Empiric Study of Ship Maintenance Price Index based on The Hedonic Model

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Abstract. Because the pure-exemplar matching method settles the ship maintenance price index compilation unavailingly due to the heterogeneity characteristics of the ship maintenance activities, the hedonic price theory is put forward into this paper, and the hedonic model of ship maintenance price is established with the combinated data modeling method. And then the hedonic price index of ship maintenance is obtained through this model. Finally, this hedonic price index is compared with the aftermath calculated on pure-exemplar matching method.

1. Introduction

For the ship maintenance price index compilation research, the USA et.al developed country had formulated some economic indicators to adjust the ship maintenance price during different years, such as dedicated inflation rate and Gelfei index [1]. Based on the statistical material, the Chinese scholar used the pure-exemplar matching method to complicate the ship maintenance price index [2]. The characteristics of the commodity or service activities are required to be invariant in this method, to reflect the pure-price change of the commodity or service. But the impact elements to ship maintenance price lead to the heterogeneity characteristics of the ship maintenance activities. If the quality of sample is not to be adjusted, the ship maintenance price index complicated on the original data would not really reflect the change features of ship maintenance price.

Therefore, the hedonic price theory is put forward into this paper, and the hedonic model of ship maintenance price is established with the combinated data modeling method. And then the hedonic price index of ship maintenance is obtained through this model. Finally, this hedonic price index is compared with the aftermath calculated on pure-exemplar matching method.

In the actual application, there are four basic hedonic models[3], such as linear regression, Log-Log regression, Semi-Log regression and Log-Linear regression[4]. And the linear regression and Log-Linear regression are the common-used model [5].

The linear regression model is

$$P = \alpha_0 + \sum \alpha_i x_i + \varepsilon_i \qquad \varepsilon_i \sim N(0, \sigma^2) \quad i = 1,2,\ldots,n \tag{1}$$

The Log-Linear regression model is

$$LnP = \alpha_0 + \sum \alpha_i x_i + \varepsilon \quad \varepsilon_i \sim N(0, \sigma^2) \qquad i = 1,2,\ldots,n \tag{2}$$

2. Selection and Quantification of Ship Maintenance Hedonic Characteristic

The first work of ship maintenance price hedonic model is the selection and quantification of ship maintenance hedonic characteristic [6]. Among the factors of ship maintenance price, the ship technology level, tonnage, rank and round turn of maintenance and district difference all can be selected as the hedonic characteristic of ship maintenance. The pure-price change index of ship maintenance cost caused by the price index can be analyzed through the virtual time variable, and the ship maintenance hedonic price index can be calculated through the parameter estimation of virtual time variable. But the ship maintenance cost sample is not large to modeling, so the combinated data modeling method was used in this paper [7].

Table 1 Quantification principle of each hedonic

Hedonic	Unit	Data range
technology level	Ten-thousand/ton	x_1>0, continuous change
tonnage	ton	x_2 >0, continuous change
rank and turn	virtual	dock repair x_3 =0,1,2,3,4; minor repair x_4 =0,1,2,3; overhaul repair x_5 =0,1.
district difference	virtual	district 2: x_6 =0 or 1; district 3: x_7 =0 or 1; and $x_6 * x_7$ =0.
time variable	virtual	second year: x_8 = 0 or 1; third year: x_9 = 0 or 1; $x_8 * x_9$ =0.

3. Foundation of Ship Maintenance Hedonic Price Model

Take the ship maintenance cost sample from 2012 to 2014 as the modeling data, and each hedonic value was calculated in table 2.

Table 2 Description of ship maintenance cost and hedonic

number	cost	x_1	x_2	rank and turn			district		time variable	
				x_3	x_4	x_5	x_6	x_7	x_8	x_9
1	170	41.617	2226	3	0	0	0	0	0	0
2	654.5	40.976	2226	0	1	0	0	0	0	0
…	…	…	…	…	…	…	…	…	…	…
25	99.280	28.364	1070	1	0	0	0	1	1	0
26	105.655	28.832	1070	1	0	0	0	1	1	0

3.1 The Hedonic Model Foundation

Take the sample of table 2 to the linear regression model, and the ship maintenance hedonic linear model can be got as (3).

$$P = -65.802 - 20.153 x_1 + 0.517 x_2 - 54.577 x_3 + 208.245 x_4 + 617.135 x_5 - 94.097 x_6 - 48.955 x_7 + 260.195 x_8 + 243.853 x_9 \quad (3)$$

And the estimate and test of each regression parameter was also showed in table 3.

Table 3 Estimate and test of each regression parameter

parameter	Estimated value	Standard deviation	t-Statistic	Prob.
α_0	-65.802	306.031	-0.215	0.833
x_1	-20.153	19.609	-1.028	0.319
x_2	0.517	0.269	1.918	0.073
x_3	-54.577	50.117	-1.089	0.292
x_4	208.245	161.387	1.290	0.215
x_5	617.135	128.922	4.787	0.000
x_6	-94.097	106.027	-0.887	0.388
x_7	-48.955	87.012	-0.563	0.582
x_8	260.195	83.760	3.106	0.007
x_9	243.854	85.297	2.859	0.011
R	0.901	Adjusted R-squared		0.764
R-squared	0.812	Akaike info criterion		12.986
F-statistic	18.618	Schwarz criterion		13.470
Prob(F-statistic)	0.000	Durbin-Watson stat		2.333

The t-Statistic and R-squared of model (3) was unsatisfactory, and the D-W value was larger than 2, there was heteroscedasticity in this model. So we should use the Log-Linear regression model.

