ISSN 3032-3533
Vol 1, No.1 (2024)

Comparison of Boosting Algorithms (LightGBM, CatBoost, and XGBoost) on Ship Ticket Sales Prediction

1st Annisa Shafira Zuhri
ComputerScience, Faculty of Engineering and Computer Science
Universitas Potensi Utama
Medan, Indonesia
zuhriannisa1@gmail.com

2nd Dr. Wanayumini, S. Kom, M. Kom
ComputerScience, Faculty of Engineering and Computer Science
Universitas Asahan
Medan, Indonesia
wanayumini@gmail.com

3rd Dr. Lili Tanti, S. Kom, M. Kom
ComputerScience, Faculty of Engineering and Computer Science
Universitas Potensi Utama
Medan, Indonesia
lilitanti82@gmail.com

***Abstract*—** Usually, in optimizing ship capacity and knowing the ship's departure schedule in the next period, the ship management makes predictions based on data from the previous period. However, the problem that occurs is the shortage of ticket sales on holidays and a decrease in ticket sales on weekdays, making it difficult for ship management to plan departures and determine schedules. Therefore, a way is needed that can make accurate predictions from previous predictions that only look at previous sales data without using better calculations based on sales data. Accurate predictions can help in planning ship capacity, scheduling, determining ticket prices, as well as marketing strategies. The prediction methods used can vary, from traditional statistical approaches to the use of machine learning and artificial intelligence that utilize historical data on ticket sales as well as appropriate external factors. Therefore, research on the prediction of sea ticket sales is an important step to improve the efficiency and profitability of shipping companies. By understanding sales patterns and trends, companies can be better prepared to face fluctuations in demand and maximize business opportunities in the marine transportation sector. There are many methods in machine learning, including LightGBM, CatBoost, and XGBoost. This study makes a comparison of the three methods so that we can find out which method is closer to the prediction results of sea ticket sales. So it is expected that.

Keywords: *Comparison, Boosting, LightGBM, CatBoost, XGBoost*

I. INTRODUCTION

Sea transportation is one of the modes of transportation that has an important role in connecting regions, especially in archipelagic countries such as Indonesia. Sea ships are a vital means of transportation for the community, both for passenger and freight delivery purposes. In the context of ocean ticket sales, a deep understanding of demand patterns and the factors affecting ticket sales is essential to optimize revenue and operational efficiency. The demand for sea tickets is often influenced by various factors, such as seasons, holidays, weather conditions, ticket prices, and promotions carried out by shipping companies. For example, during the holiday season or holidays, ticket demand tends to increase significantly. On the other hand, bad weather factors or natural disasters can lead to a decline in ticket sales. In addition, competition between shipping companies and government policies can also affect seller trends.

Usually, in optimizing ship capacity and knowing the ship's departure schedule in the next period, the ship management makes predictions based on data from the previous period. However, the problem that occurs is the shortage of ticket sales on holidays and a decrease in ticket sales on weekdays, making it difficult for ship management to plan departures and determine schedules. Therefore, a way is needed that can make accurate predictions from previous predictions that only look at previous sales data without using better calculations based on sales data.

Accurate predictions can help in planning ship capacity, scheduling, determining ticket prices, as well as marketing strategies. The prediction methods used can vary, from traditional statistical approaches to the use of machine learning and artificial intelligence that utilize historical data on ticket sales as well as appropriate external factors. Therefore, research on the prediction of sea ticket sales is an important step to improve the efficiency and profitability of shipping companies. By understanding sales patterns and trends, companies can be better prepared to face fluctuations in demand and maximize business opportunities in the marine transportation sector. There are many methods in machine learning including LightGBM, CatBoost, and XGBoost. This study makes a comparison of the three methods so that we can find out which method is closer to the prediction results of sea ticket sales.

So it is hoped that accurate prediction results can help the management of ship ticket sales in planning ship capacity, setting schedules, determining ticket prices, and marketing strategies.

II. LITERATURE REVIEW

Comparison

Comparison is a form of comparing two or more things from which from the existing similarities can be concluded. Comparative research is a research conducted to compare a research object, between different subjects or different times and find a cause-and-effect relationship. The comparative method is a method used to compare the data drawn into a new conclusion. Comparison itself from the English

language, namely compare, which means comparing to find similarities of two or more concepts. [1].

