System Dynamics and Genetic Artificial Neural Network Models for the Monitoring and Early Warning of Urban Housing Market

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Abstract

The problem of empty houses in Taiwan continues to concern the public. The Government currently conducts housing survey to detect the number of empty houses every year. But, no systematic analysis of the monitoring and early warning programme has been undertaken to improve the situation. This study formulated dynamics and genetic artificial Neural Network models for the monitoring and early warning system stimulating. Several strategy scenarios were conducted. The research findings showed that economic strategy has a more positive and profound impact than financial one; joint strategy often has a better policy assessment compared to a single strategy. The method developed in this study is a comprehensive and systematic approach to achieve the sound housing market in Taiwan.Keywords: System dynamics, Genetic artificial neural network, Monitoring and early warning, Urban housing market

1. Introduction

According to a survey (DGBAS 2011), Taiwan's housing vacancy rate (17.6%) remained high, and Taichung City was the most serious area (26%). Considerable vacant housing resources were idle, which led to a heavy cash/flow pressure, affecting society resource utilization and financial market stability. A housing bubble crisis existed. This situation was due to relaxed capital and low interest rates, resulting in large-scale fluctuation in the urban housing market.

The real estate business cycle illustrates a constrained urban housing market, shocked by the urban population increase or decrease, time limitations of market supply and demand, ups and downs of the economic environment, loosening and

tightening of financial policies, and many other factors, showing systematic, dynamic, fuzzy, feedback, causality, and sensitivity characteristics (Ho, et al, 2010; Liu Cheng-chih, etc., 2010). Due to the fickle nature of the urban housing market, the government adopts the "trial and error method" to implement its strategy. Greater use of loan interest rate movements, fiscal and financial strategies to regulate the market, and ignoring reversals caused by the market's time skew and delay characteristics result in greater fluctuation effects (Chen Hsin-yi, 2003; Ho, et al, 2010), and the strategy performance and suitability often become the focus of the debate! Because of the absence of a comprehensive systematic thinking and the non-construction of the dynamic simulation model of the housing market, the dynamics of the trend cannot be grasped. As the existing mechanism cannot integrate the strategy regulation into the system for scenario simulation, the effects of policies (in particular, the long-term effects) cannot be pre-assessed and thus easily fall into the error zone of "symptomatic solutions."

The four key operations to improve the urban housing market include understanding the past, grasping the current situation, forecasting implementation, and creating monitoring and clear early warning. This study adopted the systems engineering approach to analyze the urban housing market operation. By system dynamics, the real number genetic artificial neural network, and the empirical study of Taichung, dynamics and GANN models of were formulated using the Vensim DSS 5.10 (respectively) and Super PCNeuron 5.0, which create scenario simulations subject to high dynamic and strong instant local conditions to enhance urban housing market risk control, strengthening the effective use of resources and promoting the sound development of the urban housing market.

2. Research Method

2-1 Systems Engineering (SE)

Systems engineering is based on systematic exploration and takes into account all uncertainties. Logical and organized tools and steps are used to find the order relationship between the composition elements in the system and to measure the inter-relationships between the elements and the whole system. For an in-depth understanding of the entire system, the effects of various possible options to achieve the goals are examined. So that the overall system performance can achieve optimal goals, the optimal design of systems is obtained to assist decision makers to select the appropriate action. To face the large and complex urban housing market, this study applied the principles and methods of the Systems Engineering theory, joint with

computer technology, and conducted scientific implementation of the three levels, including system analysis (system and subsystem build, index correlation analysis), system design (dynamic modeling, scenario simulation), and system-integrated assessment (systematic reviews, innovative applications) to construct the dynamic simulation model of the urban housing market early warning system (Sage et al, 2000).

2-2 System Dynamics (SD)

System Dynamics is a specific method, tool, and concept for the study of complex systems. The process-oriented research method reaches an in-depth understanding of counter-intuitive behavior of the dynamic system. The modeling method of the causal feedback and dynamic flow diagram is used in quantitative analysis, and the computer simulation provides policy design and simulation learning. For the complex, dynamic, feedback nature and time delay problem, an overall, long-term and more comprehensive exploration is provided to specialize in cyclical, long-term, multi-variable, high-end, non-linear, delay characteristics. And with a strong forecast, the back-testing feature can achieve the purpose of combining with the history to access the trend description of future system behavior. The urban housing market involves a complex part of the overall urban development and market operation mechanism, showing “dynamic complexity,” “high nonlinearities,” “deferred delays,” and other features. However, the SD modeling techniques and the basic equation form are quite flexible. The use of dynamic modeling techniques and mathematical equations in the urban housing market system dynamics forecast simulation analysis has the unique research advantages of simplification, quantity and quality, dynamic simulation and policy assessment, etc. (Roberts, et al., 1978; Coyle, 1996; Sterman, 2000).

2-3 Genetic Artificial Neural Network (GANN)

Artificial Neural Networks (ANN) have been widely used in classification and forecast fields. However, as the nonlinear optimal solution space uses the gradient-decent search, under longer training times, they may converge to a local maximum and use the evolutionary techniques of the Genetic Algorithms (GA) to overcome this.

The GANN uses ethnic groups and possesses a hidden “parallel calculation function.” A group of equidistance discrete points synchronically computes and searches the object. More schemas will show the search ability and naturally jump to

another range to find the optimal resolution in the whole field due to execution of parallel exploration. This parallel processing model does not easily fall into the plight of local maximum solutions, but resolves the serious noise problem, nonlinearities, instability, uncertainty, and the inadequate benefit of fits between the warning signs index and the warning zone derived from the time series of the urban housing market. This study gives full play to the nonlinear processing capability and pattern recognition capabilities of the GANN, which possesses a strong function fitting ability for simulating the nonlinear reflection relationship between the urban housing market warning signs index and the warning situation to construct the urban housing market early warning model of the artificial neural network (Graupe, 1997; Yeh, 2009).

3. Model Formulation

3-1 System Dynamics Model

Based on the relevant literature, this study considers the characteristics and experiences of the urban housing market in Taiwan. Using systems engineering technology, it initially proposes objectives to develop scientific, measurable, and comparable assessment index variable sets. A total of 25 experts in the fields of urban design, urban planning, architectural design, construction management, real estate investment management, economics, and sociology were invited. Using the Delphi fuzzy expert survey method (Ho, Wang, 2008) to determine the variables set, 5 sub-systems, urban population, housing demand, housing supply, housing economy, and housing finance, and 36 index variables were compiled. Vensim Lookup was used for the process and to establish a system dynamics flow diagram and feedback loops of the urban housing market in Taichung (Fig 1).

(1) Urban Population Sub-system

The urban population sub-system represents the urban housing market scale index which evaluates market supply and demand relationships and also affects investment strategy directions. The fluctuation of the urban population, number of households and housing demand are closely related.

Bartik(1991); Gabriel(2000); Jud & Winkler(2001) both found that the urban population is an important factor of the urban housing market, The reasons that cause population number fluctuation include population natural increase and society increment. These two factors combine to become the urban population annual increase, urban population fluctuation and average household amount combine to

