Dynamics Model of Housing Market Surveillance System for Taichung City

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Abstract

In August 2007, the US subprime mortgage crisis led to a crippling global financial crisis, which created immense monetary and asset losses for the world's economy and financial organizations. Forming a financial crunch and bank credit shrinkage, it halted all economic developments in the world. So, how did Taiwan prevent its housing bubble from bursting? For the purpose of this study, the techniques of system engineering, fuzzy delphi, and system dynamics were used to formulate the dynamics model of housing market surveillance system for Taichung City. The model was simulated with different scenarios of sensitive variables to understand the prospective development of the housing market in Taichung. The research findings showed that a joined strategy of gradual price index movements, high interest rates for loans and lower unemployment rate can effectively strengthen urban housing market risk control, reinforce effective resource utilization and ultimately stimulate overall urban housing market development.

Keywords: urban housing market, system engineering, fuzzy delphi, system dynamics, sensitivity analysis, scenario analysis

Introduction

Housing is a city's most important functional element and life resource; city dwellers cannot live without housing. The highly localized urban housing market and the urban economy have a very intimate two-way relationship. Fundamental shocks to the urban economy can explain the volatility of the housing market (Quigley, 1999). The cost

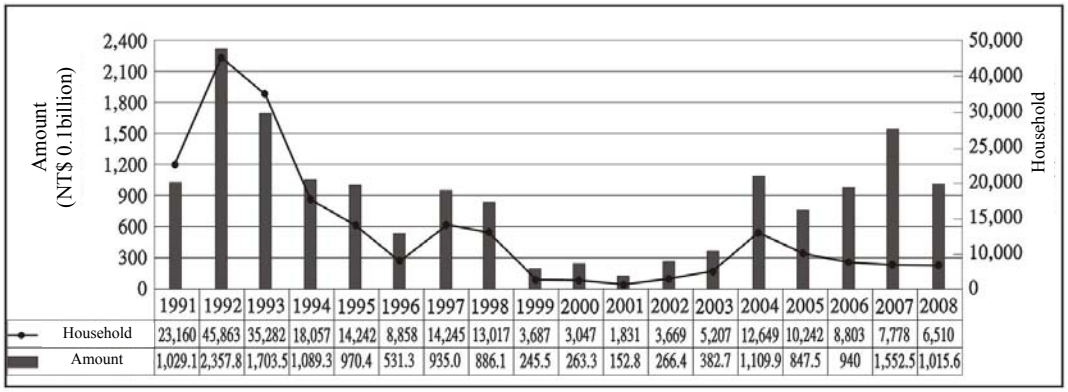
effectiveness of the urban housing market, population wealth and saving effects will also influence urban dwellers' consumption and migration and the city's urban competitiveness (Case, Quigley & Shiller, 2001). Taiwan's national housing policy states that housing possesses a dual nature: as a good and as welfare. The housing market abides by the free market mechanism and at the same time, the government supplies low-interest loans to low-income families to buy houses; the ultimate goal of the government is to help citizens afford their own houses. Faced with social changes such as an aging population, low birth rate, evolution of the family structure, wide poverty gap and high population mobility, etc., local housing needs have become increasingly imbalanced in recent years. The government housing policy is focused on sustaining a healthy housing market. The Taiwanese government has therefore established an unbiased housing subsidy program, spared no efforts in increasing overall housing quality and made our country's housing policy more complete and effective (Ministry of Interior Affairs, 2007).

