prices for a week following June 4. Therefore, it is thought that a large number of investors may have made buy-sell decisions affected by developments during the few days before June 4, leading to a sudden change in prices. On the other dates, there is a close similarity between the actual prices and the prices predicted by the XGBoost algorithm. In fact, the error metric values in Table 5 are also low for ODINE. This means that the model has lower forecasting errors. Figure 2, which shows the regression model and R^2 values established with the XGBoost algorithm for ODINE, is another indicator confirming this situation.

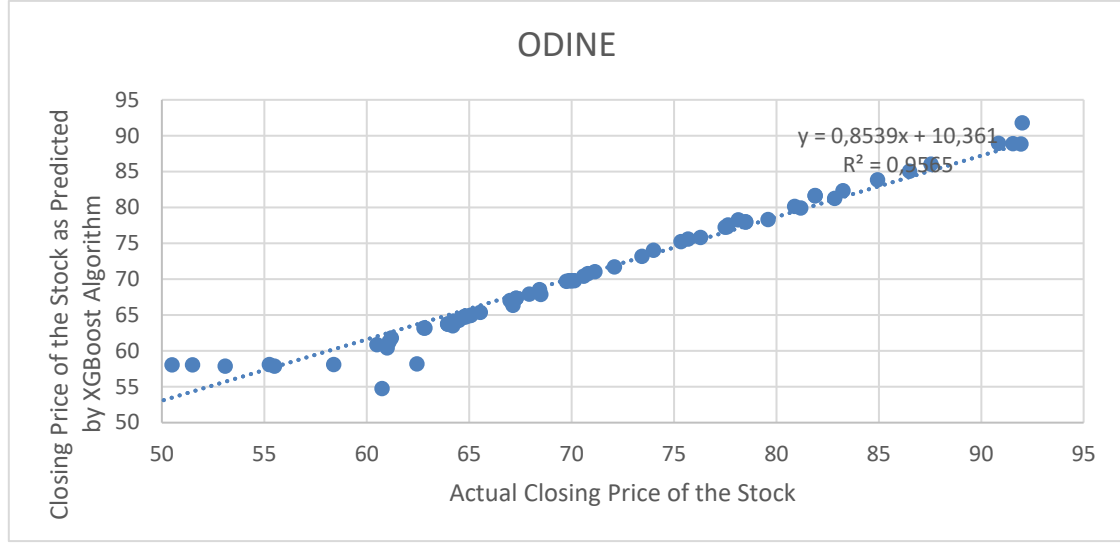


Figure 2. ODINE Stock Closing Price Prediction Model with XGBoost Algorithm

According to Figure 2, the R^2 value of the XGBoost algorithm for the stock price prediction of ODINE is 0.9565. Therefore, the regression prediction model fits the algorithm well.

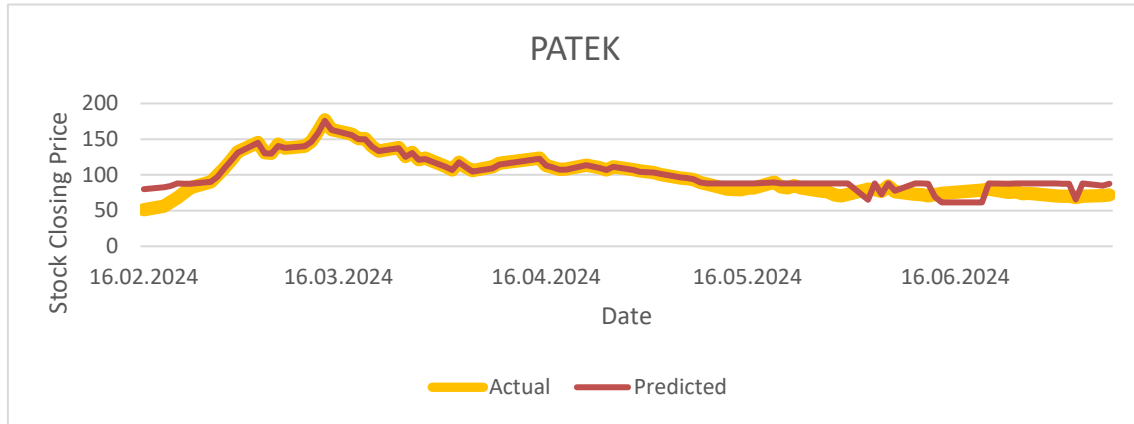


Figure 3. PATEK Stock Closing Price Prediction Graph with XGBoost Algorithm

Figure 3 shows the stock closing price prediction graph of PATEK. The yellow line in the figure represents the actual daily closing prices, and the orange line represents the daily closing prices predicted by the XGBoost algorithm. As shown in Figure 3, there are deviations between the actual and forecast prices of the firm in some periods between February 16-23, 2024, and May 31-July 5, 2024. Before evaluating the possible reasons for the deviations that occurred on the specified dates, some information that should be known about the company is summarized as follows, compiled from the company's prospectus and halkarz.com website:

