Model of forecasting public housing demand in the capital cities in China based on LS-SVMs

Ying Xie[1, a], Li Yang[1], Xiaohang Zhang[1]

[1]*Civil Engineering , Northeast Forestry University,Harbin, China*

[a]*missxie20032003@163.com*

Abstract. Public housing construction has contributed a lot to the economic development in China. Based on the fact that the demand of public housing must be reasonably forecasted, which is an important basis to ensure the sustainable development of the economy, in order to optimize public investment and land resources, there are many uncertain factors to change the medium and long-term middle-lower income families. Considering public housing construction scale typically energy-intensive and resource-intensive activities, especially for the purpose of improving performance of public housing construction in China, in this paper, based on the national statistic data, characteristics of public housing demand have been analyzed. Because of the dynamic nature of public housing demand and the specificity of sample data, leading to forecasting of public housing demand very difficult, so a intelligent estimation model based on least squares support vector machines is presented to improve the forecasting process. The proposed model takes advantage of LS-SVMs ability to solve the problem with small samples and nonlinear regression. Furthermore, the proposed approach is shown more accurate for prediction in the case of real-word application.

Keywords: Public housing , Demand, Forecasting

Introduction

After 30 years' development, public housing construction has become an important job which has been regarded as a kind of pillar basement of national economy in China [1][2]. However, public housing construction is a typical production activity of high consumption of energy and resources, which brings new pressure and challenge to Chinese governments[3].

High investment and land resource commitment has attracted general attention of government policy makers. Therefore, green building theory and social demands assessment methods are becoming important [4, 5]. However, under these circumstances, how the government investment and construction decision-makers making the rational plan and ensure the implementation of goal, is a very critical problem[6]. And that is the special significance of the suggestion to the future of construction industry in China, especially for the trends and management orientation of the real estate market. It is obvious that according to the traditional extensive economy growth mode, the resources available are far from adequate to support the rapid economy growth in China, especially for construction industry move toward a higher footprint with huge impact on land consumption and public investment. So, it is necessary to predict the overall public housing demand for construction industry development planning and offer essential data reference and basis for government decision-makers [7,8]. In this paper, we discussed the unique characteristics of public housing demands in the capital cities in China. In addition, intelligent technology is utilized due to the complexity of this research being too difficult to be quantified; a comprehensive estimation model based on Least Squares Support Vector Machines is presented to improve the prediction process for public housing demand of construction industry in China. The research is organized as follows. Section 2 presents important status of public housing construction in China's economy development and its production characteristics. Section 3 describes the status of public housing construction and its' production characteristics. Section 4 the model of public housing demand. An illustrative is presented in Section 5. Section 6 summarizes the work of this paper.

Important Status of Public Housing Construction and Its' Production Characteristics

In the process of the urbanization development in China, with the rapid economic development, the urban land prices are more and more expensive, which has resulted in higher real estate prices than most of the purchasing power of urban families. Public housing is a form of housing tenure in which the property is owned by a government authority,

which may be central or local, the common goal of public housing is to provide affordable housing.

To promote the economic sustainable development in China, public housing construction goal is explicitly stipulated by the central government. The government provides public housing through various sources, such as new housing, abandoned properties, and old flats which are rented at a low price. Additional housing is built by providing free land and exemption from fees to estate developers.

Although there are a lot of public housing productions have been provided in the past 20 years, more public housing demands were put forward with the rapid urbanization development, especially in the capital cities in China. The provision of more affordable housing is one of the key components of China's Twelfth Five-year Plan, which targets the construction of 36 million homes by 2015. That program's costs will be split mostly by the public sector. and are estimated at five trillion yuan by Chinese investment bank. Additionally, public housing construction, as part of construction industry, is also such resources-intensive production activity owning low intelligence, low added value, and high consumption. Our country has invested a large amount of resources to the construction department these years. Specifically, the related sectors of the national economy are supplied, such as building materials and other non-metallic mineral products, metal product manufacturing, machinery and equipment manufacturing, and worker compensation etc.