Comparison is the process or act of comparing two or more things, objects, concepts, or phenomena to find similarities, differences, or relationships between them. The term comes from the Latin word comparatio, which means comparison. In various fields, comparison has an important role. For example, in literature, comparison is used as a language style to compare two things directly or indirectly, such as metaphors or similes. In research, comparison helps researchers analyze differences and similarities between the v system or group being studied. In the field of economics, comparison is used to compare economic performance between countries, companies, or a specific period of time. Meanwhile, in law, legal comparison compares legal systems from different jurisdictions to understand their differences and similarities. The main goal of comparison is to gain a deeper understanding, find patterns, or make more informed decisions. [2][3].

LightGBM Algorithm

The LightGBM (Light Gradient Boosting Machine) algorithm is one of the machine learning algorithms used for prediction tasks, including number prediction (regression). LightGBM is an implementation of Gradient Boosting that is optimized for speed and memory efficiency. [4][5].

CatBoost Algorithm

The CatBoost algorithm is one of the machine learning algorithms specifically designed to handle data with categorical features efficiently. CatBoost is part of the Gradient Boosting family and is known for its ability to produce accurate models with minimal hyperparameter tuning. [6][7].

XGBoost Algorithm

The XGBoost (Extreme Gradient Boosting) algorithm is one of the most systematic and effective machine learning algorithms for prediction tasks, including regression (number prediction). XGBoost is an implementation of Gradient Boosting that is optimized for speed and performance. [8][9].

Prediction

Prediction is the process of predicting or forecasting a future event, value, or condition based on currently available data, patterns, or information. Prediction involves using analytical methods or machine learning algorithms to identify relationships between existing variables and generate estimates about what might happen next. The purpose of prediction is to provide insights or insights that can be used in decision-making. Prediction is becoming a very important tool in various fields because it helps reduce uncertainty and allows for more effective planning. However, the accuracy of the predictions is highly dependent on the quality of the data, the methods used, and the understanding of the context of the problem being analyzed. [10][11][12].

Sales

Sales is the purchase of something (goods or services) from one party to another party by getting money compensation from that party. Sales are also a source of company income, the greater the sales, the greater the income obtained by the company. Sales is an activity or business in selling products or services. Sales activities are very important for companies, especially to make profits. The general definition of sales is that buying and selling activities are carried out by two or more parties with legal means of payment. These sales can be done by various methods, such as direct sales as well as sales agents. The main purpose of sales is to bring in profits from the product or goods being sold. In its implementation, sales cannot be carried out without contributions from working actors, such as traders, agents, and marketing personnel. [13][14][15].

Ticket

A ticket is a voucher used to show that visitors or spectators have paid for the entrance ticket. A ticket is an official document or proof that gives the holder the right to access a service, event, facility, or transportation. Tickets are typically issued by service providers or event organizers and serve as a verification tool that the holder has paid for or met certain requirements to use the service or attend the event. [16][17].

Sea Ships

Sea ships are the main means of transportation by sea. The number of ocean fleets owned by national shipping companies is very disproportionate to the size of Indonesia's sea area, as well as the number of passengers and goods that must be transported. Ships are vehicles that transport passengers and goods at sea (rivers and so on) as well as canoes or smaller boats. Ships are usually large enough to carry small boats such as lifeboats, whereas in British terms, they are separated between larger ships and smaller boats. Normally ships can carry boats, but boats cannot carry ships. The actual size of which a boat is called a boat is always determined by local laws and regulations or customs. [18][19].

III. METHOD

This study uses three methods, namely LightGBM, CatBoost, and XGBoost.

1. Data Preparation
   The study has historical data on ticket sales from January to December, with months converted to numbers:
   X=[1,2,3,4,5,6,7,8,9,10,11,12]
2. Model Initialization
   Define parameters, such as:
   Feature (X) = moon number (1-12)
   Target (Y) = number of ticket sales
   Model goal = regression (predicting continuous values)
3. Model Training
   The model was trained using datasets from January to December with 6 ocean liner departure routes.
4. Prediction
   LightGBM, CatBoost, and XGBoost are applied to ocean ticket sales data.

