Proceedings of the 2nd International Conference on Mathematical Physics and Computational Simulation
DOI: 10.54254/2753-8818/42/20240667

Prediction of second-hand sailboat prices based on multivariate linear interpolation methods

Jingxuan Li[1,2,3], Shuangkai Ye[1,4], Xingyao Li[1,5]

[1]Northwestern Polytechnical University, Xi'an, 710072, PR China
[2]Corresponding author

[3]liliam@mail.nwpu.edu.cn
[4]3569884322@qq.com
[5]483886881@qq.com

Abstract. According to the requirements of the topic, our team has established a mathematical model based on a large amount of relevant data and conducted a quantitative analysis of factors such as the price of sailboats and their length, types, materials, etc. In the process of data analysis and model building, we mainly use interpolation method and error variance analysis, and display these results through charts and figures. In addition, we have used the obtained model to analyze and estimate the price of sailboats in Hong Kong.

Keywords: Sailboats price, interpolation method, error variance.

1. Introductions

1.1. Background

As a kind of luxury goods, the prices of sailboats will change as the conditions change, such as time, the type of sailboats, countries, etc. And as these conditions change, the prices of sailboats will also show some differences. In this question, we need to use existing tabular data and other information obtained through consultation to establish a mathematical model to estimate the impact of factors such as the price of different sailboats, and analyze the impact of geographical factors on the price of sailboats. After that, we need to use the established mathematical model to analyze and discuss the listing price and relevant data of sailboats in the Hong Kong market.

1.2. Restatement of Problem

After rigorous discussion, we found three main points of this question.

- The length of a sailboat is positively correlated with its tonnage.
- The length, price, and time of sailboats are all continuous data.
- Collection of other information and data to further improve the accuracy of the mathematical model

Furthermore, in order to clearly show the relationship between regions and sailing prices, we additionally searched for GDAs in different regions and gross tonnage of ships in different countries. The data involved are all continuous, so the interpolation method is a good way to analyze this problem.

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2. Assumptions

We make the following assumptions to complete our model through this paper. Furthermore, improvements of these simplified assumptions will be achieved later.

Establish a multiple linear regression model based on factors such as the length, width, and manufacturing location of the sailboats.·Find the GDP value and other relevant data of Hong Kong, bring them into the model, and obtain the results. After completing the first prediction, optimize the model based on the results to make it more accurate

3. Notations

In order to verify and confirm the difference between a monohull ship and a catamaran ship, we searched for two types of sailboats.

We use the data in Table 1 and Table 2 [1-3].

Table 1. Data related to monohull sailboats

Number	Model	Width (m)	Length (m)	Empty displacement (Kg)	Draft (m)	Fresh water capacity(L)	Brand	Place of production
1	Sun Odyssey 349	3.44	9.97	5340	1.98	206	Jeanneau	France
2	Sun Odyssey 389	3.76	10.98	6920	1.98	200	Jeanneau	France
3	Sun Fast 3600	3.55	10.8	4950	2.13	100	Jeanneau	France
4	Jeanneau 51	4.7	14.98	14400	2.78	640	Jeanneau	France
5	Moody 41AC	4.6	12.7	6872	2.01	320	Hanse	Germany
6	Dehler 32	3.23	9.75	5982	1.74	100	Hanse	Germany
7	Hanse H348	3.54	10.39	6488	1.95	210	Hanse	Germany
8	Hanse H415	4.15	12.37	7156	2.04	320	Hanse	Germany
9	Hanse H418	4.15	12.37	7234	1.74	475	Hanse	Germany
10	Hanse H675	5.88	21.06	7568	3.08	1000	Hance	Germany
2050	Catalina 315	3.57	9.48	5678	1.92	155	Catalina	USA
2051	Catalina 445	4.18	13.56	6354	1.86	676	Catalina	USA
2052	Hunter 50	4.48	15.21	6678	2.13	734	Hunter	USA
2053	Hunter 45	4.42	13.47	6578	1.98	530	Hunter	USA
2054	Hunter 41	4.04	12.29	6144	1.98	378	Hunter	USA

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Table 2. Data related to catamarans