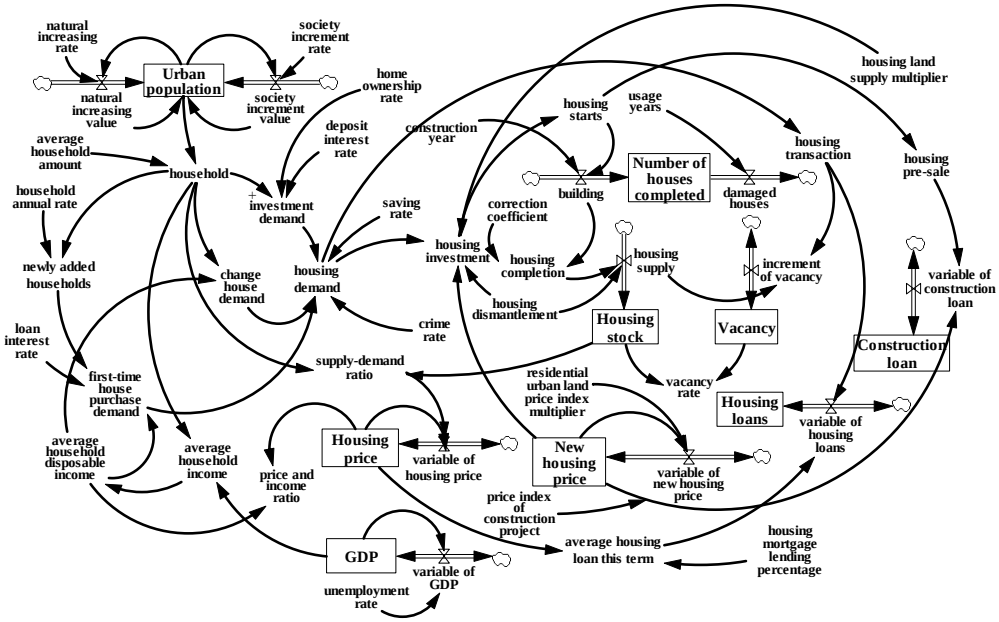

Fig 1 Flow diagram and feedback loops of the urban housing market in Taichung

affect household changes. Household demand is motivated by different causes. The causes can be divided into first-time house purchase demand and repeated house purchase demand. First-time house purchase mainly comes from new households that are formed by external households and sub-households. When new households appear on the market, the housing market will face first-time house purchase demand. We can calculate this figure by observing the number of new households. Repeated house purchase and investment demands are housing demands from existing house owners who have the ability to purchase and have sufficient financial ability to purchase another house for personal use or investment.

This sub-system model consists of 1 accumulative factor, 2 rate factors and 6 supporting variables. Urban housing living behavior is based on households as the basic unit, as is market transaction. The number of households depends on the total population and household structures. Therefore, it is necessary to first understand the situation of urban population growth and household structure changes. The total urban population is 1 accumulative factor: the total of the natural increments and social increments, separately restrained by natural increasing rates and social increasing rates.

(2) Housing Demand Sub-System

Housing demand sub-system represents the urban housing market functionality status index; it is the internal force that promotes urban housing market development. Citizens' house purchase objectives vary; urban housing markets can be divided into personal use demand (first-time house purchase, repeated house purchase) and investment demand. The former comes from satisfying self ownership needs, the

latter comes from the purpose of re-sale to achieve profit.

Jud & Winkler, (2001), Meen & Andrew (1998), Kenny (1999) study pointed out that family income is closely related to the housing price. First-time house purchase demand comes from new households living in the city. When new households are formed, the housing market will see first-time house purchase demand. This is the market's potential house purchase demand. When the average household disposable income increases, it represents an increase in consumption ability and therefore is related to first-time house purchase demand. Loan interest rates are another factor for consideration. When loan interest rates are relatively low, house buyers will be able to buy houses and therefore stimulate market demand. Therefore, first-time house purchase demand, no matter whether this demand will turn into actual home purchase behavior, average household disposable income and ability to afford houses are closely related. The causal relationship between average household disposable income and first-time purchase demand is positive, with loan interest rates, the relationship is negative.

Change house demand takes place when existing house owners wish to pursue a higher standard of living or when their houses are no longer suitable or too old. Change house demand arises from all households living in the city; similarly, change house demand is also caused by average household disposable income, the more a household earns, the higher their ability to change house.

Housing investment demand is affected by deposit interest rates, the increase and decrease of interest rates influences urban housing demand in terms of investment demand, when investment returns are higher than putting the money in a bank to collect interest, buying and selling houses becomes a very lucrative investment method. When profit is high, the investment demand will be high; when banks' deposit interest rates are low investment behavior will also be more optimistic in the urban housing market.

Saving rate and crime rate can stimulate or restrain housing demand for first-time house buyers, change house demand and investment demand and thus affect housing investment and transactions. Housing stock and household ratio are known as the supply-demand ratio, this ratio is often seen as a monitoring tool on household market supply and demand, to see if they are balanced. When the ratio is too big, it means that housing supply is higher than demand. When housing stock too high, it will lead to empty houses and increase in vacancy rates. When the ratio is too small, it means that housing supply-demand is imbalanced and thus housing price inflation is the next step.

This model consists of 8 supporting variables. According to the total households,

new households, home ownership rate, average household disposable income and impact multipliers of loan interest rate and deposit interest rate in the housing finance sub-system, first-time house purchase demand, house changing demand and investment demand are worked out, further considering the comprehensive impact of savings rate and crime rates in housing economy sub-system on the overall housing market to estimate total housing demand.

(3) Housing Supply Sub-system

The housing supply sub-system represents the urban housing market functionality status index and is also an indicator of how the urban housing market is performing. The internal energy of the housing market supply comes from the strength of housing demand; it is affected by new house prices and supply of housing land, investment demand, pre-sale housing and housing transactions. The main source of market supply is housing market investment plans. Results from the research have shown that the housing lifecycle consists of investment, construction, completion, usage, lifecycle etc. There is a two-year delay between construction and completion and a normal house typically has a 60-year usage lifetime. Then it will see damage and then finally be dismantled. These factors cause untimely housing demand and supply; therefore there are price fluctuations in the market.

The long-term supply elasticity of the domestic residential market for 1.2965, short-term housing supply elasticity is 0, indicating that long-term housing supply closer to the perfectly elastic perfectly elasticity, short-term supply inelastic.（Lin & Lin, 2001）. Houses undergo design, construction and then completion - housing supply is derived when we subtract the year the house is completed from the year in which it is dismantled. In one way it is the cumulative change in the amount of housing stock; in another it is the difference between the housing price and transacted price leading to an increase of empty houses, changing vacancy rates and -- through domestic supply and demand ratio feedback -- impacts the strength of domestic demand. Financial policies play a critical role in the housing lifecycle of investment, construction and transaction. Investors' behavior will be affected by housing loan value; house buyers will leverage long-term bank mortgages to purchase their houses. When the housing market bubble bursts, there will be housing finance risks and challenges.

The dynamic housing supply model includes 3 accumulative factors, 4 rate factors, 8 supporting variables and 3 constants. The most critical part of the system is that the housing supply is with a characteristic of an average 2-year time lag. In the model, housing was designed in the Main Chain method: from construction and completion to damage; applying the deferred function and setting up construction as 2

years, the housing completed volume was subsequently extended. This is the method used to calculate housing supply volume, housing stock, supply-demand ratio, number of vacant houses and vacancy rate.

(4) Housing economic sub-system

The Pyhrr & Copper(1982)；Chen(1989); Abraham & Hendershott(1996); Quigley(1999);; Seko(2003)；Abelson et al(2005), Huang & Wang(2005), Liu(2006) studies have shown that GDP, savings rate, the employment rate can effectively strengthen the housing capacity, and a direct impact on the urban housing market ups and downs.

The housing economic sub-system represents the urban housing market functionality status index and is also an indicator of how the urban housing market is performing. Housing transactions can be divided into two types -- pre-sale houses and middle-to-old houses. Housing prices will, therefore, differ and this research will divide studies into new housing price and old housing price. The former is mainly affected by the district or city the house is located in and the prices of the construction materials. These factors form a combined effect, restricting and affecting housing investment behavior. The latter is affected by loans and forms a negative causal relationship with supply-demand ratio. Together with the average household disposable income ratio, it is known as the price and income ratio and is a very important variable for the “House Purchase Pain Index.” To study how the urban housing market is performing, this variable is very important.

How the housing economics index impacts the urban housing market is explained by housing demand and supply. Housing demand factors include house purchase capability and strength of overall housing demand. The former is based on lower unemployment rates. Increased GDP can expand average household disposable income, reduce prices and income ratios, increase citizens’ house purchase capability and therefore stimulate housing market transactions. The latter works with high saving rates and low crime rates to build an excellent living environment and so improve overall housing demand. Housing economics refers to how housing supply is influenced by prices of construction materials and the prices of land in the district or city. When construction costs increase, housing construction will slow down and new housing prices will affect investment.

This model includes 3 accumulative factors, 3 rate factors, 5 supporting variables and 1 constant. The unemployment rate is used to determine the GDP, and the GDP distribution rate is used to estimate average household disposable income. By the construction price index and impact multiplier of the residential area urban land price index, the new housing price is determined. The supply-demand ratio from

the housing demand sub-system is used to estimate housing price changes and is joint with the average household disposable income to calculate the price-income ratio. The simulated GDP, housing price and new housing price become the explicit index to demonstrate the urban housing market.