Tabel 1. Data 2023

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	15200	14800	30000	15200	14800	30000

Feb	14500	14000	28500	14500	14000	28500
Mar	16000	15500	31500	16000	15500	31500
Apr	18500	17800	36300	18500	17800	36300
Mei	20000	19500	39500	20000	19500	39500
Juni	21500	20800	42300	21500	20800	42300
Juli	23000	22500	45500	23000	22500	45500
Agu	22500	22000	44500	22500	22000	44500
Sep	19800	19300	39100	19800	19300	39100
Okt	18000	17500	35500	18000	17500	35500
Nov	16500	16000	32500	16500	16000	32500
Des	19000	18500	37500	19000	18500	37500

LightGBM uses an equation with Regression Liner. Linear regression has the form of:

Y=aX+b……..(1)

Where:
Y = predicted ticket sales
X = month in number (13)
a = slope, with the formula:

$$a = \frac{n\sum(XY) - \sum(X)\sum(Y)}{n\sum X^2 - (\sum X)^2} \text{……(2)}$$

b = intercept (constant), with the formula:

$$b = \frac{\sum Y - a\sum X}{n} \text{……(3)}$$

Count:
$\sum X = 1+2+3+4+5+6+7+8+9+10+11+12 = 78$
$\sum X^2 = 1^2+2^2+3^2+4^2+5^2+6^2+7^2+8^2+9^2+10^2+11^2+12^2 = 650$
$\sum Y = 15200+14500+16000+18500+20000+21500+23000+22500+19800+18000+16500+19000 = 224500$
$\sum XY = (1x15200)+(2x14500)+(3x16000)+(4x18500)+(5x20000)+(6x21500+(7x23000)+(8x22500)+(9x19800)+(10x18000)+(11x16500)+(12x19000) = 1503900$

Tabel 2. Results on Route 1-3

	Rute 1	Rute 2	Rute 3
$\sum X$	78	78	78
$\sum X^2$	650	650	650
$\sum Y$	224500	257500	209500
$\sum XY$	1503900	1720000	1408000

Rute 1: Belawan – Tj Balai Karimun
Rute 2: Tj Balai Karimun – Batam
Rute 3: Batam – Jakarta

Tabel 3. Results on Route 4-6

	Rute 4	Rute 5	Rute 6
$\sum X$	78	78	78
$\sum X^2$	650	650	650
$\sum Y$	207000	255000	218200
$\sum XY$	1392200	1704200	1463000

Rute 4: Jakarta – Batam
Rute 5: Batam – Tj Balai Karimun
Rute 6: Tj Balai Karimun – Belawan

Use formula a:

$$a = \frac{(12x1503900) - (78x224500)}{(12x650) - (78^2)}$$

$$a = 312.24$$

Use formula b:

$$b = \frac{224500 - (312.24x78)}{12}$$

$$b = 16678.79$$

Use formula Y:
Y = (312.24×13)+16678.79
= 20737.91

a. LightGBM Algorithm

Here are the steps and formulas involved in using LightGBM to predict the number of ocean ticket sales:

Tabel 4. Prediction 2024

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	20738	23561	19561	19373	23373	20215
Feb	21050	23884	19884	19699	23699	20528
Mar	21362	24207	20207	20026	24026	20840
Apr	21675	24531	20531	20352	24352	21153
Mei	21987	24854	20854	20679	24679	21466
Juni	22299	25178	21178	21006	25006	21778
Juli	22611	25501	21501	21332	25332	22091
Agu	22924	25825	21825	21659	25659	22403
Sep	23236	26148	22148	21985	25985	22716
Okt	23548	26471	22471	22312	26312	23028
Nov	23860	26795	22795	22638	26638	23341
Des	24172	27118	23118	22965	26965	23654

Then calculate the Original Y-Y Prediction (Residual Error):

