# A Real Estate Early Warning System

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The real estate market is vital for national economic development, and it is of great significance to research an early warning method to identify an abnormal status of the real estate market. There is the warning status of the Beijing real estate market went from a fluctuation status to a stable "Normal" status from 2000 to 2020, and the warning status is expected to be more stable under a "Normal" status in the next decade under the same political and economic environment. The PSO-LSSVR model was found to have accurate prediction ability and demonstrated generalization ability.

## 1. Introduction

Over the past few decades, the rapid development of China's real estate market has actively contributed to the rapid growth of China's GDP, especially after the 2008 global economic crisis. Moreover, the rapid development of the real estate industry has also led to the development of the construction industry, decoration, home appliances, furniture industry and so on. According to the China Statistical Yearbook 2021, the GDP of the real estate industry accounted for 7.3 percent of the country's total GDP, and the property-related construction industry accounted for 7.2 percent of the country's total GDP in the year 2020 [1]. On the other hand, the real estate industry has become an important part of fixed asset investments, where fixed asset investments are one of the troikas for economic growth (investment, export and consumption). Hence, the developing real estate industry has become one of the important economic pillars of China's economic development. However, the excessive development of any industry will bring negative effects on society.

First, when the real estate boom is excessively prosperous, there will be a large number of excess funds, bank loans and corporate funds flowing into the real estate market, which will lead to the phenomenon of "industry emptiness" (the decline in the development level of the primary and secondary industry lead to the unbalanced structural proportion of national economic demand and the continuous shrinkage of domestic investment, which, in turn, lead to the substantial reduction in employment opportunities and social problems, such as a rising unemployment rate) [2].

Second, the development of the real estate market is closely related to the macroeconomy. Excessive development of the real estate market promotes the investment flow into related industries, which leads to a shortage of resources supplied to other industries [3]. To solve such conditions, the government usually restrains the development of the real estate industry through credit regulation and land regulation policies, which leads to the rapid cooling of the real estate industry and economic recession [4]. The excessive development of the real estate industry and the drastic macro-control will lead to excessive fluctuations in the macroeconomy [5].

Last, but not least, the rapid development of the real estate industry has introduced a large amount of investment of capital and the public. Excessive investment will lead to the market price being greater than the actual price, which leads to economic bubbles in the real estate industry [6]. When the bubble bursts, the loans from financial institutions and banks to real estate enterprises will turn into bad debts, which will lead to the occurrence of an economic crisis and financial crisis in serious cases, and then lead to industrial depression, the sharp increase in unemployment and crime rate, and other social problems [7]. The economic depression caused by the bursting of the real estate bubble will bring enormous harm to the national development and living quality, as the U.S. real estate bubble burst in the late 1980s led to the bank crisis, and at the beginning of the 21st century, the U.S. real estate bubble burst led to the subprime mortgage crisis and the biggest financial crisis since 1930. The real estate bubble burst in Japan in the 1980s set off a decades-long economic recession. These classic real estate bubble bursts offer warnings for other countries' real estate developments.

In contrast, if the real estate industry appears excessively depressed, the public, capital and government will lose confidence in the real estate industry, which will further affect the development of the real estate industry and the development of the macroeconomy [8]. Moreover, the construction industry, which is closely related to the real estate

industry, and the back-end industries will be seriously affected [9]. Therefore, it is necessary to establish an early warning system for the real estate market to prevent the bubble and further enormous harm to the national and social development. A real estate market early warning system can also help the urban government and supervisory agencies to reduce the risk of bubbles in advance [10]. Furthermore, a real estate market early warning system can provide a scientific basis for the government's macro-control and correctly guide investors away from irrational investment and consumption in the real estate market to promote the healthy and stable development of the market [11].

## 2. History and Development

The real estate industry has the characteristics of information asymmetry, fixedness and transaction dispersion [12][13], and the effective balance of the general industrial structure and supply–demand relationship of the real estate industry cannot be achieved only through market forces [14]. Hence, research on the real estate market is complicated and diverse. With the continuous development of science and technology, more and more automatic methods were applied to the sustainable development of the real estate market, such as artificial intelligence [15] and machine learning [16].