(5) Housing finance sub-system

Stein(1995); Abraham, & Hendershott(1996); Jud & Winkler(2001); Kenny (1999); Bi(2001); Chen(2005) pointed out that the mortgage is directly related to the urban housing market, and demand for houses is a stimulating role, the final drive housing prices.

The housing finance sub-system represents the urban housing market functionality status index and is also an indicator of how the urban housing market is performing. To ensure that citizens' housing demands are met and their living standards improved, the housing finance strategy is a tool that the government uses to adjust and control the urban housing market. The finance strategies used include government subsidies, tax incentives and interest rates which can be divided into loan interest rates and deposit interest rates. The former has a stronger impact on first-time house buyers. When loan interest rates are low, the number of first-time house buyers increases and vice versa; therefore, the relationship is negative. The latter has a more obvious influence on investment demand because it takes advantage of the house's store of value. For those with investment demands, when profit from the transaction is higher than putting the money in the bank, buying and selling houses becomes a very lucrative investment. Therefore, deposit interest rates retrain investment demand. This is a negative causal relationship; when deposit interest rates are low, investors are encouraged to enter the housing market.

The housing investment industry has high rewards and risks; investors have to be well-versed in housing development projects and financing methods to increase their investment capability. New construction projects cost more, the development scale is bigger, the pre-sale amount is higher and construction financing behavior is stronger. The number of construction loans requested will, therefore, increase. It will become important to observe the housing market finance index. Regarding the goal of "house dwellers to own their houses," citizens mostly see their houses as collateral and therefore many will approach financial organizations for loans, the government will suppress interest rates to enhance purchasing and to strengthen citizens' house purchase ability and these factors will cause the number of loans applied for to increase. It is the external index to observe a flourishing housing market

This sub-system model includes 2 accumulative factors, 2 rate factors and 4

variable factors. The loan interest rates and deposit interest rates in the system will determine overall demand volume. Housing loan percentages in response to housing price determine the amount of current housing loans, further affecting the housing loans. Construction loans are affected by new housing prices of the housing economy system and become the quantitative index for housing finance observation.

3-2 Sensitivity Analysis

In this study, the calculation and analysis of the sensitivity variables are undertaken to discover variables with larger impacts on the system change and to understand the main reasons causing the change of system state by dividing the variables into proactive sets and reactive sets to observe via the "Impact-response Matrix" (Kano Noriaki, 1999) the direct impacts of policy changes on the observation index. The results (Table 1) showed that, in the proactive set, the three variables with the greatest impact on the entire system are unemployment rate (30), price index of construction projects (28) and housing loan interest rates (27). Overall, the policy oriented with the housing economy has the highest relevance on urban housing market development, and housing finance orientation is second to it.

Table 1 Sensitivity Analysis (Variables-Response Matrix)

Name of parameter	Total urban population	GDP	Housing stock	Vacant houses	Housing price	New housing price	House purchase loan	Construction loan	Supply-demand ratio	Vacancy rate	Price-income ratio	Average purchase loan	AS
Natural increasing rate	1	0	1	1	3	0	2	3	3	1	3	3	**21**
Social increasing rate	2	0	1	2	3	0	3	3	3	2	3	3	**25**
Average households	0	0	2	3	3	0	3	3	3	3	3	3	**26**
Annual household increasing rate	0	0	3	3	3	0	3	3	3	3	3	2	**26**
Home ownership rate	0	0	2	3	1	0	2	3	3	3	1	1	**19**
Residential lend supply	0	0	3	3	3	0	3	3	3	3	3	2	**26**
Construction year	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Deposit interest rate	0	0	1	1	1	0	1	1	1	1	1	1	**9**
House purchase loan interest rate	0	0	3	3	3	0	3	3	3	3	3	3	**27**
House purchase loan percentage	0	0	0	0	0	0	0	0	0	0	0	3	**3**
Savings rate	0	0	1	1	3	0	1	1	1	1	3	3	**15**
Unemployment rate	0	3	3	3	3	0	3	3	3	3	3	3	**30**
Crime rate	0	0	3	3	3	0	1	3	3	3	3	3	**25**
Residential area urban land price index	0	0	1	2	3	2	1	3	2	2	3	3	**22**
Price index of construction project	0	0	2	3	3	3	2	3	3	3	3	3	**28**
PS	**3**	**3**	**26**	**31**	**35**	**5**	**28**	**35**	**34**	**31**	**35**	**36**	

Note: 1.AS: impact value, AS = Σ column values, refers to the sum of pro-active impact of variables.
2.PS: response value, PS = Σ line value, refers to the sum of passive impact of variables.

3-3 Initial Sumulation of Model

The systems dynamic model was calculated to forecast the trends of Taichung's housing market system from 2009 to 2031. The calculations show that the overall trend of the market is still growing. This is shown by the fact that in addition to the housing prices, the housing loans, population, construction loans, housing stock, GDP and new housing price all showed growth (Fig. 2). Under these circumstances, this study takes the sensitive variables of the housing loan interests, unemployment rate and cost of construction as the base of the strategy scenario analysis for the genetic artificial neural network model of Taichung housing market.

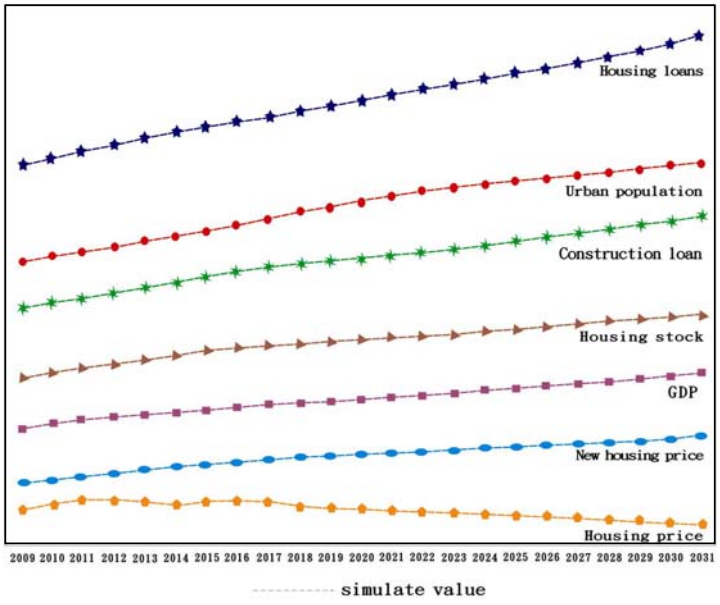

Fig 2 Initial Simulation of System Dynamics Model

3-4 Genetic Artificial Neural Network Model

The Genetic Artificial Neural Network (GANN) is an adaptive pattern recognition technology that does not require a pre-given discriminant function of the model but uses a self-learning mechanism to automatically form required decision-making regions. Such network features as topology, neuron characteristics, and learning and training decision rules make full use of the status details to conduct training on how to access the mapping relationship one-by-one. This study examines the advantages of the GANN recognition technology application in the early warning system of the urban housing market, with the GANN input nodes of the early warning indicators after pretreatment and the output nodes corresponding to the urban housing market's five-level warning degrees. Using the GANN pattern recognition technology to nonlinearly map the warning sign degrees, the alarm situation and policy

implementation of the urban housing market are evaluated (Fig 3).