The urban housing market is a complete and independent ecosystem that consistently faces external and internal influences such as urban population expansion and shrinkage, market supply and demand limitations, economic environment ups and downs, tightening or loosening of financial policies and dynamic characteristics of self-existence (Zhu, 2005). In the 1970s, as Taiwan's economy flourished and moved towards urbanization, nearly 80% of the population was living on 12% of planned urban areas; approximately 90% of the population was living in the west coast plains (National Science Council, 2008). Due to such a dense population on a small strip of land, inflated housing demand led to five economic cycles (1972-1974, 1975-1981, 1982-1989, 1993-2002 and 2003-2007). In the 1990s, as social conditions changed, housing supply and demand started to deteriorate, because Taiwan's overall economic situation was not as positive and optimistic as before. As a result, the urban housing market revealed the "Three Highs: high housing prices, high ownership rates and high vacancy rates." Overpriced urban housing ranked first among the "Top 10 Citizen Grievances" (Research, Development and Evaluation Commission, Executive Yuan, 2009). According to the survey undertaken by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan, in 2000, Taiwan's overall housing vacancy rate of 17.6% was considered high and Taichung City was the most serious at 26%. Excess housing supply led to heavy cash flow pressure, affecting society resource utilization and financial market stability. It meant an inevitable burst in the housing bubble. Since 2008, Taiwan's housing prices have been significantly affected by the USA's subprime mortgage crisis. Taichung City's housing market price in the unstable economic situation showed extreme volatility (Fig. 1). Thus, to deploy an effective strategy to address such external influences deserves more in-depth study.

Research Method

The housing lifecycle consists of investment, construction, transaction and usage; the housing market economic system has the following unique characteristics:

1. Systematic: The housing market operation is the overall performance of the housing market, affected by population, economic and financial factors.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Household	23,160	45,863	35,282	18,057	14,242	8,858	14,245	13,017	3,687	3,047	1,831	3,669	5,207	12,649	10,242	8,803	7,778	6,510
Amount	1,029.1	2,357.8	1,703.5	1,089.3	970.4	531.3	935.0	886.1	245.5	263.3	152.8	266.4	382.7	1,109.9	847.5	940	1,552.5	1,015.6

Fig. 1: Taichung City Housing Market Pricing Table

2. Dynamism: The housing lifecycle is highly dynamic, because it faces a lot of variables during planning, design, construction, completion and finally dismantlement; time lag is a very common problem and as time passes, the purpose and functionality of the house will also change.
3. Ambiguity: Many variables influence the housing market supply. These variables also impact each other; thus, fluctuations differ in range, depth and time span. As a result, the housing market is highly ambiguous.
4. Able to give feedback: The typical housing market lifecycle starts with housing demand, then construction, then market recession and finally dismantling. This is a typical feedback system which affects housing demand and supply.
5. Causality: The housing market is influenced by a group of variables which also affect each other. For example, population affects demand; demand affects supply; and supply affects demand. This creates a causal cycle.
6. Sensitivity: The housing market is frequently affected by external variables and the magnified impact spreads throughout the entire market. As a result, policy deployment requires much sensitivity as introduced changes will lead to significant impacts.

Therefore, to monitor the highly volatile "urban housing market," we cannot only use one research method. This research is based on TEI@I methodology (Wang et al., 2005), with "@" reinforcing the addition of non-additive variables. It uses a systematic engineering method to analyze urban housing market operation, referencing the Fuzzy Delphi recommendations to survey and consolidate factors that influence Taichung City's housing market. Leveraging a dynamic system method – Vensim DSS 5.9 software – to simulate the urban housing system and understand main influential factors and their causal relationships, a sensitive study will be undertaken to understand the factors that influence the housing market, and government policies will also be evaluated for their effectiveness. Various dynamic simulation models will be established to monitor housing market changes in order to have a better understanding of how to strengthen the urban housing market risk mechanism, effective resource utilization and healthy development of the urban housing market.

Variables Set of Housing Market Surveillance System

1. Initial Variables Set

This research referenced local and international articles, while taking into consideration the unique characteristics and experiences of Taiwan's urban housing market. Engineering system techniques established at the initial stage an optimistic, scientific, predictable and comparable variables set (Table 1), involving 49 variables in 5 sub-systems such as urban population, housing demand, housing supply, housing economics, housing finance, etc. The Fuzzy Delphi survey methodology (Ho & Wang, 2008), which includes "Group Strategy" and "Fuzzy Volume Assessment," offers different perspectives in selecting recommended variables. This research utilized fuzzy data in a triangular format for the purpose of ensuring that ideas and recommendations from all experts and scholars were well-utilized. The two extreme ends of the fuzzy data are "0" because it is the smallest and largest value according to experts and scholars. If membership degree is one, it means that it is the mean value and not easily affected by discrete values (non-corrected value). Once the triangular fuzzy number is established, not only can the research represent the fuzziness of the group decision making cognition, the calculation method is also made simpler and more practical.

