Winter 12-4-2009

Property Price Modelling: The Regression Model and The Neural Newtwork Model

Y V Hui

S L Cheung

PROPERTY PRICE MODELLING: THE REGRESSION MODEL AND THE NEURAL NEWTWORK MODEL

Y V Hui and S L Cheung
Department of Management Sciences
City University of Hong Kong, Hong Kong
msyervan@cityu.edu.hk

Abstract

Hedonic regression models are widely used in housing price studies. However, incorrect identification of the functional relationship may lead to potential bias. This research studies the neural network model in modeling housing price. A neural network model is regarded as a nonlinear regression model without a predetermined functional form. The adoption of the neural network model could overcome the biasness inherent in the hedonic price regression model. The performance of neural network models and hedonic regression models are discussed based on the Hong Kong property price data.

Keywords: Hedonic Regression, Neural Network Model

Introduction

There are two widely adopted approaches in modeling housing price indices. The repeated sales model follows the changes in the prices of the properties that are sold more than once in the study period and the hedonic regression model considers the relationship between the property price and the property attributes. Although repeated sales models have been used in constructing housing price indices, there are deficiencies to apply the repeated sales models in predicting property prices.

Hedonic Price Model

Hedonic regression was first introduced by Lancaster (1994) for measuring market price. Dipasquale and Wheaton (1996) suggest a multiplicative relationship between the property's sales price and its attributes. That is,

$$P_j = \prod_{j=1}^{k} X_{ij}^{\alpha_i} \qquad (1)$$

where the parameter values α of the housing attributes *X* are assumed to be stable over the study period. In order to model the relative changes in market valuation of housing attributes over time, it is multiplied by the exponential term of time shifts.

$$P_j = (\prod_{j=1}^{k} X_{ij}^{\alpha_i}) \exp(\sum_{t=1}^{T} \beta_t D_t) \qquad (2)$$

where the dummy variables *D* account for the trend in housing prices over the study period. The modeling of Hong Kong residential property prices using hedonic regression models are presented in Mok et al. (1995) and Cheung (2003). Cheung (2003) also discussed the construction of the Hong Kong residential property price index, Centa-City Index, using the hedonic regression approach.

Housing Attributes

Kingswood Villa is one of the popular residential estates in the suburban area of Hong Kong. All units are high-rise apartments in a total of 58 blocks constructed in six phases. There were over four thousands transactions in 1997 and over one thousand transactions annually. Since all housing units in this study are high-rise units, twenty four housing attributes such as floor level, direction, window view, etc are selected as important factors to affect the selling price. The hedonic price regression model is developed using the Land Registry's transaction data recorded from July 1996 to June 1997 and the unit attributes collected from Centaline Property Agency Limited. A set of time-dependent variables is added to model the monthly changes in the market evaluation of housing attributes. The data was fitted to the following hedonic regression model:

$$\ln P_j = \sum_{i=1}^{k} \ln \alpha_i X_{ij} + \sum_{t=1}^{T} \beta_t D_t \qquad (3)$$

It is found that twenty unit attributes and all time dependent variables are significant.

Neural Network Model

It is known that the hedonic regression model may encounter potential bias from incorrect specification of the functional form between unit attributes and housing price. A neural network model combines many computing modules (neurons) into an interconnected system (neural network). It mimics the complex relationship between the dependent variables (output modes) and the independent variables (input nodes). A neural network model is regarded as a flexible nonlinear regression model without an explicit form. It could overcome the bias problem inherent in the hedonic regression model.

The Kingswood Villa data is considered in the neural network study. The dependent variable is the logarithm of unit price per square foot and all the unit attributes in the hedonic regression model are included in the neural network models. We include the time variable, WEEK, to represent the weekly change in the economy in the neural network model.

The data set (4,639 records) are split into three parts: training data set (40%), validation data set (30%) and testing data set (30%). Two neural networks: MLP(2, 2) and MLP(3, 3) are constructed. The model sum of squared errors are 3.6333 and 4.0233 for MLP(2, 2) and MLP(3, 3) respectively.

Comparisons Between Neural Network Model and Hedonic Price Model

Theoretically, the neural network model is preferred over the hedonic price model since it assumes a nonlinear relationship between the dependent variable and the independent variables. However, a common phenomenon, overfitting, usually exists in neural network modeling. In this case, the model gives a small sum of squared errors but its prediction power is not guaranteed.

Eight hundred transaction records (out sample) are taken from the period immediately after the study period that the hedonic regression model and the neural network models are fitted. The sum of squared prediction error is used to evaluate the model performance. The results are presented in the following table:

Model	**Sum of Squared Error**	
	In sample	**Out sample**
MLP(2,2)	3.6333	5.8515
Hedonic regression	3.7983	4.0873

It is shown that the out-of-sample prediction error of the hedonic price model is smaller than that of the proposed neural network model.

Conclusion

Although neural network models overcome the bias encountered in the hedonic price models, hedonic price models usually have better prediction powers.

References

[1] Cheung, S.L., A study of the Hong Kong housing prices, MPhil thesis, City University of Hong Kong, 2003.

[2] Dipasquale, D. and Wheaton, W.C., *Urban Economics and Rea Estate Markets*, Prentice Hall, New Jersey, 1996.

[3] Lancaster, K.J., A new approach to consumer theory, *Journal of Political Economy*, 74, 1966, 132-157.

[4] Mok, H.M.K., Chan, P.P.K. and Cho, Y.S., A hedonic price model for private properties in Hong Kong, *Journal of Real Estate Finance and Economics,* 10, 1995, 37-48.