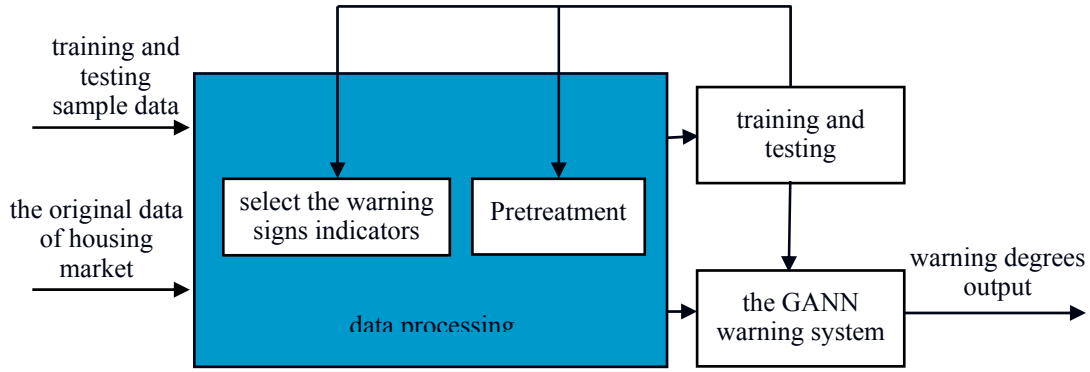

Fig 3 The model of GANN recognition technology to housing market early warning system

The GANN inputs are a set of warning indicators that reflect the urban housing market conditions, including the city's total population (X1), GDP (X2), housing stock (X3), vacancy volume (X4), housing prices (X5), new case standard unit prices (X6), purchases of housing loan balances (X7), construction loan balance (X8), period average housing loan amount (X9), housing price-income ratio (X10), supply and demand ratio (X11), and vacancy rate (X12), for a total of 12. Each indicator of the input layer consisting of 12 neurons has only 17 data entries. The data 17 years of data were processed prior to input. To prevent the system's data size causing early-warning performance interference, the original data is replaced with the rate of change to build the early warning model.

The GANN output is designed to reflect the alarm level of the urban housing market, or the "warning degree." In the design of the early warning system for urban housing markets, the five monitoring indicators of (0,0,0,0,1) (0,0,0,1,0), (0,0,1,0,0), (0, 1,0,0,0), (1,0,0,0,0) correspond respectively to the five market conditions of the overheated market (red bar), the heating-up market (yellow-red bar), the stable market (green bar), the stagnant market (yellow-blue bar), and the freezing market (blue bar). The output layer has 5 neurons and seeks a 12-dimensional Euclidean space R12 to 5-dimensional space R5 to approximate the model mapping process (Table 2).

The Taichung housing market served as the empirical object, with the sample training and testing conducted based on the decision network structure and size. The test results show that the mode training sample's root mean square error (RMSE) was 0.04387, and the test sample root mean square error (RMSE) was 0.02878, indicating a good training effectiveness as a feasible GANN early warning mode for the urban housing market.

Table 2 Housing market indicators warning criteria

score	signal	warning degrees	warning intelligence	exclusion policies
49-60	Red	5	overheated	to control economic growth
41-48	Yellow-red	4	heating up	Health areas, but growth has accelerated, short-term transfer of heat or slowing
33-40	Green	3	stable	To promote stable economic growth
25-32	Yellow-blue	2	cooling	health areas, growth has slowed, the short term the cold or stabilization
12-24	Blue	1	freezing	growth strongly stimulate economic

Further study was conducted on empirical early warning samples, and the housing market warning signs data for 2010-2031 was applied in the urban housing market system dynamic simulation model, pretreated by rate of change, and guided into the GANN network. The trained warning database is used to simulate and reflect the future alarm situation of the Taichung housing market. The results show a long period of stagnantion is predicted for the housing market for 2010-2031. Strategies will need to be actively implemented to boost the market economy (Figure 4).

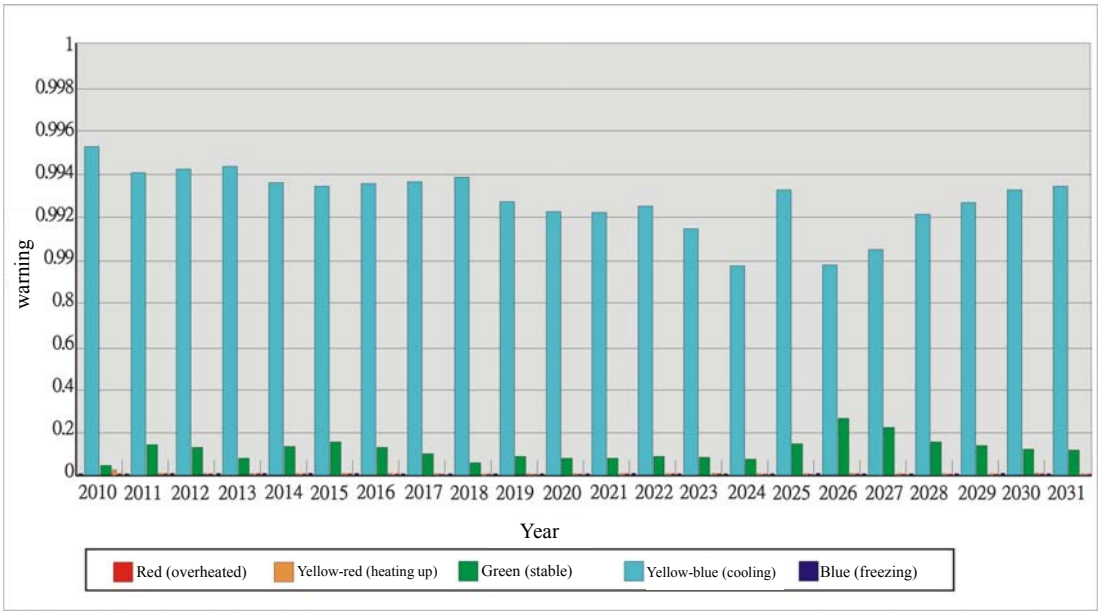

Figure 4 The Prosperity of the Housing Market in Taichung (2010-2031)

4. Strategy Scenario Analysis

In the urban housing market changing mode of this study, the main exogenous variables can be the intervention point to improve the model behavior. As proposed by

Legasto & Maciariello (1980), clear policy objectives are set in a goal-oriented way to implement the policy in sequence. To ensure the effective use of urban housing resources, the policy objectives are to enhance the public housing purchase ability and improve the housing finance environment. Housing prices, new case standard unit price, supply and demand ratio, housing price-income ratio, and vacancy rate in the basic simulation are used as benchmarks to measure improvements in the system performance, and the behavioral change trends of the housing price and other indicators of the system model after the implementation of home loan interest rate, the unemployment rate, the single strategy and comprehensive strategies of the construction cost are observed for policy assessment.

4-1 Single Strategy

(1) Financial policy-raising home loan rates and the improved housing financial environment

In response to the economy stimulus package and the reduction of the domestic public burden of home loan interest, the government has approved the "NT$120 billion Youth preferential mortgage and credit guarantee project" and the "NT$200 billion preferential housing project" since 1990, followed by "NT$200 billion in preferential housing project loans" and "housing subsidies low-interest mortgages." The "Youth's housing subsidy program" and "NT$200 billion in preferential housing project loans" and other multiple housing loan preferential projects were also launched in early 2009. To stimulate the housing market prosperity, the government provided interest subsidies, resulting in the longest era of low interest rates. The bank lending rate dropped sharply from 9.6% in 1993 to 2.27% in 2006. So far, the totals of construction financing, public home loans, and home improvement loans have been more than 40% the credit amount. The capital flows into a single industry, seriously distorting the country's overall financial structure. In simulation, the setting is adjusted to either 3.5% or 5.5% for 2011.