Table 1 Initial Variables Set of Housing Market Surveillance System

System	Sub-System	System Variable	References
Housing Market Surveillance System	Urban Population	Urban population	Pyhrr & Cooper (1982); Quigley(1999); Seko (2003); Kahn (2008)
		Urban space	Ho (1996); Wang (2004); Yuan (2005)
		Household	Quigley (1999); Chen (2003); Housing Information Statistics - Quarterly Report (2009)
		Urban population density	Ho (1996); United Nations Housing Statistics Index (1998); Yu (2004)
		Average household amount	Zhang & Lai (1990); Wang (2004); Abelson, et al. (2005)
		Natural increasing rate	Chen (2003); Zhang (2008); Taiwan Real Estate Cycle Indicators Quarterly Report (2009)
		Society increment rate	United Nations Housing Statistics Index (1998); USA Housing Statistics Index (2009)
		Household annual rate	Chen (2003); Housing Statistics Quarterly Report (2009)
	Housing Demand	Average household income	Poterba (1991); Quigley (1999); Yu (2004); Wang (2004)
		Average household disposable income	Seko(2003); Chen (2003); Yu (2004); Huang & Wang (2005)
		Average salary of employee in construction industry	Taiwan Real Estate Cycle Indicators Quarterly Report (2009); Directorate-General of Budget, Accounting and Statistics, Executive Yuan (2009)
		Home ownership rate	Zhang & Lai (1990); He (1996); Housing Statistics Quarterly Report (2009)
		Capita living space	Ho (1996); Yu (2004); Yuan (2005)
		Housing demand	Hong Kong Housing Statistics Index (2004); USA Housing Statistics Index (2009)
		Supply-demand ratio	Barras (1994); Chen (2003); Wang (2004); Yuan (2005)
	Housing Supply	Housing land supply	Ho (1996); Hu (2004); Huang & Wang (2005); Kahn (2008)
		Indicator of trading volume of vacant land	Zhang & Lai (1990); Taiwan Real Estate Cycle Indicators Quarterly Report (2009)
		Housing stock	Jacobsen & Naug (2005); Kahn (2008); Housing Statistics Quarterly Report (2009)