- The company's IPO dates are February 6-7, 2024,
- IPO price is 35 TL,
- Form of public offering is capital increase and joint sale,
- The IPO method is to collect demand at a fixed price and distribute it equally,

- The brokerage method is best-effort brokerage,
- The number of shares offered to the public is TL 27,000,000,
- Consortium leader Halk Yatırım Menkul Değerler A.Ş.,
- Free float is 20.15%,
- The funds raised through the IPO will be used 45% for capital expenditures, 35% for R&D new product investments and 20% for working capital
- Date of establishment is 10.06.2015.

When evaluating PATEK in terms of the factors affecting the initial public offering price, it is noteworthy that the firm has a nine-year history. Since this situation indicates that the company has a relatively new period of activity, it may be perceived as uncertainty for investors. Therefore, there may be an expectation that the company will be assigned a lower valuation. On the other hand, the fact that only 20% of the funds raised through the public offering will remain as working capital may give a positive signal to investors (Savaşkan, 2005: 15). Therefore, this signal reduces the likelihood that the firm will be perceived by investors as obliged to go public because it cannot be self-sufficient. A firm with a relatively low IPO rate of 20.15% may send a negative signal to investors, suggesting that they may not see themselves as potential shareholders in the company. As stated in Keasey and Short (1992) and Chen et al. (2000), this is a factor that increases the expectation that the firm will be underpriced as a result of high management ownership.

In addition to these comments, when the dates on which the deviations between the actual closing prices and the closing prices predicted by the XGBoost algorithm occurred are evaluated on a company basis and on the basis of financial developments in the country/world, the following points come to the fore:

On February 21, 2024 the company notified PDP that the company's shares would not be subject to credit transactions from the beginning of the session on February 22, 2024 until the end of the session on March 21, 2024 in accordance with the Volatility Based Measure System (VBMS). The company also announced the appointment of a general manager and the purchase of financial assets on the same dates.

On May 30, 2024, it was reported to PDP that TİTRA Teknoloji A.Ş., a subsidiary of the company, increased its capital through a rights issue, Group B shares were transferred to the Venture Capital Investment Fund and the subsidiary rented a factory building and moved on May 31, 2024.

On June 7, June 10, and June 24, 2024 the company reported to PDP that circuit breaker application started during the transaction. In addition, it was reported on June 25 that the articles of association of the company were updated and on June 27 that no dividend distribution would be made and that the date of the general assembly meeting was announced (<https://www.kap.org.tr/tr/sirket-bilgileri/ozet/8acae2c58b2fa64e018d63b9afbd4e6c>; <https://www.kap.org.tr/tr/Bildirim/1297142>).

On July 5, PDP was notified that the continuous trading of the company's shares was suspended, single price order collection was started, and an explanation regarding related party transactions was disclosed to PDP.

Tacirler Yatırım stated that the price stabilization period for PATEK is 30 days after the shares start trading on BIST (<https://www.kap.org.tr/tr/sirket->

bilgileri/ozet/8acae2c58b2fa64e018d63b9afbd4e6c; <https://tacirler.com.tr/pasifik-donanim-ve-yazilim-bilgi-teknolojileri-a-s-patek-br-halka-arz-ediliyor>).

According to the July 1 report, the real sector confidence index in Turkey decreased by 2.6 points in June compared to the previous month. In addition, inflation expectations for July decreased. CBRT kept the policy interest rate unchanged Vakıfbank (2024)

The developments that are thought to have an impact on stock prices are listed above. For the firm with a price stabilization period of 30 days, the forecasts for the period after the initial public offering, did not match the actual prices as quickly as in ODINE. However, the period between June 4 and June 11, when prices deviated in ODINE, was also one of the periods when deviations occurred for PATEK. In addition, the disclosures made to the PDP at the end of May and June may have affected the price movements of the firm. Therefore, although the deviation for PATEK appears to be minimal in the medium term as can be seen from the error metrics given in Table 5, the predicted price level of the firm is somewhat far from the actual prices. This is particularly evident in the initial stages of the IPO and in the period after May 31st. The regression model and R^2 values in Figure 4 also support this finding.