Take the sample of table 2 to the Log-Linear regression model, and the ship maintenance hedonic Log-Linear model can be got as (4).

$$\ln P = -2.377 - 0.810 \ln x_1 + 1.285 \ln x_2 + 0.139 x_3 + 1.1481 x_4 + 2.083 x_5 + 0.174 x_6 + 0.285 x_7 + 0.160 x_8 + 0.307 x_9 \quad (4)$$

And the estimate and test of each regression parameter was also showed in table 4.

Table 4 test of of model 4

parameter	Estimated value	Standard deviation	t-Statistic	Prob.
α_0	-2.377	2.135	-1.113	0.040
$\ln x_1$	-0.810	1.145	-0.707	0.015
$\ln x_2$	1.285	0.796	1.615	0.047
x_3	0.139	0.110	1.268	0.023
x_4	1.481	0.334	4.434	0.000
x_5	2.083	0.283	7.362	0.000
x_6	0.174	0.210	0.829	0.031
x_7	0.285	0.175	1.631	0.036
x_8	0.160	0.172	0.929	0.009
x_9	0.307	0.179	1.715	0.026
R	0.973	Adjusted R-squared		0.915
R-squared	0.946	Akaike info criterion		0.565
F-statistic	30.853	Schwarz criterion		1.049
Prob(F-statistic)	0.000	Durbin-Watson stat		1.890

Test analysis

1) D-W value test. The D-W value of model (4) was 1.890, so the heteroscedasticity was inexistence in model (4).

2) Variance homogeneity test. In the majority situation, the observed value distributed randomly around the linear line, which passed through the 0, this condition can be showed as fig 1.

3) Normality test of residual. The fig. 2 was Residual histogram, and fig. 3 was Residuals of the cumulative probability map. Through the two figures, we could say the residual satisfied the normal distribution.

3.2 Calculation and analysis of ship maintenance price index

In the model (4), the parameter of time variable in 2013 was 0.160, this value in 2014 was 0.307. If the ship maintenance price in 2012 was P_1, the price in 2013 was P_2, and the price in 2014 was P_3, according to the model (4), we could get this result: $\ln P_2 - \ln P_1 = 0.160$, $\ln P_3 - \ln P_1 = 0.307$.

So, if the 2012 was base year, the ship maintenance price index in 2013 and 2014 respectively was $LI_{2013}=\exp(0.160)\times 100 = 117.4$, $LI_{2014}=\exp(0.307)\times 100 = 135.9$.

4. Summary

As one mean to reflect the change of ship maintenance cost, the hip maintenance price index is the important standard to formulate and adjust the ship maintenance plan. The hedonic theory was put forward into this paper, and the hedonic model of ship maintenance price is established with the combinated data modeling method. And then the hedonic price index of ship maintenance is obtained through this model. Meanwhile, this method used in this paper can be popularized into the calculation other equipment price index.

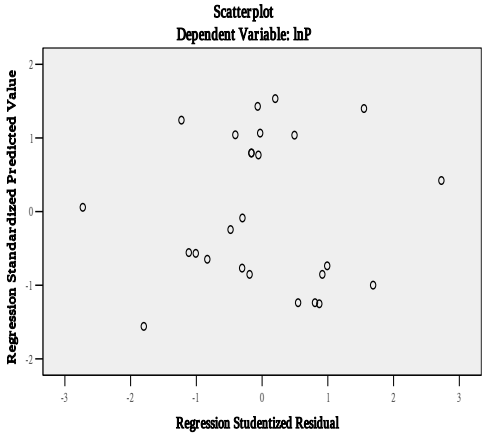

Fig. 1 Predictive value of the dependent variable and the residual scatter plot

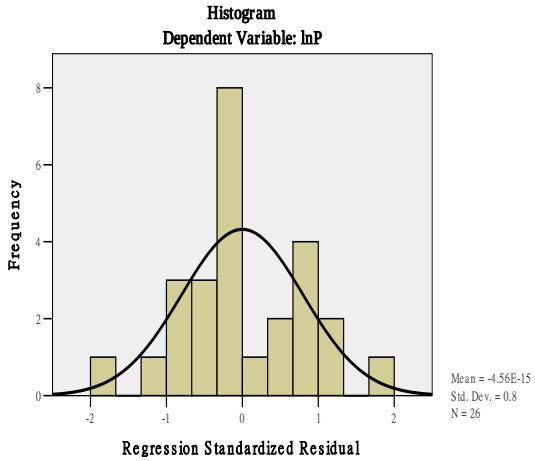

Fig. 2 Residual histogram

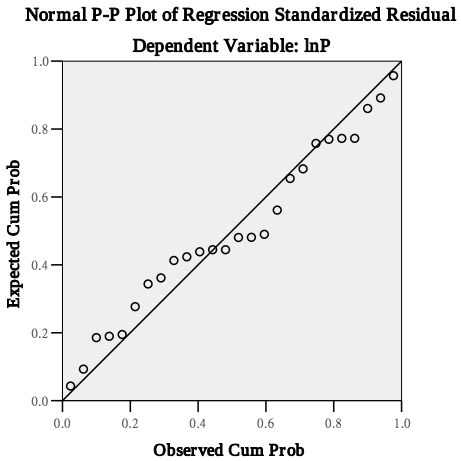

Fig. 3 Residuals of the cumulative probability map

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