Tabel 5. Residual Error

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	-5537	-5560	-5561	-5572	-5573	-5415
Feb	-6550	-6384	-6384	-6499	-6499	-6528
Mar	-5362	-5207	-5207	-5225	-5226	-5340
Apr	-3174	-3531	-3531	-3552	-3552	-3353
Mei	-1986	-2354	-2354	-2379	-2379	-1966
Juni	-799	-1177	-1178	-1205	-1205	-978
Juli	388	-1,2	-1	-32	-32	409
Agu	-423	-825	-825	-859	-859	-403
Sep	-3435	-3648	-3648	-3685	-3685	-3416
Okt	-5548	-5471	-5471	-5512	-5512	-5528
Nov	-7360	-7295	-7295	-7338	-7338	-7341
Des	-5172	-5561	-5118	-5165	-5165	-5154

Then calculate the Learning Rate (0.1):
Ynew = Ypred+(0.1xRE)

Tabel 5. Prediction

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	20184	23004	19005	18815	22815	19674
Feb	20395	23246	19245	19049	23049	19875
Mar	20826	23687	19686	19503	23503	20306
Apr	21357	24178	20177	19997	23997	20818
Mei	21788	24619	20618	20441	24441	21269
Juni	22219	25060	21059	20885	24885	21680
Juli	22650	25501	21501	21329	25329	22132
Agu	22881	25742	21742	21573	25573	22363

Sep	22892	25783	21783	21617	25617	22374
Okt	22993	25924	21924	21761	25761	22476
Nov	23124	26065	22065	21905	25905	22607
Des	23655	23004	22606	22449	26449	23138

Then look for the percentage value:
Percentage = Yasli/Ybaru
Or
Percentage = Ybaru/Yasli

Tabel 6. Percentage

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	75%	78%	74%	73%	78%	75%
Feb	71%	75%	70%	69%	75%	70%
Mar	77%	80%	76%	76%	80%	76%
Apr	87%	87%	84%	84%	87%	86%
Mei	92%	91%	90%	90%	91%	92%
Juni	97%	96%	95%	95%	96%	96%
Juli	98%	99%	99%	99%	99%	98%
Agu	98%	97%	97%	96%	97%	98%
Sep	86%	87%	85%	85%	87%	86%
Okt	78%	81%	78%	77%	81%	78%
Nov	71%	75%	70%	70%	75%	71%
Des	80%	83%	80%	79%	82%	80%
	84%	**86%**	**83%**	**83%**	**86%**	**84%**

$$\text{Average accuracy}=\frac{84\%+86\%+83\%+83\%+86\%+84\%)}{6}$$
$$= 84\%$$

b. CatBoost Algorithm

Here are the steps and formulas involved in using CatBoost to predict the number of ocean ticket sales:
Ynew = Ypred+(0.03xRE)

Tabel 7. Prediction

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	20572	23394	19394	19206	23206	20053
Feb	20854	23693	19693	19504	23504	20332
Mar	21201	24051	20051	19869	23869	20680
Apr	21579	24425	20425	20246	24246	21052
Mei	21927	24784	20784	20608	24608	21407
Juni	22275	25142	21142	20969	24969	21749
Juli	22623	25501	21501	21331	25331	22103
Agu	22911	25800	21800	21633	25633	22391
Sep	23133	26039	22039	21875	25875	22613
Okt	23382	26307	22307	22147	26147	22863
Nov	23639	26576	22576	22418	26418	23121
Des	24017	26965	22965	22810	26810	23499

Then look for the percentage value:
Percentage = Yasli/Ybaru
Or
Percentage = Ybaru/Yasli

Tabel 8. Percentage

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	74%	77%	72%	72%	77%	74%
Feb	70%	74%	69%	68%	73%	69%
Mar	75%	79%	75%	74%	79%	75%
Apr	86%	86%	83%	83%	86%	85%
Mei	91%	91%	89%	89%	91%	91%
Juni	97%	95%	95%	94%	95%	96%
Juli	98%	99%	99%	99%	99%	98%
Agu	98%	97%	96%	96%	97%	98%
Sep	86%	86%	84%	84%	86%	85%
Okt	77%	80%	76%	76%	80%	77%
Nov	70%	73%	69%	68%	73%	69%
Des	79%	82%	78%	78%	81%	79%
	83%	**85%**	**82%**	**82%**	**85%**	**83%**

$$\text{Average accuracy}=\frac{83\%+85\%+82\%+82\%+85\%+83\%)}{6}$$
$$= 83\%$$

c. XGBoost Algorithm

Here are the steps and formulas involved in using XGBoost to predict the number of ocean ticket sales:

1. Model Training

$$Y_{predawal}=\frac{15200+14500+16000+18500+20000+21500+23000+22500+19800+18000+16500+19000}{12}$$

$Y_{predawal}$=18708.33

2. Residual

Residual= Y_{asli}- $Y_{pred\ awal}$

Tabel 9. Percentage

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	-3508	-708	-4708	-4908	-908	-3908
Feb	-4208	-1208	-5208	-5508	-1508	-4708
Mar	-2708	292	-3708	-3908	92	-3208
Apr	-208	2292	-1708	-1908	2092	-908
Mei	1292	3792	-208	-408	3592	792
Juni	2792	5292	1292	1092	5092	2092
Juli	4292	6792	2792	2592	6592	3792
Agu	3792	6292	2292	2092	6092	3292
Sep	1092	3792	-208	-408	3592	592
Okt	-708	2292	-1708	-1908	2092	-1208
Nov	-2208	792	-3208	-3408	592	-2708
Des	292	3292	-708	-908	3092	-208

3. Hasil Gradien

g = -2 x Residual

Tabel 9. Percentage

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	7017	1417	9417	9817	1817	7017
Feb	8417	2417	10417	11017	3017	8417
Mar	5417	583	7417	7817	183	5417
Apr	417	4583	3417	3817	4183	417
Mei	2583	7583	417	817	7183	2583
Juni	5583	10583	2583	2183	10183	5583
Juli	8583	13583	5583	5183	13183	8583
Agu	7583	12583	4583	4183	12183	7583
Sep	2183	7583	417	817	7183	2183
Okt	1417	4583	3417	3817	4183	1417
Nov	4417	1583	6417	6817	1183	4417
Des	583	6583	1417	1817	6183	583

4. Update

$$\text{Update} = \frac{g}{h}$$

Tabel 10. Update

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	3508	708	4708	4908	908	3908
Feb	4208	1208	5208	5508	1508	4708
Mar	2708	292	3708	3908	92	3208
Apr	208	2292	1708	1908	2092	908
Mei	1292	3792	208	408	3592	792
Juni	2792	5292	1292	1092	5092	2092
Juli	4292	6792	2792	2592	6592	3792
Agu	3792	6292	2292	2092	6092	3292

Sep	1092	3792	208	408	3592	592
Okt	708	2292	1708	1908	2092	1208
Nov	2208	792	3208	3408	592	2708
Des	292	3292	708	908	3092	208

5. Prediksi

Use the trained model to predict the number of tests with n as the Learning Rate (0.1).

$Y_{baru} = Y_{pred} + n \times Update$

Tabel 11. Prediksi

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	19059	18779	19179	19199	18799	19099
Feb	19129	18829	19229	19259	18859	19179
Mar	18979	18738	19079	19099	18718	19029
Apr	18729	18938	18879	18899	18918	18799
Mei	18838	19088	18729	18749	19068	18788
Juni	18988	19238	18838	18818	19218	18918
Juli	19138	19388	18988	18968	19368	19088
Agu	19088	19338	18938	18918	19318	19038
Sep	18818	19088	18729	18749	19068	18768
Okt	18779	18938	18879	18899	18918	18829
Nov	18929	18788	19029	19049	18768	18979
Des	18738	19038	18779	18799	19018	18729

Then look for the percentage value:
Percentage = Yasli/Ybaru
Or
Percentage = Ybaru/Yasli

Tabel 12. Percentage

	Rute 1	Rute 2	Rute 3	Rute 4	Rute 5	Rute 6
Jan	80%	96%	73%	72%	95%	77%
Feb	76%	93%	70%	69%	91%	73%
Mar	84%	99%	79%	77%	100%	81%
Apr	99%	90%	90%	89%	91%	95%
Mei	94%	85%	99%	98%	86%	96%
Juni	88%	80%	94%	95%	81%	91%
Juli	83%	76%	88%	89%	77%	85%
Agu	85%	77%	90%	91%	78%	87%
Sep	95%	85%	99%	98%	86%	97%
Okt	96%	90%	90%	89%	91%	93%
Nov	87%	96%	81%	80%	97%	84%
Des	99%	87%	96%	95%	87%	99%
	89%	88%	87%	87%	88%	88%

$$\text{Average accuracy} = \frac{89\%+88\%+87\%+87\%+88\%+88\%)}{6}$$
$$= 88\%$$

Tabel 13. Comparison Results

	LightGBM	CatBoost	XGBoost
Akurasi	84%	83%	88%

IV. Result And Discussion

A comparison of LightGBM, CatBoost, and XGBoost algorithms was tested using ocean ticket sales data in 2023 and 2024. The 2023 data is used to predict ticket sales in 2024, this is done to get the percentage of prediction accuracy.