In a previous study, Pyhrr et al. observed the cyclical phenomenon of the Western real estate market since the 1960s and then researched the change laws and periodic mechanism of the real estate market [17][18]. With the in-depth study of the real estate cycle, scholars gradually realized the importance of early warning for the real estate market. In the 1990s, Nieboer et al. first established a real estate market early warning system based on the housing vacancy rate by studying the relationship between the housing vacancy rate and the trend of the real estate market in the Netherlands [19]. Subsequently, as a country with a well-developed real estate market, the United States found the real estate downturn signal of the Chicago community by observing the fluctuation and mechanism of the real estate cycle, and then detecting seven abnormal change indicators and establishing the original real estate early warning model [20]. With the proposal of the Case–Shiller (CS) housing price index, scholars used to research the relationship between the real estate market and macroeconomic phenomena by combining the Case–Shiller housing price index and early warning leading indicators [21][22]. Huang et al. adopted the deep learning method in the Time-Varying Parameter-Vector Autoregression (TVP-VAR) model to research the monitoring and early warning of systemic financial risk, where the results showed that the real estate market is closely related to the country's systemic financial risk [23].

In addition, scholars in different fields researched the methods and applications of early warning systems [24]. With the development of the research field, the concept and methods of early warning systems have been widely introduced into the aerospace study [25][26], ecological systems research [27], seismic research [28][29], transportation study [30][31], medical study [32][33] and real estate study [34].

With the rapid development of science and technology, more methods have been adopted in the research of early warning systems. Begusic et al. adopted the system dynamics to research the system risk in the financial market and real estate market, which was achieved by researching the spatio-temporal spillover effect of system information feedback to obtain early warning signals of the market [35]. Huang and Feng proposed an early warning method based on the monitor indicators and statistical method and simulated the policy regulation of the real estate market in Shenzhen by combining system dynamics [36]. Yang used computer technology based on the principle of the PROBIT model to design an early warning system to analyze risk verification in the real estate market and the results showed that the early warning system had an approximately 85% early warning rate [37]. Kholodilin and Michelsen used modern machine learning methods to forecast the real estate market bubbles in Germany and presented an early warning model to analyze the speculative risk in the real estate market; furthermore, they provided some market intervention suggestions for the German government [38]. Wang et al. analyzed the real estate market in Beijing by establishing an early warning model based on multi-class support vector machines and put forward policy suggestions for the healthy operation of the real estate market [34]. Based on previous research on the real estate market, it was found that the machine learning model has better processing capacity than the transmission statistical model for solving nonlinear problems [39][40]. In recent years, scholars established early warning index systems for the real estate market through different methods, and conducted early warning research through qualitative and quantitative methods, promoting the research of early warning index systems to gradually reach a mature stage of development.

Based on the relatively mature development of the real estate early warning indicators research, further research of indicator selection should take into account the market supply–demand relationship, internal coordination, external economic factors and so on. The methods for early warning systems were developed from basic index analysis research methods to statistical research methods and then to comprehensive early warning models. Moreover, with the in-depth research, the early warning research of the real estate market has changed from qualitative research to a combination of qualitative and quantitative research. With the rapid development of computer science and artificial intelligence, more and

more theories and methods were introduced into the real estate early warning model, and new research ideas were developed [41]. However, in the current research on the real estate market early warning, the problems of a small sample, overall generalization ability and nonlinearity cannot be solved easily.

Due to the complexity of the real estate market system and the lack of historical data, there will be insufficient training, unstable performance and overlearning when the neural network is training. All of these factors will lead to unsatisfactory prediction results. As a result, Cortes [42] proposed the support vector regression (SVM), which has demonstrated excellent performance in solving small-sample, nonlinear, high-dimensional problems. That is why SVR, the regression version of SVM, is widely used in energy research [43]. SuyKens et al. [44] improved least-squares support vector regression (LSSVR) in 1999, the least-squares formulation of SVR, which has better generalization abilities and powerful computation. Chou et al. [45] found that LSSVR is more accurate than regression analysis and neural networks for building energy consumption. However, there are still disadvantages to LSSVR due to the choice of kernel and regularization parameters; therefore, particle swarm optimization (PSO) was introduced to improve the LSSVR. PSO-LSSVR was successfully employed in many fields, especially in the evaluation of engineering projects. For this reason, some scholars specifically analyzed and examined its operating principle [46][47]. In addition, the LSSVR model has the characteristics of a fast training speed, which is helpful to obtain a more effective regression model in a complex system. The PSO model has the characteristic of a fast convergence speed, which can further improve the accuracy of the prediction. Through continuous iteration of the PSO model, the most appropriate prediction parameters can be quickly found. The most important point is that the LSSVR model is suitable for exploring potential lows from historical data and predictions, while the PSO model has relatively low requirements for optimization functions; therefore, the PSO-LSSVR model is more suitable for the research of the real estate market with small data [48]. However, PSO-LSSVR in real estate market prediction has not been widely applied.

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