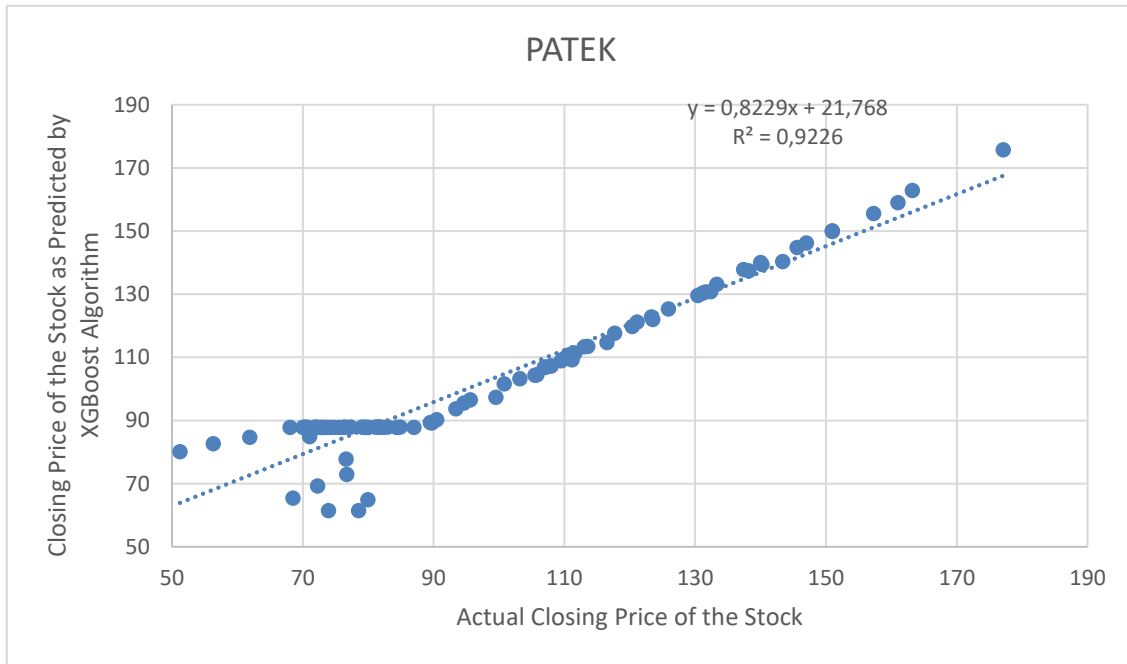


Figure 4. PATEK Stock Closing Price Prediction Model with XGBoost Algorithm

Figure 4 shows that the R^2 value of the XGBoost algorithm for the stock price prediction of PATEK is 0.9226. This result shows that the regression prediction model fit of the algorithm is still at a high level, although not as high as ODINE.

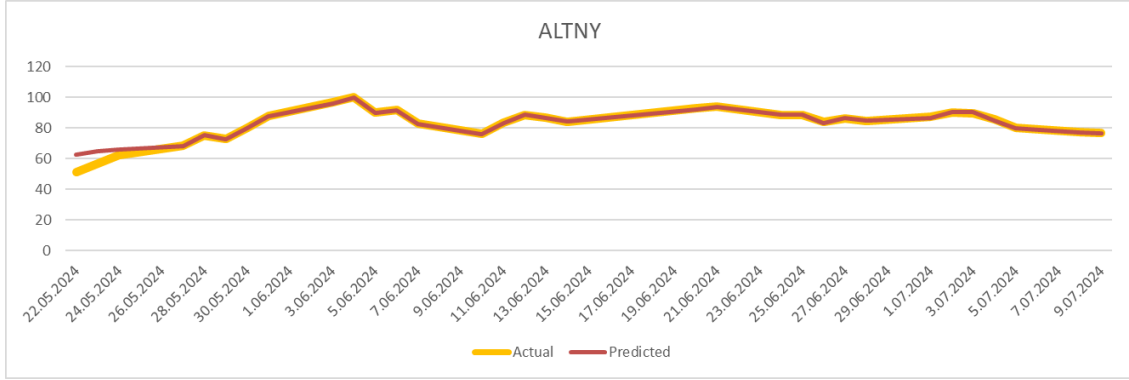


Figure 5. ALTNY Stock Closing Price Prediction Graph with XGBoost Algorithm

Figure 5 shows the stock closing price prediction graph of ALTNY. The yellow line in the figure represents the actual daily closing prices of the firm, while the orange line represents the daily closing prices predicted by the XGBoost algorithm. It is observed that ALTNY, the most recent IPO among the firms in the sample, has a deviation between the actual closing price and the predicted closing price only between May 22 and 24, 2024. Before moving on to the possible reasons for this deviation, the information gathered about the firm from the prospectus and the halkarz.com website can be listed as follows:

- The company's demand collection dates are May 8-10, 2024,
- IPO price is 32 TL,
- Form of public offering is capital increase and joint sale,
- The IPO method is to collect demand at a fixed price and distribute it equally,
- The brokerage method is best-effort brokerage,
- The number of shares offered to the public is TL 58,823,530,
- Consortium leaders TSKB / Ziraat Yatırım Menkul Değerler A.Ş./ Yatırım Finansman Menkul Değerler A.Ş.,
- Free float is 25%,
- Fund utilization areas are as follows: 50% investments in new facilities and production technologies, 15% investments in testing and verification technologies, R&D and product development, 5% investments in global sales and marketing network, 15% working capital, 5% financial debt payments, 10% acquisitions and/or establishment of joint ventures,
- The company's price stabilization transactions are 15 days from the start of trading of the shares on BIST,
- Date of establishment is 27.05.2014

When ALTNY, which has ten years of experience in the sector, is evaluated according to the factors affecting the initial public offering price, it may create an expectation of low pricing, as the age of the company creates a situation of uncertainty for investors. This interpretation is supported by various findings in the literature (Durukan, 2002; Rosenboom, 2012). In addition, the fact that the funds obtained as a result of the IPO will be mostly used for new investments may be perceived by investors as a positive signaling effect (Deb, 2013; Park et al., 2016). In addition, the firm's public offering ratio of 25% can be interpreted as indicating that there is no problem between the main shareholders. As can be seen in Figure 5, the deviation between the

actual and predicted stock prices of ALTNY, the last IPO from the technology sector until July 2024, when this study was prepared, is only in the initial public offering period. Even though the subsequent period is short, the actual and predicted prices are quite close to each other. It is noteworthy that, even between June 4 and 11, 2024 when there is a deviation between the prices of both ODINE and PATEK, the predicted prices of ALTNY are in line with the actual prices. In the early periods of the IPO, for example, it was reported that the company made notifications to the PDP on May 23, 2024 regarding the capacity increase, and on May 24, 2024 regarding the implementation of the volatility-based measure system on a per-share basis (<https://www.kap.org.tr/tr/Bildirim/1289988>; <https://www.kap.org.tr/tr/Bildirim/1290891>).

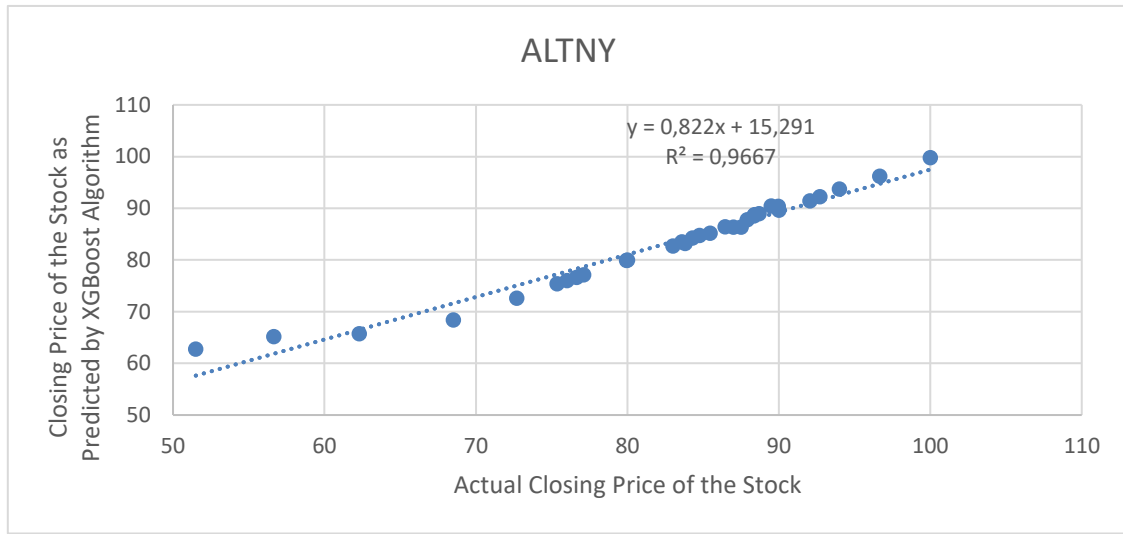


Figure 6. ALTNY Stock Closing Price Prediction Model with XGBoost Algorithm

Figure 6 shows the XGBoost regression model and R^2 values established with the XGBoost algorithm for ALTNY. Accordingly, the R^2 value in the XGBoost algorithm for the stock price prediction of the firm is 0.9667, indicating a strong model fit. As a result of the steps applied with the XGBoost algorithm, the predicted and realized closing prices of the firms in the sample for days ranging from five to ten are given in Table 6.