	Housing investment	Hong Kong Housing Statistics Index (2004); Huang & Wang (2005); Barlas (2007)
	Housing pre-sale	Lu & He (2004); Yu (2004); Huang & Wang (2005)
	Housing starts	Pyhrr & Cooper (1982); Quigley (1999); Seko (2003); Barlas (2007)
	Housing completion	Ho (1996); Huang & Wang (2005); Housing Statistics Quarterly Report (2009)
	Housing dismantlement	Pyhrr & Cooper (1982); Chen i (2003); Housing Statistics Quarterly Report (2009)
	Housing transaction	Zhang & Lai Bi-Ying (1990); Chen (2003); Yu (2004); Kahn (2008); Housing Statistics Quarterly Report (2009); USA Housing Statistics Index (2009)
	Housing auctioned by court	Yu-Jian (2004); Housing Statistics Quarterly Report (2009)
	Vacancy rate	Quigley (1999); Zhou (2005); Huang & Wang (2005)
	Construction Year	Chen (2003); Zhang (2008)
Housing Economics	GDP	Barras (1994); Huang & Wang (2005); Housing Statistics Quarterly Report (2009)
	Saving rate	Yu (2004); Huang & Wang (2005); Hu et al. (2006)
	Consumer price index	Pyhrr & Cooper (1982); Seko (2003); Huang & Wang (2005)
	Construction stocks index	Yu (2004); Taiwan Real Estate Cycle Indicators Quarterly Report (2009)
	Unemployment rate	Pyhrr & Cooper (1982); Yu (2004); Abelson, et al. (2005)
	Crime rate	Ho (1996); Pyhrr (1982); Potepan (1996); NEWS (2009)
	Housing rent price index	United Nations Housing Statistics Index (1998); Directorate-General of Budget, Accounting and Statistics, Executive Yuan (2009)
	Residential urban land price index	Yu (2004); Wang (2004); Housing Statistics Quarterly Report (2009)
	Housing price	Quigley (1999); Seko (2003); Barlas (2007); NEWS (2009)
	Price and income ratio	United Nations Housing Statistics Index (1998); Hu (2004); Wang (2004)
	Price index of construction project	Taiwan Real Estate Cycle Indicators Quarterly Report (2009); Directorate-General of Budget, Accounting and Statistics, Executive Yuan (2009)
	New housing price	Ho (1996); Barlas (2007); Housing Statistics Quarterly Report (2009)
Housing Finance	Regulating rate of money supply (M2)	Glascock (1993); Yu (2004); Taiwan Real Estate Cycle Indicators Quarterly Report (2009)
	Deposit interest rate	Chen (2003); Wang (2004); Zhou (2005)
	loan interest rate	Darrat (1993); Potepan (1996); Taiwan Real Estate Cycle Indicators Quarterly Report (2009)
	Burden rate of loan	Yu (2004); Housing Statistics Quarterly Report (2009)
	Housing mortgage lending percentage	Zhang & Lai (1990); Yu (2004); Housing Statistics Quarterly Report (2009)
	Housing loans	Hong Kong Housing Statistics Index (2004); Housing Statistics Quarterly Report (2009)
	Loan default rate	Hong Kong Housing Statistics Index (2004); Housing Statistics Quarterly Report (2009)
	Number of housing sale deed tax	Yu (2004); Housing Statistics Quarterly Report (2009)
	Construction loan	Pyhrr & Cooper (1982); Zhou (2005); Housing Statistics Quarterly Report (2009)
	Average housing loan this term	Hong Kong Housing Statistics Index (2004); Housing Statistics Quarterly Report (2009)

2. Selected Variables Set

The questionnaire developed for this research revolved around urban design and planning, construction design and management, real estate investment management, and economic and social factors. Twenty-eight questionnaires were distributed with a 100% recovery rate, of which 89.3% (25 out of 28) were effective. Through the Fuzzy Delphi methodology, results showed that when Zi value＞0, assessment is restrained and expert opinions are consistent. In consideration of the research goal, when the threshold value Gi (experts agreed value) is set at 6, research results showed that 13 variables including urban space, urban population density, average salary of employee in construction industry, capita living space, indicator of trading volume of vacant land, housing auctioned by court, consumer price index, construction stocks index, housing rent price index, regulating rate of money supply (M2), burden rate of loan, loan default rate, number of housing sale deed tax, etc., did not achieve threshold value or Zi (test value) is smaller than 0 and therefore were removed from the research. The number of variables was reduced from 49 to 36; the urban population sub-system included six variables, the housing demand sub-system included five variables, the housing supply sub-system included 10 variables, the housing economics sub-system included nine variables, and the housing finance sub-system included six variables (Table 2).

Dynamics Model of Housing Market Surveillance System

1. Causal Loop Diagrams for Sub-System

We provide the following description of the cause-and-effect relationships for the variables within the sub-systems of housing market surveillance system.

(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.

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, and urban population fluctuation and average household amount combine to affect household changes. Household demand is motivated by different causes, which 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 (Fig. 2).