Order Number	Model	Width (m)	Length (m)	Empty displacement (Kg)	Draft (m)	Fresh water Capacity (L)	Brand	Place of Production
1	Sun Odyssey 349	3.44	9.97	5340	1.98	206	Jeanneau	France
2	Sun Odyssey 389	3.76	10.98	6920	1.98	200	Jeanneau	France
3	Sun Fast 3600	3.55	10.8	4950	2.13	100	Jeanneau	France
4	Jeanneau 51	4.7	14.98	14400	2.78	640	Jeanneau	France
5	Moody 41AC	4.6	12.7	6872	2.01	320	Hanse	Germany
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4. Data Processing

In statistics, the lack of data is very common in the dataset and may cause certain bias in the conclusion. Therefore, data imputation is necessary to eliminate such bias and obtain more concrete results. Through preliminary observation on the dataset, we find that some are missing and garbled data, which has an important impact on the analysis of the problem. Therefore, we first distinguish the anomalous information from the database and then process the missing data. We use the method of deleting by list to do data interpolation.

In order to make up for the lack of relevant data, we have found a series of models of sailing ships of different brands and corresponding parameters, such as ship width, no-load displacement, number of cabins, etc. We also searched and collated some data on second-hand sailboats.

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Table 3. Data related to second-hand sailboats [2]

Model	Length (ft)	Country	year	Listing Price (RMB)	Listing Price (USD)
nautitec541 fly catamaran	53.5	Germany	2016	800	1160799.791
Yano 45 sailboat	45	France	2010	100	145099.9739
Hanse 548 imported sailboat	53.2	Germany	2018	300	435299.9216
Hanse575 luxury yacht	55	Germany	2013	200	290199.9478
Bavarian34 footsailboat	34	Germany	2016	800	1160799.791
Bonado 45 foot sailboat	45	France	2013	200	290199.9478
14.5 meter sailboat	48	China	2011	90	130589.9765
Bavarian 45 foot sailboat	45	Germany	2013	100	145099.9739
Beneteau First 40.7 sailboat	39	France	2008	90	130589.9765
45 foot French catamaran	45	France	2016	400	580399.8955
55 foot catamaran	55	China	2016	300	435299.9216
Jeanneau54 sailboat	53	France	2016	300	435299.9216
46-foot French catamaran	46	France	2020	500	725499.8694
52 foot catamaran	52	China	2019	300	435299.9216
56 foot Geman sailboat	56	Germany	2015	200	290199.9478
German 55 foot sailboat	55	Germany	2010	200	290199.9478
French44 foot catamaran	44	France	2014	200	290199.9478
Italian Comar 37 catamaran	38.2	Italy	2015	200	290199.9478
French 50 foot sailboat	50.5	France	2014	200	290199.9478
Yano 42 sailboat	41.3	France	2007	100	145099.9739
H80 small sailboat	26	China	2021	20	29019.99478
J80 sailing boat	26	China	2016	10	14509.99739
Sunreef 62 catamaran	60	poland	2010	600	870599.8433
Lagoon 420 catamaran	41.3	France	2008	100	145099.9739
Hanse 575 sailboat	56.3	Germany	2016	500	725499.8694

5. Model Construction

5.1. Model

Based on the above table data, we obtained the following result through multiple linear regression [4, 5]of the data:

Price=8.848*len-2.53*GDP

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5.2. Modeling visualization images