According to Table 6, the difference between the closing prices of each firm predicted by the XGBoost algorithm and the actual closing prices gradually decreased in the following days. The absolute values of this difference also decreased considerably and were found to be (11.16-8.83-4.78-0.30-0.71-0.20) for ODINE, (28.89-22.78-19.77-12.94-5.49-0.24) for PATEK and (11.26-8.48-3.45-0.11-0.05-0.11) for ALTNY.

Table 6. Actual and Predicted Price Information of the Sample Firms between Five and Ten Days

		Real	Predicted	Date
ODINE	Days	43.9	55.0630	26.03.2024
	Day 5	48.28	56.8128	27.03.2024
	Day 6	53.1	57.8805	28.03.2024
	Day 7	58.4	58.0943	29.03.2024
	Day 8	64.2	63.4837	1.04.2024
	Day 9	70.6	70.3944	2.04.2024
	Day 10	43.9	55.0630	26.03.2024
PATEK	Days	56.3	82.6366	19.02.2024
	Day 5	61.9	84.6820	20.02.2024
	Day 6	68.05	87.8220	21.02.2024
	Day 7	74.85	87.7996	22.02.2024
	Day 8	82.3	87.7936	23.02.2024
	Day 9	90.5	90.2512	26.02.2024
	Day 10	56.3	82.6366	19.02.2024
ALTNY	Days	51.5	62.7615	22.05.2024
	Day 5	56.65	65.1352	23.05.2024
	Day 6	62.3	65.7511	24.05.2024
	Day 7	68.5	68.3853	27.05.2024
	Day 8	75.35	75.4071	28.05.2024
	Day 9	72.7	72.5800	29.05.2024
	Day 10	51.5	62.7615	22.05.2024

4. Conclusion

IPOs, which are considered an important milestone in the history of the firm, provide various advantages, such as ease of financing and liquidity and paving an important path towards institutionalization. In addition, IPOs are of great importance for national markets. Especially in developing countries, IPOs contribute to the further development of the capital markets of these countries. From the investors' perspective, investing in stocks during the initial period plays an important role in generating positive returns. This is supported by the findings of Otlu and Ölmöz, 2011; Kurtaran 2013; Balıkçı and Tunçel, 2025 that investors generally experience positive returns in the first days.

The aim of the study is to make short-term price forecasts for IPOs in order for investors to achieve positive returns. For this forecast, a model was created with the XGBoost algorithm, and ODINE, PATEK, and ALTNY—companies which operate in the technology sector and completed their IPOs in 2024— were selected as the sample for the reasons stated in the methodology section of the study. A model was designed and a data set created for predicting the price on the fifth day after the initial public offering. After dividing the dataset into training and test datasets, the training dataset is further divided into input and output datasets. The closing stock prices of FORTE, a company operating in the technology sector and first offered to the public in 2023, for four days after the IPO date, along with the daily closing values of the BIST technology and BIST IPO indices, constitute the input of the training set. The closing stock prices of FORTE on the fifth day constitute the output of the training set. Therefore, when the model is given four days of stock closing prices and the aforementioned index values as input, it is expected to predict the price of the fifth day. The R^2 value of the trained model is 0.9324, which means that the model explains 93.24% of the variance. The reason for forecasting the fifth day price within the scope of the study is that the five-day period is typically considered short-term in the literature.

In IPOs, it is known that stock prices increase from the first trading day until the equilibrium point, where the investors who participate in the public offering find the profits obtained satisfactory, and the appetite of those who want to invest in stocks decreases. Although it is difficult to know when this point will occur, this point is generally estimated to occur between five and ten days (Düzer, 2020: 249; Yetim ve Koy, 2022: 949), sometimes, 15 days (Tunçay, 2019: Kahraman ve Coşkun, 2020: Brau ve Fawcett, 2006). After the analysis, it is observed that the difference between the predicted and realized closing prices of the firms in the sample (Table 6) for the days in the five to ten range decreases as the days pass.

Policy recommendations regarding the findings of the study can be listed as follows. The use of powerful machine learning algorithms such as XGBoost has significant potential to support investment decisions. Therefore, financial institutions and investors may prioritize training and infrastructure investments to increase the applicability of such models. In addition, forecasting models for the early performance of IPOs may provide investors with the opportunity to make more informed decisions. Accordingly, the results of such algorithms can be presented to investors in investment advisory services and strategies to reduce short-term risks can be developed. In addition, this study is a pioneering study in this field in the Turkish context by focusing on the short-term prediction of the stock prices of technology firms listed on Borsa Istanbul. The successful performance of the XGBoost algorithm suggests that it is a powerful tool for future financial forecasting research. While the literature has generally focused on long-term performance evaluations, this study extends the existing body of knowledge by focusing on short-term price forecasting. Modeling price fluctuations, especially in the first days after an IPO, can contribute to a better understanding of investor behavior. The development of a model specific to the technology sector fills an important gap in the literature to better understand sector-specific differences and is a valuable reference for the design of models that can be adapted to other sectors in the future.