- Strategy 1 (s1): Low intensity raised lending rates: Home loan lending rate + STEP (0.746, 2011)
- Strategy 2 (s2): High intensity raised lending rates: Home loan lending rate + STEP (2.746, 2011)

Overall, the upward adjustment of lending rates adds to the burden of homebuyers, shrinking the demand side and causing a reaction from the supply side. Besides the supply and demand ratio maintaining a more consistent developing trend of the original model, other warning indicators show different changes. In s1 strategy, the fine adjustment of the 3.5% lending rate for housing stock, purchase of housing

loan balance and construction loan balance produces a more moderate downward revision. The vacancy volume and vacancy rate produce short- and medium-term effects, but are adverse to long-term operation. Adverse to the housing market operation, the suppression of prices, the price-income ratio, and the reduction of the period average home loan amount have a short-term effect and medium- and long-term slow rise. In the s2 strategy, the 5.5% loan interest rates for the housing stock, vacancy volume, vacancy rate, home loan balance, and construction loan balance substantially improves the whole process. Curbing housing prices, housing price-income ratio, and reduction of the period average home loan amount produce a significant short-term effect and a significant medium-term reversal. Adverse to prices, the long-term effect shows the stagnant constrained circumstances of excessive tightening of supply and demand in the housing market (Fig 5-8)

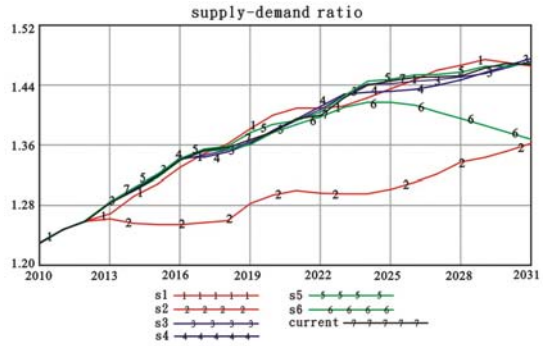

Fig 5: Scenario results of supply-demand ratio for single strategy

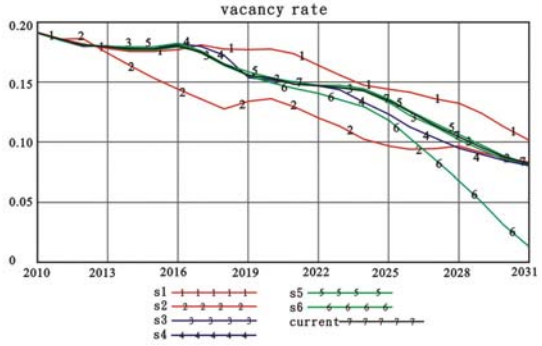

Fig 6. Scenario results of vacancy rate for single strategy

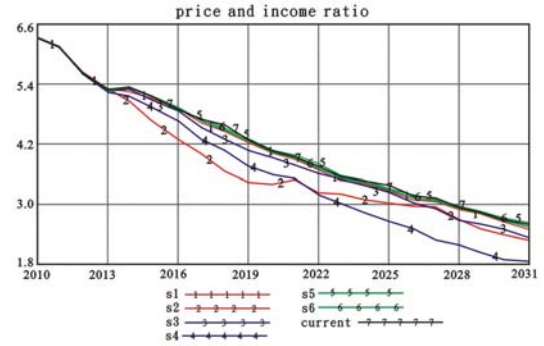

Fig 7. Scenario results of price and income ratio for single strategy

Fig 8. Scenario results of housing price for single strategy

The implementation of s1 and s2 financial strategies reflects the impact time and impact size of changes in loan interest rates of different intensities on different warning signs. To enter the warning sign changing rate into the original GANN model, under the s1 low intensity raised lending rate (3.5%), the future warning situation of the housing market is still cooling (Figure 9). Under the s2 high intensity raised lending rates (5.5%), the market shows an easy short-term situation from 2017-2019, freezing conditions in 2028, and still cooling for other years (Figure 10).

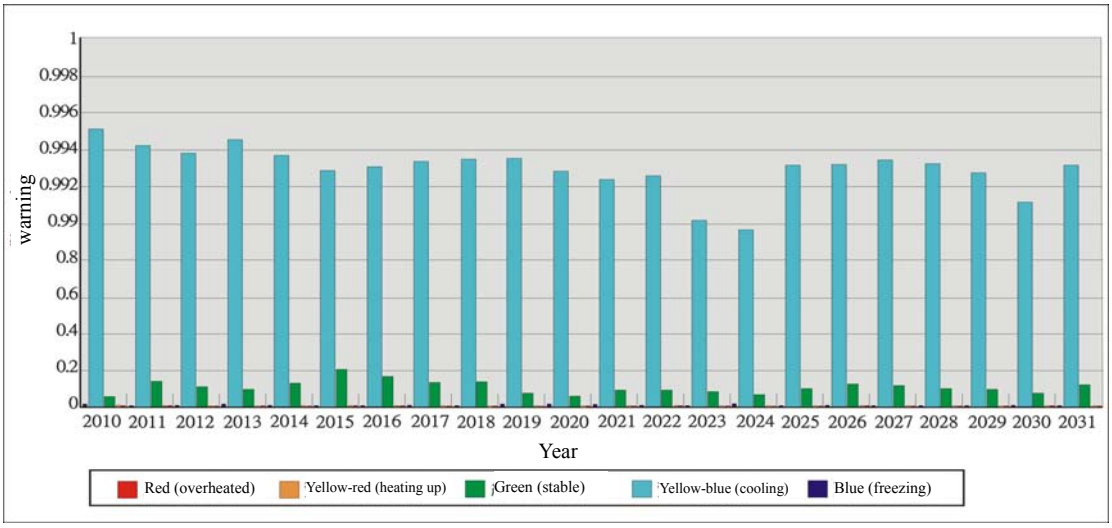

Figure 9 The monitoring indicators of the housing market in Taichung under implementation of s1

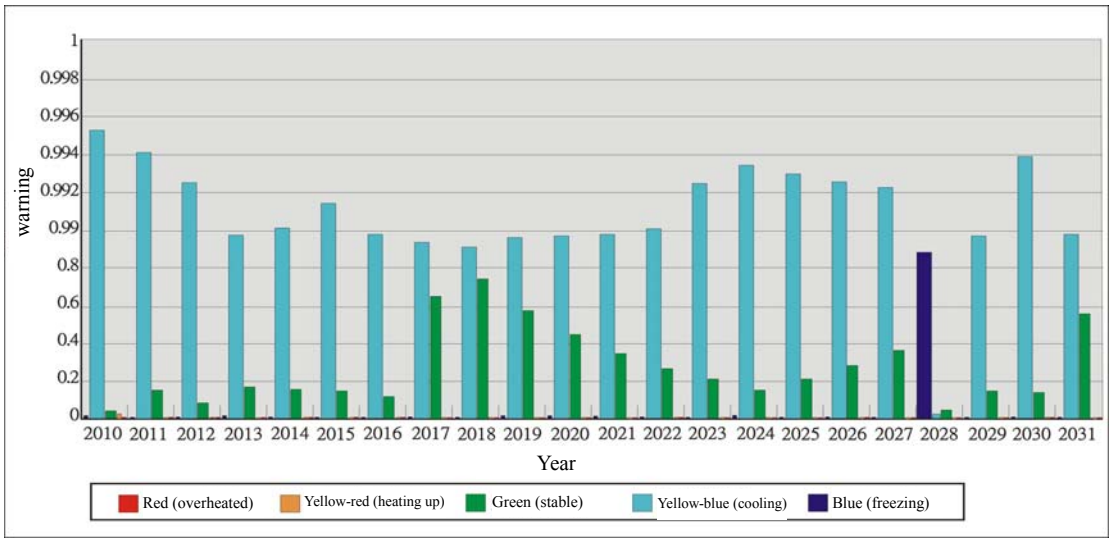

Figure 10 The monitoring indicators of the housing market in Taichung under implementation of s2

(2) Economic policy – reducing the unemployment rate, improving the ability of public housing

The overall domestic unemployment rate saw a reversal of changes in line with economic growth trends. To maintain the lower level of about 1.5% unemployment rate in 1995 and gradually move up to 5.74% in 2009, which, although lower than the United States (10.0%), Canada (8.5%), United Kingdom (7.8%), and Germany (7.8%), but higher than Japan (5.2%), Hong Kong (4.9%), South Korea (3.5%), and Singapore (3.4%), ranked first among the Four Asian Little Dragons (National Statistics Taiwan, 2010), resulting in a low domestic economic growth rate (-2.53% to 5.98%, 3.36% on average) and a low GDP annual growth rate (-2.52% to 6.25% average annual growth

rate of 2.66%) for nearly 10 years. The slow growth rate of economic conditions squeezed the ability of public housing, which derived “the housing misery index” from the housing price-income ratio. Since 2005, the Taichung unemployment rates ranged from 4% to -4.7%, and the housing price-income ratio climbed from 5.65% to 7.56%. The United Nations “Urban Indicators Guidelines” mentions for cities in developing countries, a housing price-income rate of 1:(4-6) being appropriate. In this study, the unemployment rates for 2011-2015 were consecutively decreased by 0.1% and 0.3%, and follow-up maintained at 3.7% and 2.7%, observing the housing market changes.