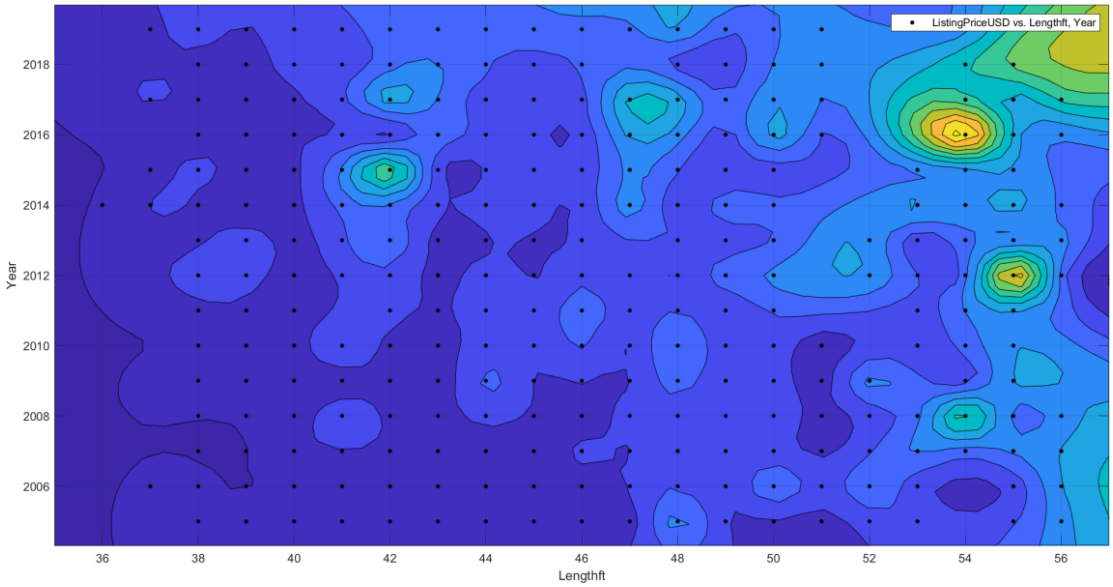

Figure 1. European

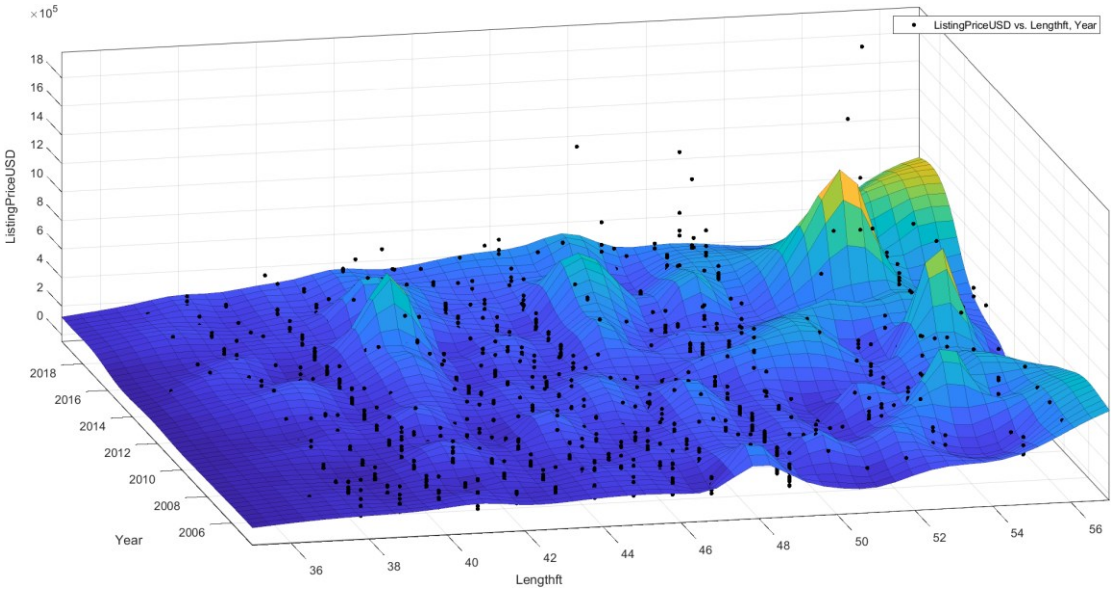

Figure 2. USA

DOI: 10.54254/2753-8818/42/20240667

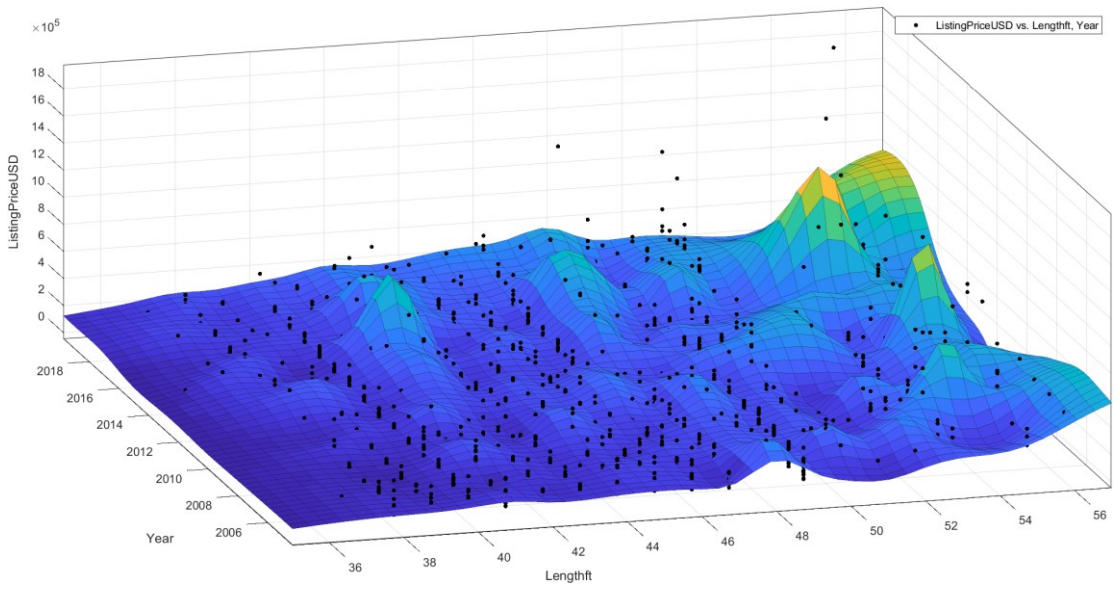

Figure 3. Carlibbean

5.3. Code

```
>> Lengthft = MCMProblemYBoatsWithGDP.Lengththft;
>> ListingPriceUSD=MCMProblemYBoatsWithGDP.ListingPriceUSD;
>> GDP=MCMProblemYBoatsWithGDP.GDP;
>> X=[ones(size(Lengthft)) Lengthft GDP];
>> y=ListingPriceUSD;
>> [b,bint,r,rint,stats]=regress(y,r);

>> disp(b)
   1.0e+0.3*
                    0
   8.848350536861910
  -0.000000000002533
clc, clear, close all, format long g
syms x1 x2 a f=(339-a*x1-0.003*x2)*x1+(399-0.004*x1-0.01*x2)*x2-
(400000+195*x1+225*x2)
f=simplify(f)
f1=diff(f,x1), f2=diff(f,x2)
[x10,x20]=solve(f1,f2)
pretty(x10), pretty(x20)
subplot(121), fplot(x10,[0.002,0.02]), title('')
xlabel('$a$','Interpreter','Latex')
ylabel('$x_1$','Interpreter','Latex','Rotation',0)
subplot(122), fplot(x20,[0.002,0.02]), title('')
xlabel('$a$','Interpreter','Latex')
ylabel('$x_2$','Interpreter','Latex','Rotation',0)
dx1=diff(x10,a), dx10=subs(dx1,a,0.01), dx10=double(dx10)
sx1a=dx10*0.01/4735
dx2=diff(x20,a), dx20=subs(dx2,a,0.01), dx20=double(dx20)
sx2a=dx20*0.01/7043
```

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```
F=subs(f,{x1,x2},{x10,x20})
F=simplify(F)
figure, fplot(F,[0.002,0.02]), title('')
xlabel('$a$','Interpreter','Latex')
ylabel('$y$','Interpreter','Latex','Rotation',0)
Sya=-4735^2*0.01/553641
f3=subs(f,{x1,x2,a},{4735,7043,0.011});
f3=double(f3)
f4=subs(F,a,0.011); f4=double(f4)
delta=(f4-f3)/f4
```

6. Model Analysis

The advantage of this model is that the processing of data is relatively simple, avoiding the impact of some unrelated factors, and being able to analyze the price of sailboats in different countries.

However, the shortcomings of this model are also obvious. Using multivariate interpolation without using machine learning algorithms will inevitably lead to inaccurate prediction results. At the same time, when some conditions change, the model cannot quickly adapt to the changes

7. Conclusion

In summary, we can find that the price of sailboats is not only related to the type, but also closely related to factors such as length, width, manufacturing location, draft, and so on. Through the method of multivariate linear interpolation, we can obtain a mathematical model for predicting the price of sailboats. We also found that the per capita GDP of the region also has a significant impact on the price of sailboats

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