(2) Housing Demand Sub-System

Table 2 Selected variables and their evaluation value (＊): Remove index Gi=6 Zi＞0

Sub-System	System Variable	Maximum		Minimum		Maximum Geometric Mean	Minimum Geometric Mean	Optimum		Optimum Geometric Mean	Gi Expert Consensus	Zi Test Value	Overall Ranking
		min	max	min	max			min	max				
Urban Population	Urban population	7	10	5	8	8.9631	6.4139	6	10	7.7432	9.8494	1.5492	1
	Urban space (＊)	5	10	3	8	7.7122	5.2100	4	9	6.6012	6.2475	-0.4978	
	Household	7	10	3	8	8.3214	5.6848	5	9	6.9903	7.5280	1.6366	19
	Urban population density (＊)	3	10	1	8	7.1463	4.5155	2	9	5.9768	5.8336	-2.3692	
	Average household amount	5	9	1	7	7.5718	4.7438	3	8	6.2738	6.9014	0.8279	30
	Natural increasing rate	5	9	3	7	7.2396	4.7328	3	8	6.0392	6.1821	0.5068	34
	Society increment rate	6	9	4	7	7.9532	5.5348	5	8	6.7443	8.4496	1.4184	11
	Household annual rate	5	9	4	7	7.7953	5.5286	5	9	6.8877	7.9600	0.2667	14
Housing Demand	Average household income	8	10	4	8	9.1394	6.4450	6	9	7.8886	9.8166	2.6944	2
	Average household disposable income	8	10	4	8	9.0156	6.4324	6	9	7.8836	9.4603	2.5832	3
	Average salary of employee in construction industry (＊)	3	10	1	7	7.0563	4.4293	2	8	5.8341	5.8518	-1.3730	
	Home ownership rate	6	10	3	7	8.1691	5.5366	5	9	6.9090	7.8685	1.6325	16
	Capita living space (＊)	3	10	1	7	7.2784	4.3096	2	9	5.8768	5.9848	-1.0312	
	Housing demand	7	10	4	8	8.8361	6.3055	6	9	7.6695	8.9512	1.5306	7
	Supply-demand ratio	7	10	4	8	8.9586	6.4889	6	9	7.7949	9.3163	1.4697	6
Housing Supply	Housing land supply	7	10	3	8	8.4303	5.7023	5	9	7.1671	7.7301	1.7280	17
	Indicator of trading volume of vacant land (＊)	4	10	2	7	7.4080	4.6531	4	8	6.2111	6.2022	-0.2451	
	Housing stock	7	10	4	8	8.3015	5.6766	5	9	7.0334	7.3379	1.6249	22
	Housing investment	6	10	3	8	8.2066	5.5322	5	9	7.0493	7.2410	0.6744	24
	Housing pre-sale	6	10	2	8	8.1280	5.3964	5	9	6.9566	7.2060	0.7316	25
	Housing starts	5	10	3	7	7.8065	5.3896	4	9	6.6734	7.1777	0.4169	26
	Housing completion	6	10	3	8	7.9678	5.7393	4	9	6.6015	6.9984	0.2284	28
	Housing dismantlement	5	9	2	7	7.3700	4.7032	3	9	6.1638	6.5376	0.6668	33
	Housing transaction	6	10	3	8	8.3176	5.3122	5	10	7.0953	7.2904	1.0054	23
	Housing auctioned by court (＊)	4	10	3	7	7.5942	4.8065	4	8	6.3256	6.4252	-0.2124	
	Vacancy rate	6	10	3	8	8.5584	5.8809	4	9	7.1981	8.0529	0.6775	12
	Construction Year	5	9	3	7	7.5182	4.9569	4	8	6.3555	6.8666	0.5613	31
Housing Economics	GDP	6	10	4	8	8.1704	5.6877	5	9	6.9947	7.0728	0.4828	27
	Saving rate	7	10	4	7	8.4314	5.6858	5	9	7.0989	8.8675	2.7456	8
	Consumer price index (＊)	3	10	1	7	7.2349	4.2416	2	9	5.8018	5.8961	-1.0067	
	Construction stocks index (＊)	5	10	3	8	7.6400	5.0215	4	9	6.3856	5.9831	-0.3816	
	Unemployment rate	6	10	3	8	7.6312	5.1102	3	9	6.3014	6.0509	0.5210	35
	Crime rate	5	10	1	8	7.4404	4.3950	4	9	6.0954	6.0374	0.0455	36
	Housing rent price index (＊)	3	10	1	8	7.2337	4.5990	1	9	5.8059	5.9683	-2.3653	
	Residential urban land price index	7	10	4	8	8.3172	5.8277	6	9	7.2277	7.4853	1.4895	20
	Housing price	7	10	5	8	8.8361	6.4721	6	9	7.6224	9.3783	1.3640	5
	Price and income ratio	8	10	3	8	8.7774	6.1570	6	9	7.5861	8.5783	2.6204	9
	Price index of construction project	6	10	3	8	8.0686	5.2931	5	9	6.7719	6.8484	0.7754	32
	New housing price	6	10	2	8	7.9403	5.3303	5	9	6.7509	6.9208	0.6100	29
Housing Finance	Regulating rate of money supply (M2) (＊)	5	10	2	8	7.7546	5.0241	3	9	6.3889	6.4980	-0.2694	
	Deposit interest rate	6	10	3	8	8.3444	5.4864	4	9	6.7817	7.4514	0.8580	21
	Loan interest rate	7	10	3	8	9.1722	6.3075	5	9	7.9363	9.4491	1.8647	4
	Burden rate of loan (＊)	5	10	2	8	8.5692	5.6563	4	9	7.3490	7.9736	-0.0872	
	Housing mortgage lending percentage	6	10	4	8	8.5015	5.9228	5	9	7.2828	7.9582	0.5787	15
	Housing loans	6	9	3	7	7.9417	5.3599	5	8	6.8111	7.9687	1.5818	13
	Loan default rate (＊)	5	9	3	9	7.5157	5.1813	4	8	6.3752	5.3557	-1.6655	
	Number of housing sale deed tax (＊)	3	9	1	7	7.2841	3.8340	2	8	5.9623	6.0453	-0.5499	
	Construction loan	6	9	4	7	7.9792	5.2806	5	8	6.6863	8.4840	1.6986	10
	Average housing loan this term	6	10	4	8	8.3485	5.8560	5	8	7.1400	7.5724	0.4925	8