- Strategy 3 (s3) low intensity to reduce the unemployment rate: Unemployment rate + RAMP (-0.1, 2011, 2015)
- Strategy 4 (s4) medium intensity to reduce the unemployment rate: Unemployment rate + RAMP (-0.3, 2011, 2015)

In revised-down scenarios of the unemployment rate, both strategies result in a GDP increase, relative increases in the average household disposable income, a strengthening of the housing ability, and a rising housing demand and supply side. The vacancy volume, supply and demand ratios, vacancy rates, and housing price-income ratios decline. The housing prices and period average home loan amounts increase slightly. The construction loan balances and home loan balances in the short and long term slightly reduce, showing a slight rise in the long term. It should be noted the new case housing price-income ratios under both strategies have a more substantial improvement. Overall, the project to reduce the unemployment rate by 0.3% has had a better effect, showing that a more substantially reduced unemployment rate can enhance housing ability, which is conducive to reducing “the housing misery index.” In bringing the changing rates of the warning signs into the original GANN model under the implementation of s3 and s4 strategies, the future alarm situation of the market still showed cooling conditions (Figure 11, Figure 12).

(3) Economic policy - Control engineering price changes, and promote efficient use of resources.

The price index, also known as the commodity price index, reflects the commodity price level changes in various periods. When the prices of goods or services change, the price index also changes. The urban housing price is highly constrained by construction costs and is directly reflected in the new case standard unit price. In this study, the Building Construction Index of the price index of construction projects was taken as a reference, and the index changes observed in

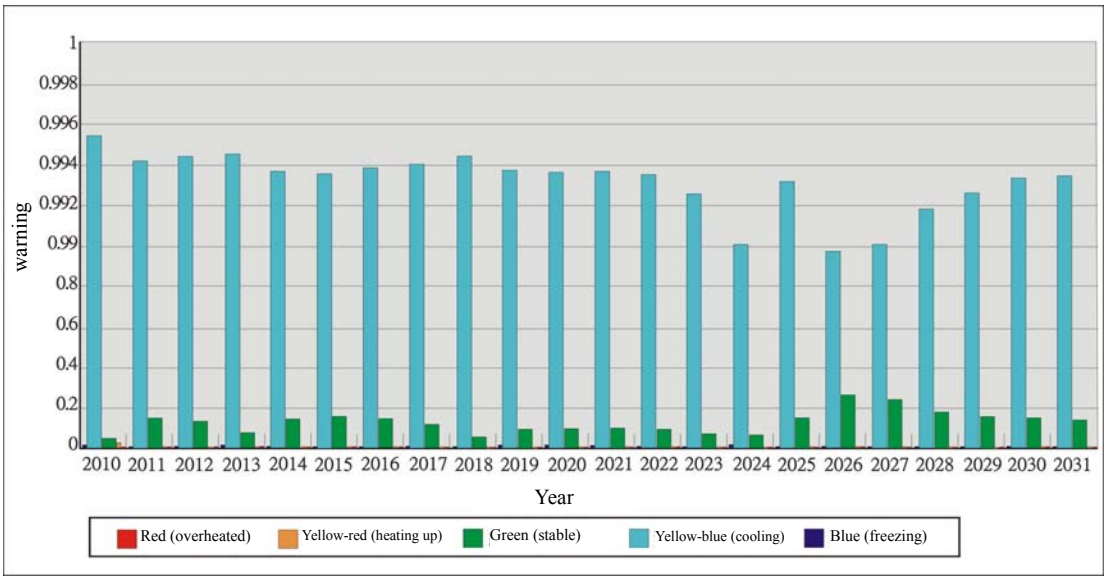

Figure 11 The monitoring indicators of the housing market in Taichung under the implementation of s3

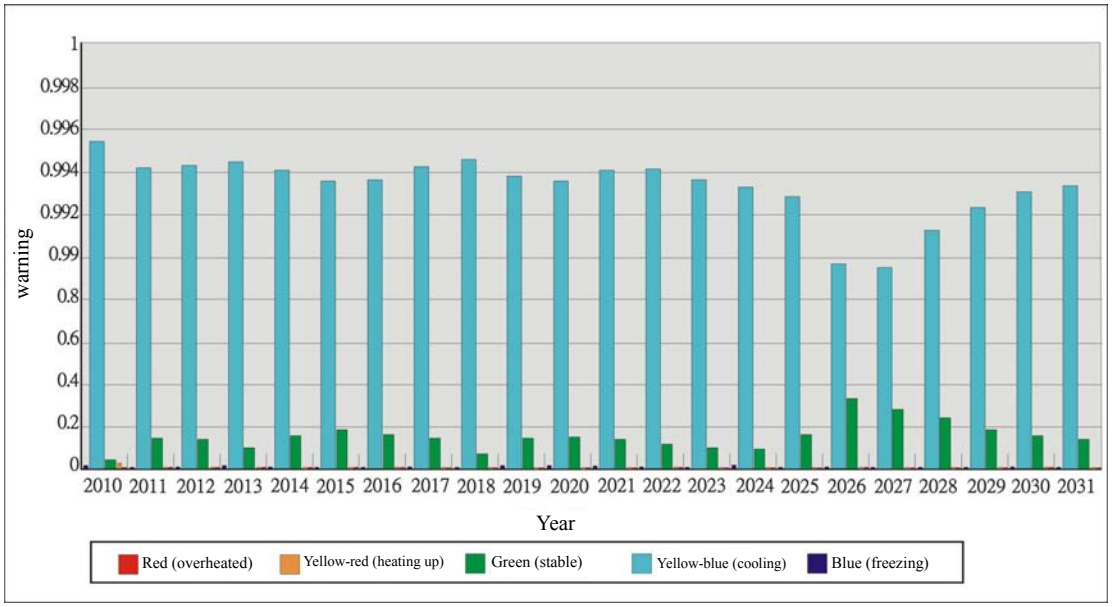

Figure 12. The monitoring indicators of the housing market in Taichung under the implementation of s4

2004 were taken as the base period. The building engineering construction project price index surged from 81.6 in 2003 to 122.13 in 2008, an average increase of 8% over five years, and the new housing price soared from NT$6.654 million to an all-time high of NT$10.678 million. Since 2011, the original model maintained a minimum 8% increase and an annual growth rate of 4% and 8% of the price index of construction projects observing the housing market changes.

- Strategy 5 (s5). low price growth rate: Price Index of Construction Engineering + RAMP (0.4, 2011, 2031)
- Strategy 6 (s6). high price growth rate: Price Index of Construction Engineering + the RAMP (0.8, 2011, 2031)

Overall, through the control of the construction project price index, resulting in the decline of construction costs, both strategies revised down the new case housing prices, relatively raised the housing stocks, vacancy volumes, supply and demand ratios, and vacancy rates, and decreased the new case housing price-income ratios. The synchronized decreases of housing prices, period average housing loan amounts, construction loan balances, and home loan balances indicate that the appropriate price control has a deep impact on the overall operation of the market. However, as compared to s6, s5 has a greater downward revision, so the effect is more significant.

After the implementation of the s5 and s6 economic strategies in bringing the changing rates of the warning signs into the original GANN model under s3 and s4 strategies, the future warning situation of the market still showed cooling conditions (Fig. 13, Fig. 14).