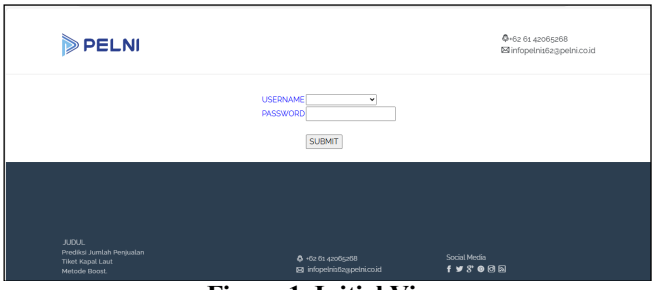

Figure 1. Initial View

Figure 1 is the initial view, to be able to use it, it must enter correctly and be presented as in Figure 2.

Figure 2. Menu Display

Figure 2 is a menu that presents options for ticket data processing, sales, and predictions, then if you click on a ticket, it is presented as shown in Figure 3.

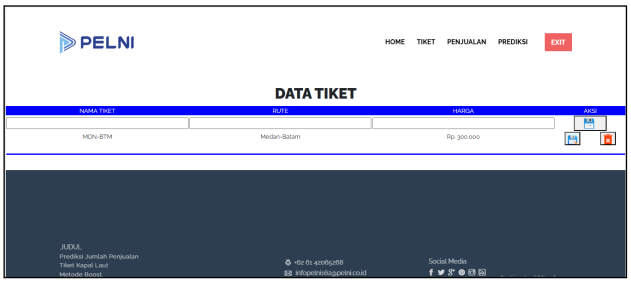

Figure 3. Ticket Display

Figure 3 ticket display, can manage ticket data with new data, change and delete. Then if you choose sales, then it is as shown in Figure 4.

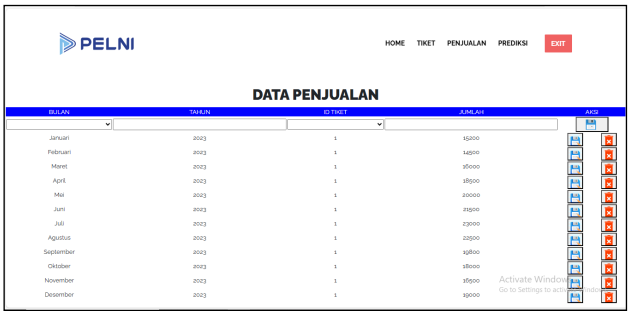

Figure 4. Sales Display

Figure 4 sales display, can manage sales data with new data, change and delete. Then if you choose a prediction, then it is like in Figure 5.

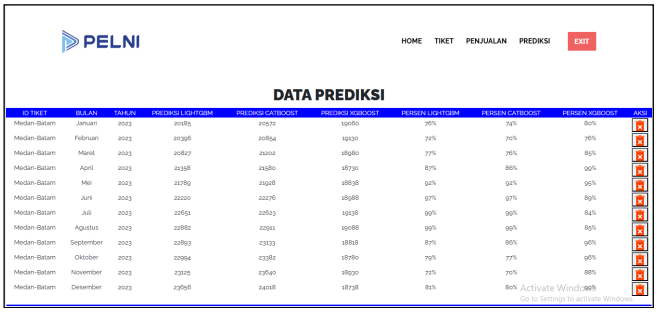

Figure 5. Prediction Result Display

If the user is going to make a prediction, then access is logged in as a user and presented as shown in Figure 6.