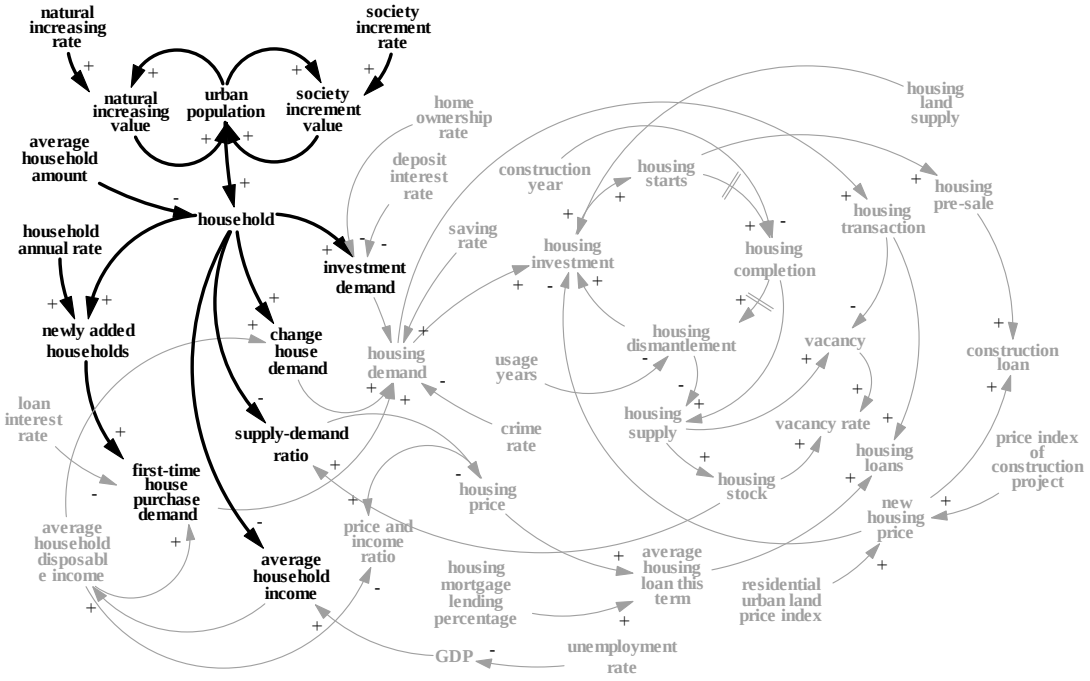


Fig. 2: Urban population sub-system causal loop diagram

The housing demand sub-system represents the urban housing market functionality status index and 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, and the latter comes from the purpose of re-sale to achieve profit.