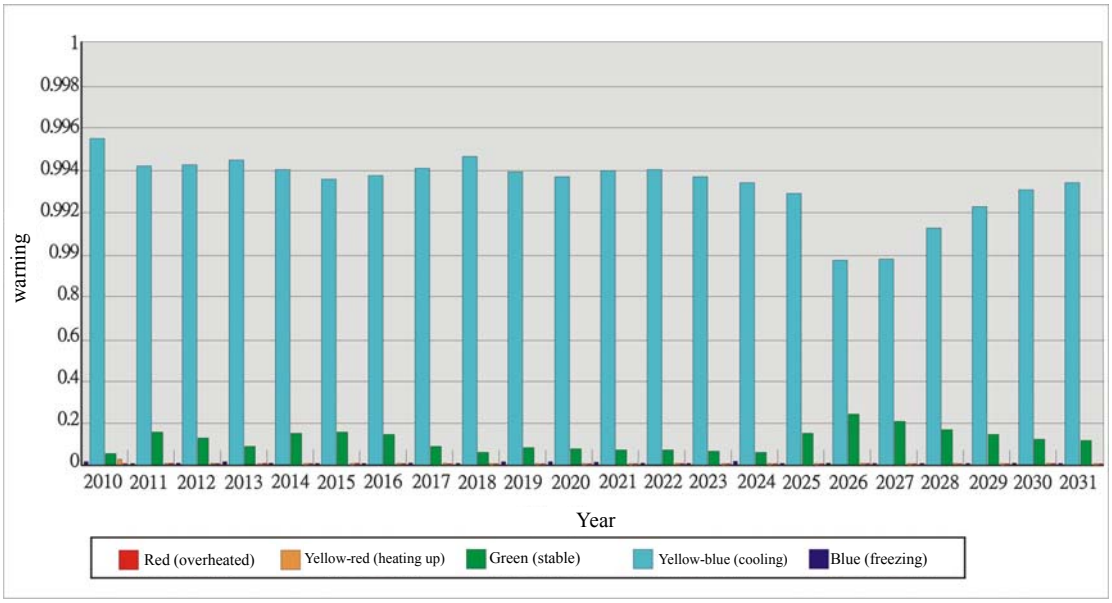

Figure 13 The monitoring indicators of the housing market in Taichung under the implementation of s5

In a single scenario simulation, by inputting a model of different policies to improve the model behavior, the simulation results show that an individual policy produces a different impact in the short, medium, and long term for various warning indicators, and excessive implementation may have after-effects analogous to drinking poison to quench a thirst. The GANN alarm situation assessment also shows

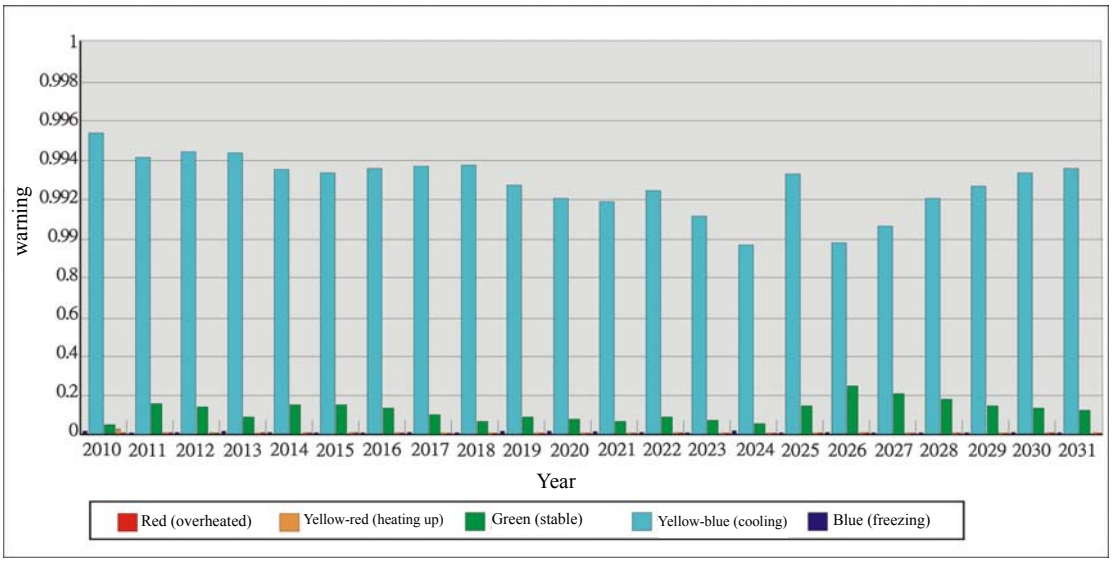

Figure 14 The monitoring indicators of the housing market in Taichung under the implementation of s6

that a single policy does not take into account the demand of a multi-objective policy in the housing market, such as the effective use of the urban housing resources, enhancing the ability of public housing, and improving the housing finance environment when the market alarm situation is still stagnant. Therefore, this study further attempts to combine a variety of strategy situations and to implement multiple strategies at the same time to explore the feasibility of a multi-objective policy to improve the alarm situation of the housing market.

4-2 Joint Strategy

The “urban housing market” refers to the sum of the urban housing commodity exchange relationships, most of which require using market strategy mechanisms to regulate the housing market supply and demand relations to maintain quasi-equilibrium. The single strategy input test cannot improve a variety of system behaviors, but it can explore the effectiveness of the multi-oriented strategy in improving the system.

To strengthen and ensure the effective use of urban housing resources, enhance the ability of public housing, improve the housing financial environment, and achieve other policy objectives, this study joint the aforementioned strategies into two strategies based on the period 2011:

- Joint strategy 1 – (js1) –

  s2 high intensity to raise its lending rates: Housing lending rate + STEP (2.746, 2011)

  s4 medium intensity to reduce the unemployment rate: Unemployment rate + RAMP (-0.3, 2011, 2015)

  s5 low price growth rate: Price Index of Construction Engineering + RAMP (0.4, 2011, 2031)

- Joint strategy (js2) –

  s1 low intensity to raise lending rates: Housing lending rate + STEP (0.746, 2011)

  s3 low intensity to reduce the unemployment rate: Unemployment rate + RAMP (-0.1, 2011, 2015)

  s6 high price growth rate: Price Index of Construction Engineering + RAMP (0.8, 2011, 2031)

In the joint scenario simulation of various strategies, the behavioral trends shown by the system compared to a single scenario are more ideal. In the long-term trends algorithm, the raised lending rate effectively suppresses the increase in housing demand, controls the unemployment rate, increases GDP, and enhances housing ability. Along with price control of construction projects, the new case price will slowly increase, effectively slowing the high price shock in the market side. The three, when simultaneously implemented, will effectively reduce the housing stock, vacant housing volume, average housing mortgage amount for the term, home loan balance, and construction loan balance and gradually revise down the supply and demand ratio, vacancy rate, housing price-income ratio, and new case housing price-income ratio to achieve the policy objectives to ensure the efficient use of urban housing resources, enhance the ability of public housing, and improve the housing financial environment. It is worth noting that, although the increase of interest rates for housing can quickly lower housing prices in the short-term, the mid-term reversal amplitude is proportional to the rising amplitude of housing interest rates, but also causes greater fluctuation of housing prices, housing price-income ratio, and the average housing mortgage amount for the term (Fig 15-18).

The GANN test shows js1 has moderate price fluctuations and is favored by a higher lending rate and lower unemployment rate, making the original cooling market in 2016, 2017, 2018, 2019 show a steady alarm situation. The simulation results are better than those of ms2 (Figure 19, Figure 20).