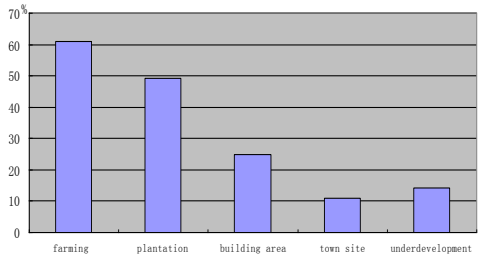

Fig. 1 Statistics of land utilization in Harbin

The social population. The development of urban population is a dynamic process, which is closely related with the country's population policy, economic development, social environment and land resources etc. For example, in Harbin, the permanent population of the sixth national registration is about 10.64 million, with an increase of 1.222612 million people than the fifth national registration, in average annual growth rate of 1.23%.

Model of Public Housing Demand Forecasting

In many practical situations, the information about public housing and their performances are incomplete and uncertain. Therefore, multi-attribute estimation models are needed to solve effective public housing demand under incomplete information.

We formulate the estimation problem as a typical nonlinear higher-dimensional estimation problem with small samples. Due to the short history and the complexity of its internal attributes, public housing demand results in the inapplicability by traditional

Attributes of Public Housing Demand the Capital Cities

Land utilization. In the process of our country's urbanization, the rest of land resources is increasingly a most pressing problem. A large amount of infrastructure construction projects have caused serious damage to the ecological land environment. The higher construction outputs, the more serious shortage of the land resources. In terms of normal and past routine, the land resources the capital cities are classified into three categories, farming land, building area and the land of underdevelopment etc. The detailed statistics of land utilization is shown in Fig. 1.

The worker wages. In the capital cities, jobs are mainly concentrated in the unprivate economic entities, the total number of employment of State-owned enterprises and collective enterprises decreased year by year. At the same time, the average wage income of people in state-owned enterprises and collective enterprises appeared increasing more smoothly, shown in Fig. 2. Only the low-income employees have the potential demand for public housing.

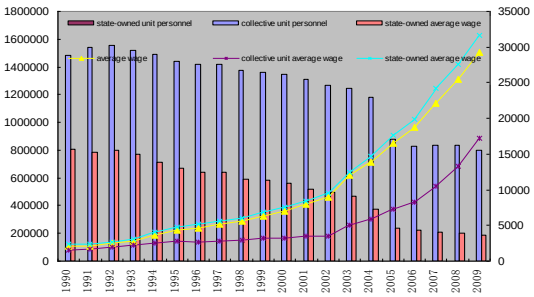

Fig. 2 Statistics of the work wage in Harbin

methods. Artificial neural networks (NNs) are one of artificial intelligence means. However, the basic principle of NNs is empirical risk minimization (ERM) principle, and which makes neural networks suffer

critical drawbacks, such as over-fitting problem of NNs. Recently, least squares versions of SVMs have been investigated for classification and function estimation [9]. Least Squares Support Vector Machines (LS-SVMs) are reformulations to the standard SVMs which lead to solving linear Karush-Kuhn-Tucker (KKT) systems. In these LS-SVM formulations, computational calculations of SVMs are simplified by implementation of a least-squares version instead of inequality constraints and a sum squared error cost function as it is frequently used in training of classical neural networks. This reformulation greatly simplies the problem in solving a set of linear equations, instead of the quadratic programming used in classical SVMs.

In order to investigate the public housing demand, this study forecasts middle-lower population in the big cities in China based on LS-SVMs. Due to the dynamics of a non-linear system, LS-SVMs is selected to configure

model structure. The aim of public housing demand forecasting is to find a mapping with excellent generalization capability. Let the estimation function of the public housing demand be

$$Q = Z(y)\cdot\lambda \quad (1)$$

where λ is the selected floor space standard, and $Z(y)$ is the base of middle-lower population , commonly is some statistic indicator of middle-lower population, affected by the construction attributes above.