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. The increase in the average household disposable income represents an increase in consumption ability and is therefore 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, regardless of whether or not first-time house purchase 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, as the increase and

decrease of interest rates influence urban housing demand in terms of investment demand. When investment returns are higher than depositing 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, and this ratio is often seen as a monitoring tool to check if household market supply and demand balance. 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 (Fig 3).

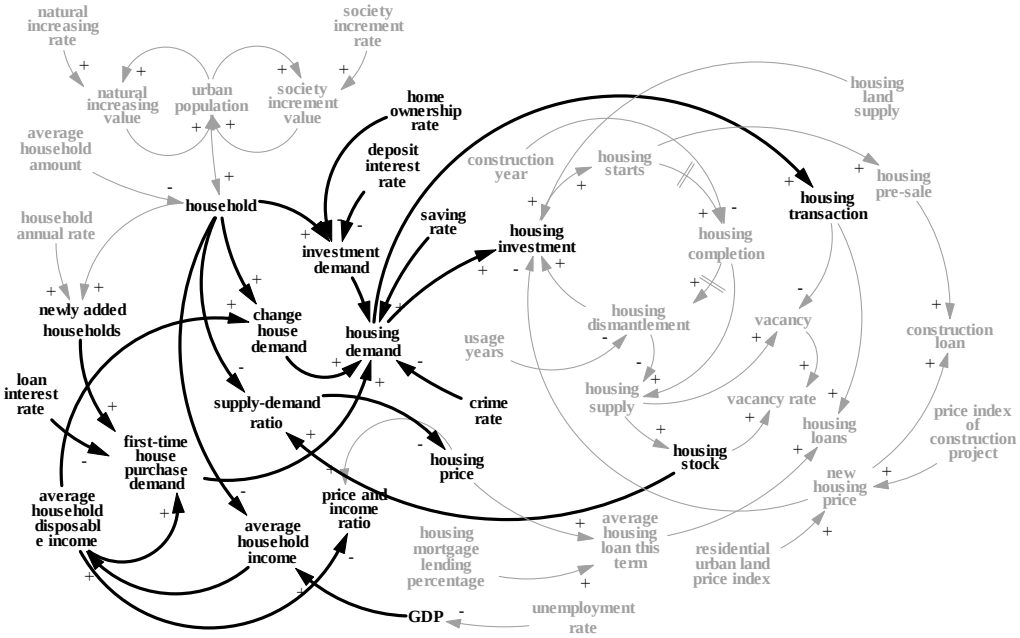


Fig. 3: Causal loop diagram for housing demand sub-system

(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 2-year delay between construction and completion and a normal house typically has a 60-year usage lifetime before it will deteriorate and then finally be dismantled. These factors cause untimely housing demand and supply; therefore, price fluctuations result in the market.

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 (Fig. 4).