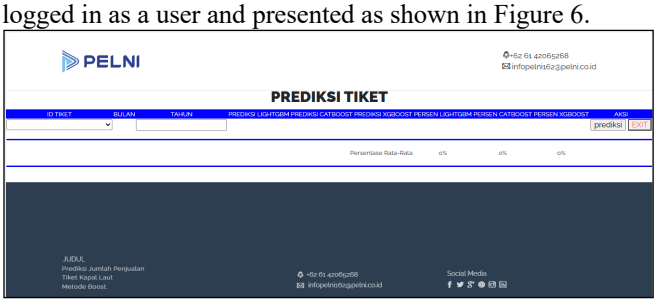

Figure 6. Prediction Display

Figure 6 prediction display, in this section users can make predictions by entering ticket data, year data and can be seen on Figure 7.

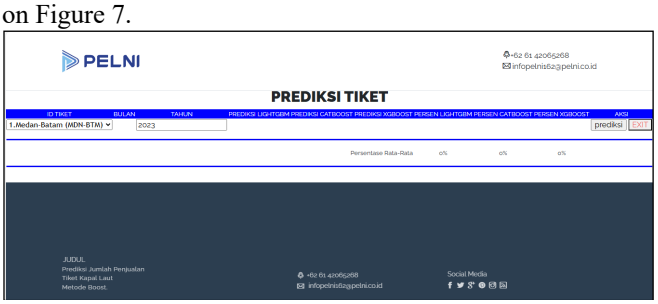

Figure 7. Display input results

Figure 7 Display the results of the input, in this section the user can make predictions by clicking the prediction button and can be seen on Figure 8.

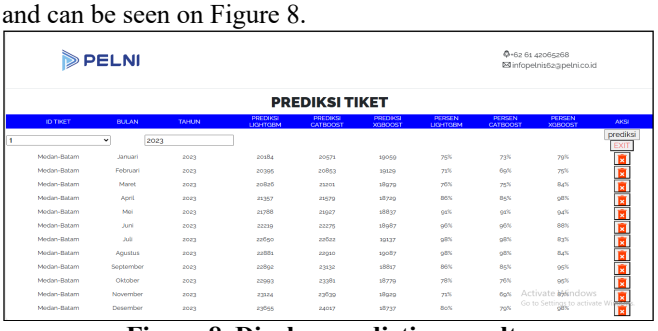

Figure 8. Display prediction results

V. CONCLUSION

Conclusion

By using LightGBM, Catboost, and Xgboost, the ship management can predict sales of ship tickets so that they can optimize the capacity of the ship and find out the ship's departure schedule in the next period. By calculating each algorithm, namely LightGBM, Catboost, and Xgboost, it can compose the LightGBM, Catboost, and XgBoost algorithm comparation. By using ship ticket sales data from PT Pelni, it can implement a comparison algorithm from LightGBM, Catboost, and Xgboost. With the application of LightGBM, Catboost, and Xgboost, it can test data on ship ticket sales so as to get predictions.

REFERENCES

[1] Hariyadi, M., & Muhammad, A. (2022). Rekonstruksi Tafsir Muqâran. *Mumtaz: Jurnal Studi Al-Quran dan Keislaman*, *6*(1), 1-17.

[2] Sofyana, H. D., Fatkhurrohman, F., & Sunarko, A. (2023). KONSEP PENGEMBANGAN KURIKULUM DALAM PEMBELAJARAN BAHASA ARAB (Studi Komparasi antara Buku Karya Prof. Dr. Moh. Ainin dan Buku Karya Dr. Ahmad Muradi, M. Ag. & Dr. Taufiqurrahman, M. *Alphateach (Jurnal Profesi Kependidikan Dan Keguruan)*, *3*(1).

[3] Putra, W. S. (2021). Komparasi Etika Hedonisme Epikuros Dengan Filsafat Cārvāka. *Widya Katambung*, *12*(2), 41-51.

[4] Kusuma, A. M., Harianto, R. A., & Pramana, E. (2023). Prediksi Stok Produk Sari Roti Untuk Penjualan Online Melalui Whatsapp Menggunakan Metode LightGBM dan LSTM. *Joutica*, *8*(2), 45-50.

[5] Febriantoro, E., Setyati, E., & Santoso, J. (2023). Pemodelan Prediksi Kuantitas Penjualan Mainan menggunakan LightGBM. *SMARTICS Journal*, *9*(1), 7-13.