In conclusion, which aims to make short-term price forecasts in IPOs, shows that the model is considered to be successful; this is evidenced by the high R^2 values. However, while the absolute values of the differences between the prices predicted by the algorithm and the realized prices were higher on the fifth day, these values were below 0.25 for each firm until the tenth day. Therefore, the predictive power of the model increases with time after the IPO. In addition, the application of the model in different sectors can be recommended for future studies.

Declaration of Research and Publication Ethics

This study, which does not require ethics committee approval and/or legal/specific permission, complies with research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflict of interest in this study.

References

- Bakırhan, C. and Sayılğan, G. (2023). *Hisse senedi ilk halka arzlarının kısa ve uzun dönemli performans analizi: Borsa İstanbul örneđi (1993-2020)*. Ankara Üniversitesi SBF Dergisi, 78(4), 635-661. <https://doi.org/10.33630/ausbf.1134693>
- Balıkçı, B. and Tunçel, M.B. (2025). Halka arz işlemleri ile yatırımcı portföyleri arasındaki ilişkinin incelenmesi. *İktisadi İdari ve Siyasal Arařtırmalar Dergisi*, 10(26), 1-11. <https://doi.org/10.25204/iktisad.1459848>
- Beatty, R.P. and Ritter, J.R. (1986). Investment banking, reputation, and the underpricing of initial public offerings. *Journal of Financial Economics*, 15(1-2), 213-232. [https://doi.org/10.1016/0304-405X\(86\)90055-3](https://doi.org/10.1016/0304-405X(86)90055-3)
- Brau, J.C. and Fawcett, S.E. (2006). Initial public offerings: An analysis of theory and practice. *The Journal of Finance*, 61(1), 399-436. <https://doi.org/10.1111/j.1540-6261.2006.00840.x>
- Brownlee, J. (2018). *Deep learning for time series forecasting: Predict the future with MLPs, CNNs and LSTMs in Python*. San Francisco: Machine Learning Mastery.
- Cai, K. and Lee, H. (2013). Stock price reactions to debt initial public offering announcements. *Journal of Applied Business Research*, 29(1), 69-78. Retrieved from <https://core.ac.uk/>
- Chen, G., Firth, M. and Kim, J.B. (2000). The post-issue market performance of initial public offerings in China's new stock markets. *Review of Quantitative Finance and Accounting*, 14, 319-339. <https://doi.org/10.1023/A:1008358609204>
- Chen, T. and Guestrin, C. (2016). XGboost: A scalable tree boosting system. In B. Krishnapuram et al. (Eds.), *Proceedings of the 22nd ACM SIGKDD international conference on knowledge discovery and data mining* (pp. 785-794). <https://doi.org/10.1145/2939672.293978>
- Chi, J. and Padgett, C. (2005). Short-Run underpricing and its characteristics in Chinese initial public offering (IPO) markets. *Research in International Business and Finance*, 19(1), 71-93. <https://doi.org/10.1016/j.ribaf.2004.10.004>
- Dawson, S.M. (1987). Secondary stock market performance of initial public offers, Hong Kong, Singapore and Malaysia: 1978- 1984. *Journal of Business Finance B Accounting*, 14(1), 65-76. <https://doi.org/10.1111/j.1468-5957.1987.tb00529.x>
- Deb, P. (2013). Signaling type and post-IPO performance. *European Management Review*, 10(2), 99-116. <https://doi.org/10.1111/emre.12012>
- Durukan, M.B. (2002). The relationship between IPO returns and factors influencing IPO performance: Case of Istanbul Stock exchange. *Managerial Finance*, 28(2), 18-38. <https://doi.org/10.1108/03074350210767672>
- Düzer, M. (2022). İlk halka arzlarına yönelik kısa dönem fiyat performans incelemesi ve sektörel karşılaştırma. *Çankırı Karatekin Üniversitesi İİBF Dergisi*, 12(1), 249-275. <https://doi.org/10.18074/ckuiibfd.1038703>
- Elma, O.E. (2017). *İlk halka arzlarda değerlendirme etkisi: Borsa İstanbul'da bir uygulama*. Pamukkale Üniversitesi Sosyal Bilimler Enstitüsü, Doktora Tezi, Denizli.
- Emeç, M. and Özcanhan, M. H. (2023). Makine öğrenmesi algoritmalarında hiper parametre belirleme. In E. Yiğit and U. Özkaya (Eds.), *Mühendislikte öncü ve çağdaş yaklaşımlar* (pp. 71-98). İzmir: Duvar Publishing.
- Fischer, T. and Krauss, C. (2018). Deep learning with long short-term memory networks for financial market predictions. *European Journal of Operational Research*, 270(2), 654-669. <https://doi.org/10.1016/j.ejor.2017.11.054>
- Gupta, V., Singh, S. and Yadav, S.S. (2023), Disaggregated IPO returns, economic uncertainty and the long-run performance of SME IPOs. *International Journal of Emerging Markets*, 18(10), 3847 – 3867. <https://doi.org/10.1108/IJOEM-09-2020-1098>