In LS-SVMs, the solution is characterized by a linear system. Such linear system has been called Karush-Kuhn-Tucker (KKT) system and their numerical stability has been investigated. Due to using of equality instead of inequality constraints in the problem formulation, it takes a similar form as the linear system that one solves in every iteration step by interior point methods for standard SVMs and can be efficiently solved [10].In LS-SVMs, a linear estimation is done in a kernel-induced feature space

$$z(\mathrm{y}) = \omega^{\mathrm{T}}\varphi(\mathrm{y}) + b \quad (2)$$

As in SVMs, it is necessary to minimize a cost function containing a penalized regression error, as

$$\min_{\omega,e} J(\omega,e) = \frac{1}{2}\omega^{\mathrm{T}}\omega + \frac{1}{2}\gamma\sum_{i=1}^{d} e_i^2 \quad (3)$$

The second part of the above model is the regression error for all training data. The parameter γ has to be optimized by the user. Equation (3) gives the definition of the regression error.

We have a typical problem of convex optimization which can be solved by using the Lagrangian multipliers method. One defines the Lagrangian

$$L(\boldsymbol{\omega},b,e,\alpha) = J(\boldsymbol{\omega},e) - \sum_{i=1}^{d}\alpha_i\left[\boldsymbol{\omega}^{T}\varphi(\mathbf{x}_i) + b + e_i - z_i\right] \quad (4)$$

with Lagrangian multipliers $\alpha_i \in R$, $z_i = \boldsymbol{\omega}^{\mathrm{T}}\varphi(y_i) + b + e_i$, i=1,2,…,d, and $e_i \in R$.

The conditions for optimality are given by

$$\begin{cases} \dfrac{\partial L}{\partial \boldsymbol{\omega}} = 0 \quad \rightarrow \boldsymbol{\omega} = \sum_{i=1}^{d}\alpha_i\varphi(\boldsymbol{x}_i) \\ \dfrac{\partial L}{\partial b} = 0 \quad \rightarrow \sum_{i=1}^{d}\alpha_i = 0 \\ \dfrac{\partial L}{\partial e_i} = 0 \quad \rightarrow \alpha_i = \gamma\, e_i \quad i = 1,\cdots,d \\ \dfrac{\partial L}{\partial \alpha_i} = 0 \quad \rightarrow z_i = \boldsymbol{\omega}^{\mathrm{T}}\varphi(\boldsymbol{x}_i) + b + e_i \quad i = 1,\cdots,d \end{cases} \quad (5)$$

These conditions are similar to standard SVM optimality conditions, except for the condition $a_i = \gamma e_i$. According to Mercer's condition, there exists a mapping and an expansion

$$K_{ij} = K(y_i, y_j) = \varphi^{\mathrm{T}}(y_i)\varphi(y_j) \quad (6)$$

Where $y_i, y_j \in R^{n^*}$, i,j=1,2,…,d.

After elimination of ω and e, the solution is obtained

$$\begin{bmatrix} 0 & \mathbf{1}^{\mathrm{T}} \\ \mathbf{1} & \mathbf{K} + \boldsymbol{\Lambda} \end{bmatrix}\begin{bmatrix} \mathrm{b} \\ \boldsymbol{\alpha} \end{bmatrix} = \begin{bmatrix} 0 \\ \mathbf{z} \end{bmatrix} \quad (7)$$

With

$\mathbf{z} = (z_1,\cdots,z_d)^{\mathrm{T}}$, $\Lambda = diag\left\{\frac{1}{\gamma},\cdots,\frac{1}{\gamma}\right\}$, $\mathrm{K} = \{k_{ij}\}_{d\times d}$, $\boldsymbol{\alpha} = (\alpha_1,\cdots,\alpha_d)^{\mathrm{T}}$, and $\mathbf{1} = (1,\cdots,1)^{\mathrm{T}}$.

As a result, the LS-SVMs model of the public housing demand becomes

$$z(\mathrm{x}) = \sum_{i=1}^{d}\alpha_i K(\mathrm{y},\mathrm{y}_i) + b \quad (8)$$

Where $k(\cdot,\cdot)$ is defined as the kernel function.

Based on Mercer's condition, we defined $k(Y,Y_i) = \phi^{\mathrm{T}}(Y)\phi(Y_i)$.