[6] Syandika, N. D., & Yustanti, W. (2023). Deteksi Anomali Terhadap Pembatalan Transaksi Pada Platform Tiktok Shop dengan Algoritma Categorical Boosting (Catboost). *Journal of Informatics and Computer Science (JINACS)*, *5*(02), 149-156.

[7] Firmandani, A. M. E. F., AS, A. H., & Tholib, A. (2024). Optimasi Model CatBoost dengan Feature Selection dan Hyperparameter Tuning untuk Prediksi Nasabah Bank Potensial. *Academic Journal of Computer Science Research*, *6*(2), 118-127.

[8] Meningkatkan Prediksi Penjualan Retail Xyz Dengan Teknik Optimasi Random Search Pada Model Xgboost Hendra Wijaya 1 , Dandy Pramana Hostiadi 2 , Evi Triandini 3

[9] Siringoringo, R., Perangin-Angin, R., & Purba, M. J. (2021). Segmentasi Dan Peramalan Pasar Retail Menggunakan Xgboost Dan Principal Component Analysis. *METHOMIKA: Jurnal Manajemen Informatika & Komputerisasi Akuntansi*, *5*(1), 42-47.

[10] Siringoringo, R., Perangin-Angin, R., & Purba, M. J. (2021). Segmentasi Dan Peramalan Pasar Retail Menggunakan Xgboost Dan Principal Component Analysis. *METHOMIKA: Jurnal Manajemen Informatika & Komputerisasi Akuntansi*, *5*(1), 42-47.

[11] Kurniawan, W., & Indahyanti, U. (2024). Prediksi Angka Harapan Hidup Penduduk Menggunakan Metode XGBoost. *Indonesian Journal of Applied Technology*, *1*(2), 18-18

[12] Effendi, M. E., Yuadi, I., & Puspitasari, I. (2023). Prediksi Guru Kemungkinan Tetap Bekerja di Sekolah Al Uswah Surabaya Menggunakan Machine Learning. *Jurnal Informasi Dan Teknologi*, 129-137.

[13] Nur, A., Huffaz, D., Suryani, A. R., Zahra, R. N., & Hutabarat, L. P. T. (2024). Perancangan UI/UX Penjualan Produk Makanan Cireng Mercon Berbasis Mobile di Kota Jakarta. *Journal Of Informatics And Busisnes*, *2*(3), 421-431.

[14] Sitorus, M. C., & Kurniawan, A. (2021). Pengaruh penjualan tunai dan penjualan kredit terhadap profitabilitas perusahaan pada PD Gloria Bandung. *Jurnal Financia*, *2*(1), 13-23.

[15] Maranisya, U., & Putri, S. A. (2022). Pengaruh harga dan sistem penjualan tiket terhadap kepuasan penonton di event konser Be The Sun In Jakarta 2022. *Jurnal Pendidikan Dan Konseling (JPDK)*, *4*(6), 3225-3232.

[16] Balido, A. Z. S., & Setiono, B. A. (2023). Analisis Prosedur Pelayanan Penjualan Tiket Kapal Terhadap Kepuasan Penumpang Pada PT. Pelayaran Nasional Indonesia (PELNI) Cabang Surabaya. *Jurnal Aplikasi Pelayaran dan Kepelabuhanan*, *13*(2), 76-88.

[17] Rahayu, W. I., Andini, A. N., & Salwa, S. (2024). Sistem Transaksi Untuk Penjualan Tiket Event Musik Berbasis Web. *Jurnal Teknik Informatika*, *16*(1), 39-46.

[18] Barit, B. (2021). PERTANGGUNGJAWABAN NAKHODA DI ATAS KAPAL MENURUT UNDANG-UNDANG NOMOR 17 TAHUN 2008 TENTANG PELAYARAN. *Journal of Law (Jurnal Ilmu Hukum)*, *7*(1), 186-198.

[19] Habeahan, H. R., & Lilis, L. (2024). Kinerja Agen Diatas Kapal Dalam Menangani Kedatangan Dan Keberangkatan Kapal Di Pt. Putra Andalas Samudera Dumai. *Journal of Maritime and Education (JME)*, *6*(1), 615-626