- Haque, M. I., Prince, M. and Shaik, A.R. (2023). Predicting Aramco’s IPO Long-Term Performance During COVID Times. In A. Khanna, Z. Polkowski and O. Castillo (Eds.) *Proceedings of data analytics and management* (pp. 69-80). https://doi.org/10.1007/978-981-19-7615-5_6
- Hyndman, R.J. and Athanasopoulos, G. (2021). *Forecasting: Principles and practice* (3rd ed.). OTexts: Melbourne, Australia.
- İmece, S. (2019). *Demand forecasting with individual and combined models in pharmaceutical industry* (Unpublished doctoral dissertation). Istanbul Technical University, Istanbul, Türkiye.
- Isbank. (2024). İş bankası. Erişim adresi: https://ekonomi.isbank.com.tr/contentmanagement/Documents/tr03_aylik/2024/DTEG_202406.pdf
- Jabeur, S.B., Mefteh-Wali, S. and Viviani, J.L. (2024). Forecasting gold price with the XGBoost algorithm and SHAP interaction values. *Annals of Operations Research*, 334(1), 679-699. <https://doi.org/10.1007/s10479-021-04187-w>
- Jamaani, F. and Abdullahi, D.A. (2021). Modifier effects of country-level transparency on global underpricing difference: New hierarchical evidence. *International Review of Financial Analysis*, 74(C), 1016-1067. <https://doi.org/10.1016/j.irfa.2021.101667>
- Jindal, M., Nagariy, R. Rajendran, V. Tiwari, A. and Sharma, D. (2024). Post-listing pricing performance of initial public offers: Insights from India. *Proceedings on Engineering Sciences*, 6(2), 827 – 836. Retrieved from <https://oaji.net/>
- Kahraman, İ.K. ve Coşkun, E. (2020). İlk halka arzda düşük fiyatlama seviyesi zamanla değişiyor mu? Borsa İstanbul üzerine bir araştırma. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 34(1), 141-161. <https://doi.org/10.16951/atauniiibd.620084>
- KAP. (2024). Şirket bilgileri. Erişim adresi: <https://www.kap.org.tr/tr/sirket-bilgileri/ozet>
- Keasey, K. and Short, H. (1992). The winner's curse model of underpricing: A critical assessment. *Accounting and Business Research*, 23(89), 74-78. <https://doi.org/10.1080/00014788.1992.9729862>
- Kim, K.J. and Won, C.H. (2018). Forecasting the volatility of stock price index: A hybrid model integrating LSTM with multiple GARCH-type models. *Expert Systems with Applications*, 103, 25–37. <https://doi.org/10.1016/j.eswa.2018.03.002>
- Kirkulak, B. and Davis, C. (2005). Underwriter reputation and underpricing: Evidence from the Japanese IPO market. *Pacific-Basin Finance Journal*, 13(4), 451-470. <https://doi.org/10.1016/j.pacfin.2004.09.004>
- Kıymaz, H. (1997). İMKB’de halka arz edilen mali sektör hisse senetlerinin performanslarını etkileyen faktörlerin incelenmesi. *İMKB Dergisi*, 1(2), 69-90. Erişim adresi: <https://www.borsaistanbul.com/>
- Kurtaran, A.T. (2013). Türkiye’deki ilk halka arzların ilk getirileri ile uzun dönem fiyat performansları arasındaki ilişkinin analizi. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, 11, 185-210. Erişim adresi: <https://dergipark.org.tr/en/pub/ulikidince/>
- Malik, S., Harode, R. and Kunwar, A.S. (2020). *Xgboost: A deep dive into boosting*. Simon Fraser University, Burnaby, BC, Canada.
- Mangala, D. and Dhanda, M. (2022). Earnings management around initial public offerings (IPO): Impact on post issue stock performance in India. *Finance India*, 36(4), 1245 – 1272. Retrieved from ebscohost.com
- Orhan, M. (2006). Short-and long-run performance of IPOs traded on the Istanbul Stock Exchange. In G.N. Gregoriou (Ed.), *Initial public offerings* (pp. 45-55). Oxford: Butterworth-Heinemann.
- Otlu, F. and Ölmez, S. (2011). Halka ilk kez arz edilen hisse senetlerinin kısa dönem fiyat performansları ile fiyat performansını etkileyen faktörlerin incelenmesi, İMKB’de bir uygulama. *Akademik Yaklaşımlar Dergisi*, 2(2), 14-44. Retrieved from <https://dergipark.org.tr/en/pub/ayd/>
- Park, U.D., Borah, A. and Kotha, S. (2016). Signaling revisited: The use of signals in the market for IPOs. *Strategic Management Journal*, 37(11), 2362–2377. Retrieved from <http://www.jstor.org/stable/26155229>