For $k(\cdot,\cdot)$, we select the Gaussian kernel

$$k(\mathrm{Y},\mathrm{Y}_i) = exp\left\{-\frac{\|\mathrm{Y}-\mathrm{Y}_i\|^2}{\sigma^2}\right\} \quad (9)$$

Case Studies

For evaluating the validity of the proposed model, in the case studies, we perform public housing demand by using the data of National Bureau of Statistics of Harbin. According to the method of computing resources used, the floor space standard is 60 m^2 . According to the above floor space standard, the core issue is to how to forecast the scale of floor space of buildings under construction. The database comprises 14 samples in all. Simulation is made to provide a controlled public housing construction scale which is useful to assess the effectiveness of the proposed model.

The estimating accuracy is tested in terms of the mean absolute percentage error (MAPE) defined by

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{\left|z_{actual(i)} - z_{forecast(i)}\right|}{z_{actual(i)}} \cdot 100\% \quad (10)$$

To demonstrate the validity of the proposed model, public housing demand scale were estimated respectively by conventional approach based on ANN,SVMs and the presented model and the forecast results were illustrated in Table Ⅰ.

Model	IMAPE（%）
ANN	9.03
SVMs	8.26
LS-SVMs	8.34

Table 1. Comparison between Models of Different Algorithms

According to Table Ⅰ, it could be concluded that the proposed model could provide a more accurate construction cost estimating than the conventional SVMs and LS-SVMs models.The estimation result shows the scale of public housing construction scale will reach 1.152 million square meters if the average wage growth rate contains 12.5 percent in 2013.

Summary

In this paper, the main characteristics and attributes of public housing demand was first analyzed. Then, attributes obtained were input into LS-SVMs to estimate effectively public housing demand. As a result, we could acquire higher estimating accuracy model of public housing demand better than the conventional ANNs and SVMs models. This motivates further reach in this direction in the future.

Acknowledgements

This research was supported under the postdoctoral research project of "Study on the Key Technologies of Public Housing Plan based on the Complex Spaces: An Example of Harbin" funded by Heilongjiang Ministry of Human Resources and Social Security.

References

[1] Pan Yuhong, Shao Huilin, 2009. 'An Outline of the Chongqing Construction Industry for Housing Industrialization'. *International Conference on Management and Service Science* , pp. 1-4.

[2] Hao Deng, Jin Xu & Hong Zeng. 2008, 'Study on Measures and Strategies of Use Safety Management of Buildings in Longgang District of Shenzhen'. *International Conference on Information Management, Innovation Management and Industrial Engineering*, pp. 490-493.

[3] Shi, J.J., Zeng, S.X. & Tam, C.M. 1998. 'Modeling and simulation of public housing construction in Hong Kong', *Simulation Conference Proceedings*, pp. 1305-1310.

[4] Ibrahim Dincer& Marc A. Rosen. 1999, 'Energy, environment and sustainable Development', *Applied Energy* vol 64, pp. 427-440.

[5] Jun Li,Michel Colombier 2009. 'Managing carbon emissions in China through building energy efficiency,' *Journal of Environmental Management* vol 90, pp. 2436–2447.

[6] Cherry, S. 2007, 'How to Build A Green City,' *Spectrum, IEEE* , pp.26 - 29.

[7] Qian Shi & Shoufeng Chen. 2008, 'Evaluation of Green Construction Alternatives Based on Value Engineering,' *WiCOM'08. 4th International Conference on Wireless Communications, Networking and Mobile Computing*, pp.1–6.

[8] Shang Chunjing, & Zhang Zhihui. 'Building a New Concept System for Construction Quality Assessment of Life-cycle Carbon Emission for Buildings,' *Journal of Engineering Management*, 2010, pp. 2–6.

[9] Suykens J A K, & Vandewalle J. 1999, 'Least Squares Support Vector Machine Classifiers,' *Neural Processing Letter*, vol. 9(3), pp: 293-300.

[10] Li Xie, Hua Zheng, Lizi Zhang, Dec. 2007, 'Electricity price forecasting by clustering-LSSVM,' *Power Engineering Conference,IPEC 2007. International*, , pp. 697-702.