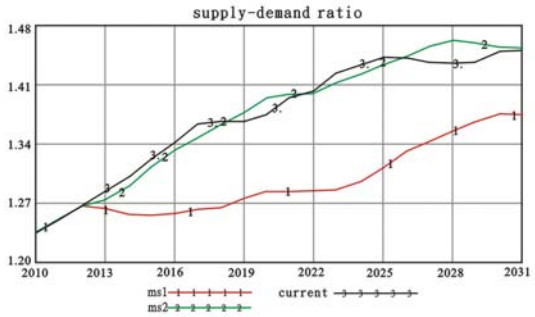

Fig 15. Scenario results of supply-demand ratio for multiple strategy

Fig 16. Scenario results of vacancy rate for multiple strategy

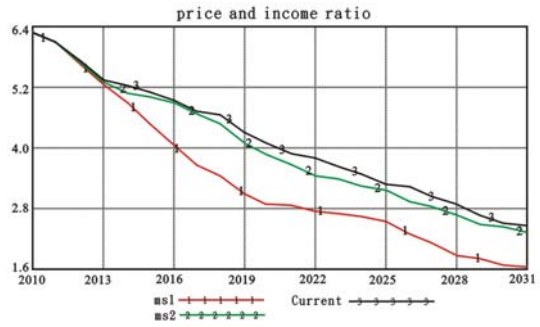

Fig 17. Scenario results of price and income ratio for multiple strategy

Fig 18. Scenario results of housing price for multiple strategy

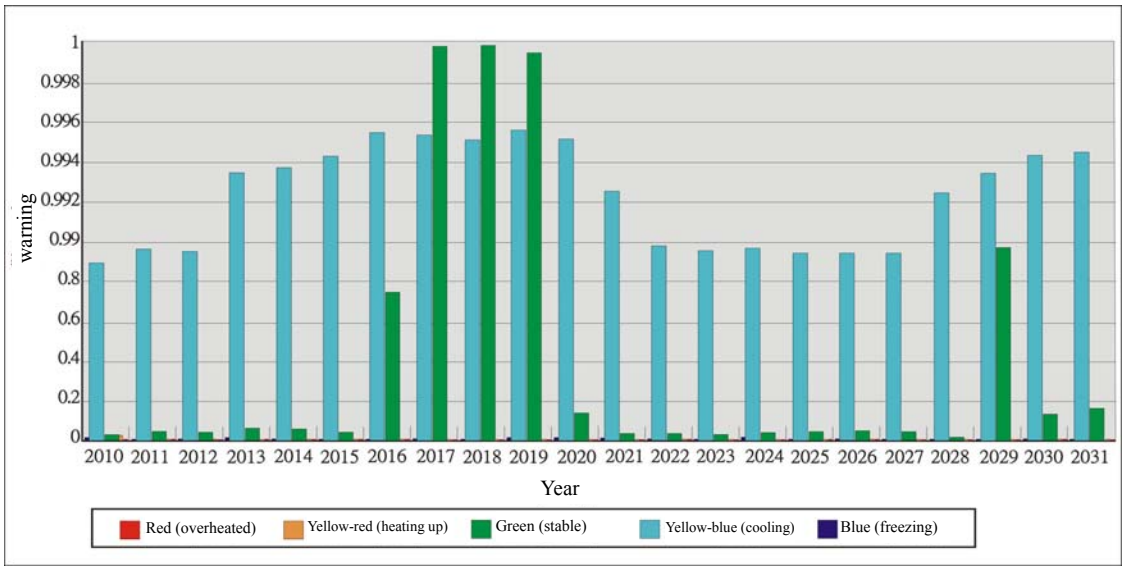

Figure 19 The monitoring indicators of the housing market in Taichung under the implementation of js1

To exclude and relieve the increasingly cold Taichung City housing market each year, the Sensitivity Analysis Method filters out the loan interest rate, unemployment rate, the construction cost index of a financial variable, and two economic variables. The three exogenous variables are a strategy implementation leverage point. After

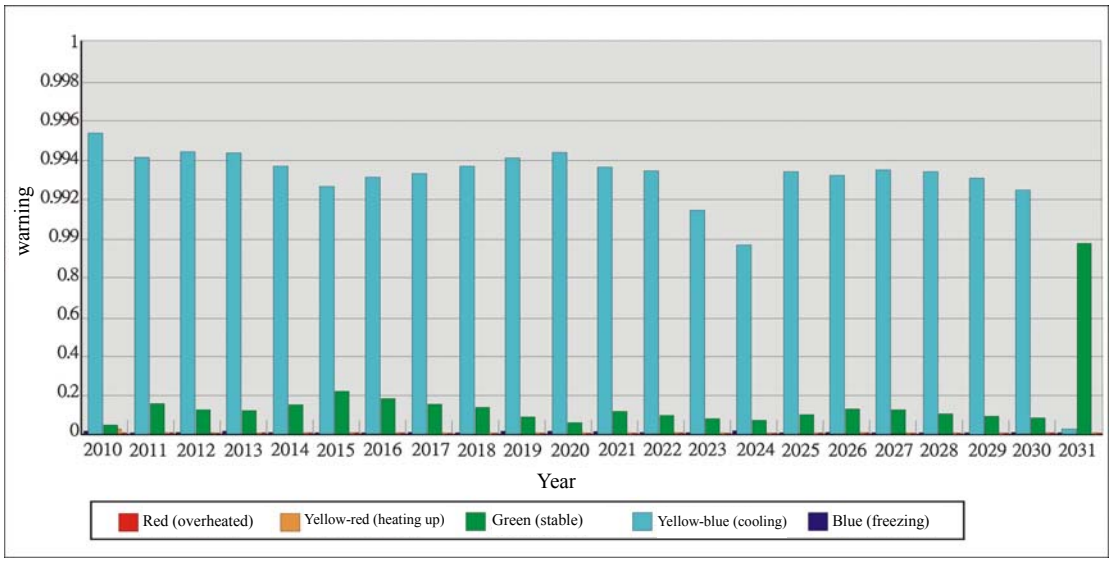

Figure 20 The monitoring indicators of the housing market in Taichung under the implementation of js2

simulation of the alarm situation change of the housing market under a single strategy and joint strategy, a strategy assessment by GANN was conducted to clarify the impact of different strategies on different warning signs. The implementation of joint strategy resulted in mild price fluctuations and higher loan rates, and the lower unemployment rate can gradually push the long cooling situation of the housing market toward stability to achieve the policy objectives of ensuring efficient use of urban housing resources, enhancing the ability of public housing, and improving the housing financial environment.

5. Conclusion and Suggestion

The housing market is an important part of the urban economic system in urban economic development. Its development and evolution depend on the Taichung's economic situation, the goal of urban development, and urban-related policies. Therefore, the urban housing market research, quantitative measurement, and policy simulations conducted from the urban perspective on the reaction intensity, frequency, and duration of the housing market and the urban economic interaction system will help attain a better understanding of the regional economic variables influencing the housing market operation and the interactive fabric of the housing market and urban economy. It will also help the government compare, elect, select, and achieve programs of optimal effect, regulate the urban housing market for high efficiency, and

improve the urban competitiveness to achieve a high-quality urban environment. Regarding the anti-fluctuation behavior of urban housing market with thinking and dynamic view systems, this study makes the following conclusions and suggestions:

5-1 Conclusion

1. An overall system view for urban housing market early warning

   The urban housing market as a high-end, non-linear, and relayed joint socio-economic system should take the systems engineering as its structure and through systems thinking logically and scientifically construct the overall system and subsystems.

2. Economic strategy has a more positive and profound impact than financial strategy

   Loan interest rate adjustment will only bring about the effect of a profit in the short term and a loss in the long term, which will cause a serious recession in housing supply and demand and generate a market depression not conducive to the sound development of the overall housing market. And in the dimension of the economy, the unemployment rate drop and the effective price control and other strategies will have the benign effects of improving the urban housing market operation, so the authorities should focus on the implementation measures of the economic strategy.

3. Joint strategy often have a better policy assessment compared to a single strategy implementation

   In this study, the loan interest rate, unemployment rate, and construction cost index were taken as the leverage points of strategy implementation. After the simulation of the alarm situation changes of the housing market under a single strategy and joint strategies, the strategy assessment by GANN showed the joint strategy produced mild price fluctuations and higher loan rates, and the lower unemployment rate is more feasible for achieving a stable market and increasingly cold policy objectives. At the same time, joint strategy usually has better policy assessment compared to a single strategy implementation.

5-2 Suggestions

1. Set a “urban housing market early warning system dynamic simulation laboratory”

   For the urban housing market in future international socio-economic conditions and financial environment changes, the conduction velocity will be more rapid,

periodical fluctuations will be more vague, and the impact will be even more deep; in response to rapid changes, it should constantly simulate and observe market fluctuation trends and direction and thus grasp the most suitable plan to make the most appropriate decisions. Building an "urban housing market early warning system dynamic simulation laboratory" is the most fundamental and crucial behavior to achieve real-time, early warning monitoring.

2. Buildings use and repair strategies implementation should be comprehensively planned.

   Since 1990, the domestic quantity ratio to apply for new construction permits has dropped to about 3%, and old buildings account for a high of 97% (Hsiao Wen-hsiung et al, 2007); obviously, we have entered an era of buildings repairing. In strengthening the mainstream concept of "sustainable building development" and "aging in place," "building renovation" has become the core focus of building management policies in various countries. Conducting building renovation policies and strategies implementation well will help guide the housing market trends, reduce housing demands, and relieve the high price pressure brought about by pre-sale housing.

3. Endeavor to promote and improve the housing real-estate rental market

   The twin-engine supplies for housing, housing development and housing leases have a competing and complementary relationship with each other. The domestic housing rental market is about 10-12%, which is relatively low compared to advanced countries such as Europe and America. If we can guide and improve the housing rental market, it will have a structural improvement effect on the housing supply and demand market.

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