- Ritter, J.R. (1991). The long-run performance of initial public offerings. *The Journal of Finance*, 46(1), 3-27. <https://doi.org/10.1111/j.1540-6261.1991.tb03743.x>
- Rock, K. (1986). Why new issues are underpriced. *Journal of Financial Economics*, 15(1-2), 187-212. [https://doi.org/10.1016/0304-405X\(86\)90054-1](https://doi.org/10.1016/0304-405X(86)90054-1)
- Rosenboom, P. (2012). Valuing and Pricing IPO's. *Journal of Banking and Finance*, 36(6), 1653-1664. <https://doi.org/10.1016/j.jbankfin.2012.01.009>
- Savařkan, O. (2005). *Halka arz fiyatının belirlenmesinde kullanılan yöntemler, halka arz sonrası hisse senedi performansı*. SPK Yeterlilik Etüdü, İstanbul.
- Su, D. and Fleisher, B.M. (1999). An empirical investigation of underpricing in Chinese IPOs. *Pacific-Basin Finance Journal*, 7(2), 173-202. [https://doi.org/10.1016/S0927-538X\(99\)00005-0](https://doi.org/10.1016/S0927-538X(99)00005-0)
- Tacirler. (2024). *Tacirler yatırım*. Eriřim adresi: <https://tacirler.com.tr>
- Tong, L.Y. and Ahmad, R. (2015). The signaling power of the investment banks' reputation on the performance of IPOs on Bursa Malaysia. *Jurnal Pengurusan*, 45, 27-37. Retrieved from <https://www.ukm.my/jurnalpengurusan/>
- Tunçay, E. (2019). *Borsada ilk halka arzların performansının deęerlendirilmesi: Borsa İstanbul üzerine bir uygulama* (Yayımlanmamıř Doktora Tezi). Hacettepe Üniversitesi, Ankara.
- Ülker, M. (2023). *Makine öğrenmesi yöntemleriyle zaman serilerinde deęer tahminleme* (Unpublished doctoral dissertation). Erciyes University, Kayseri, Türkiye.
- Usanmaz, S. and Söylemez, A.O. (2021). Halka arzlarda anormal getiriye etki eden faktörlerin tespiti. *Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 43(2), 312-328. doi:10.14780/muiibd.1052085
- Vakıfbank. (2024). *Vakıfbank*. Eriřim adresi: <https://vbassets.vakifbank.com.tr/bireysel/yatirim/ekonomik-arastirmalar/vakifbank-haftalik-rapor-01072024.pdf>
- Yahoo Finance. (2024). *Yahoo finance* [Dataset]. Retrieved from www.finance.yahoo.com
- Yetim, S.B. and Koy, A. (2022). İlk halka arzların BİST100 endeksi volatilitesine etkisi: Covid-19 pandemisi dönemi. *Ekonomi, Politika & Finans Arařtırmaları Dergisi*, 7(4), 944-965. <https://doi.org/10.30784/epfad.1211766>
- Yıldırım, D. and Dursun, A. (2016). Borsa İstanbul'daki ilk halka arzlarda ilk gün düşük fiyat anomalisi. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 30(1), 189-202. Retrieved from <https://dergipark.org.tr/tr/pub/atauniiibd/>
- Yılmaz, A. and Abdioęlu, N. (2023). İlk halka arzlarda düşük fiyatlama anomalisi: Borsa İstanbul'da piyasaya göre düzeltilmiř anormal getiri modeli ile SVFM karşılaştırılması. *İřletme Bilimi Dergisi*, 11(3), 227-252. <https://doi.org/10.22139/jobs.1372488>
- Zhang, G.P., Patuwo, B.E. and Hu, M.Y. (1998). Forecasting with artificial neural networks: The state of the art. *International Journal of Forecasting*, 14(1), 35-62. [https://doi.org/10.1016/S0169-2070\(97\)00044-7](https://doi.org/10.1016/S0169-2070(97)00044-7)