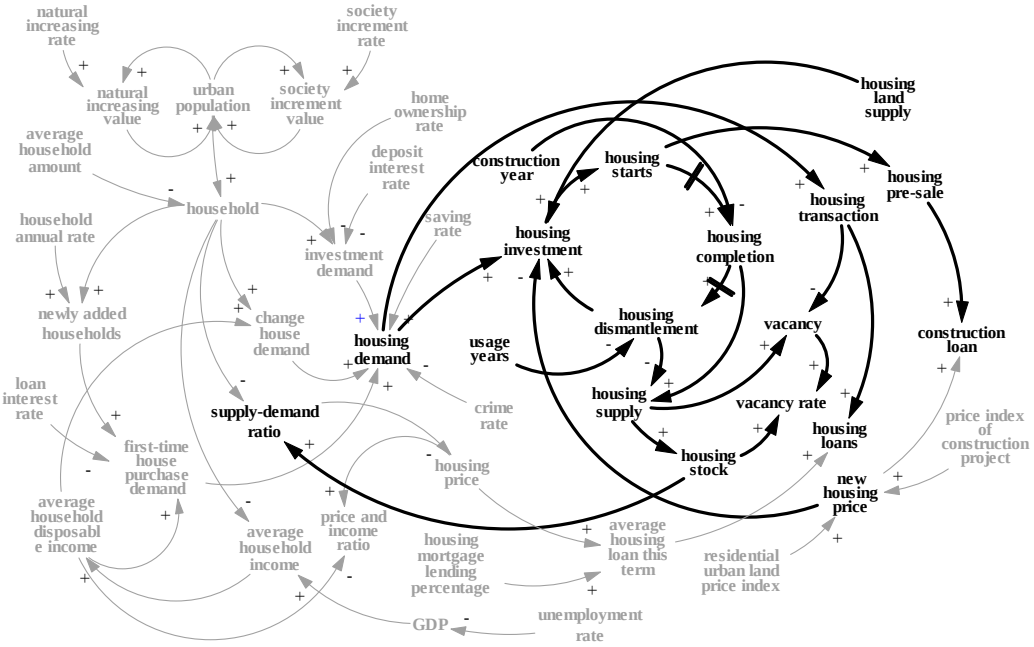


Fig. 4: Causal loop diagram for housing supply sub-system

(4) Housing economic sub-system

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 (Fig. 5).

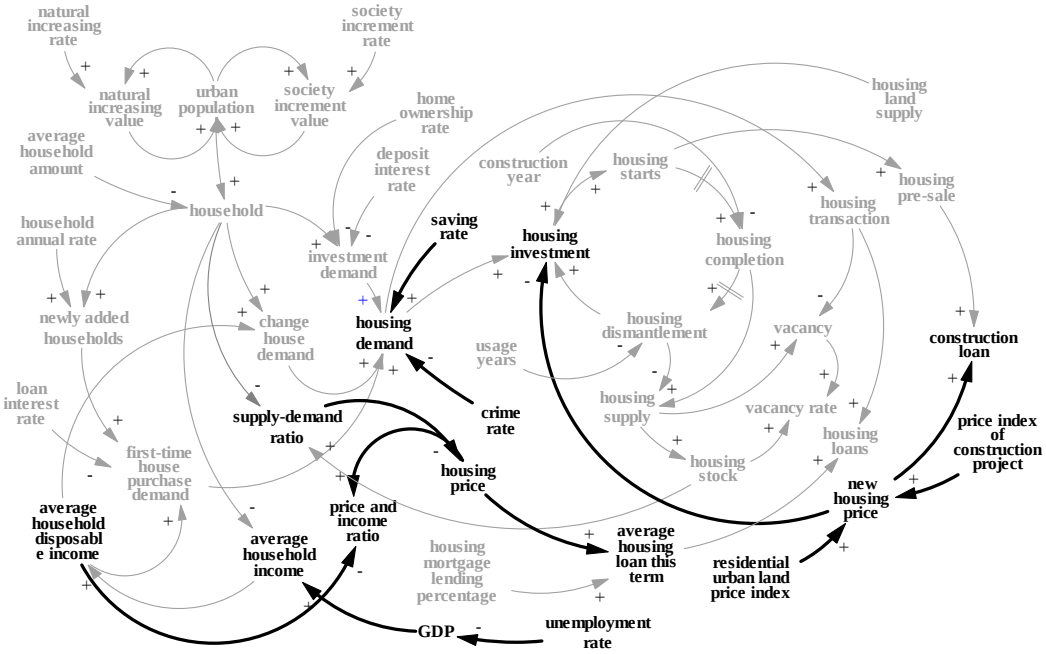


Fig. 5: Causal loop diagram for housing economic sub-system

(5) Housing finance sub-system

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 restrain 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 (Fig. 6).

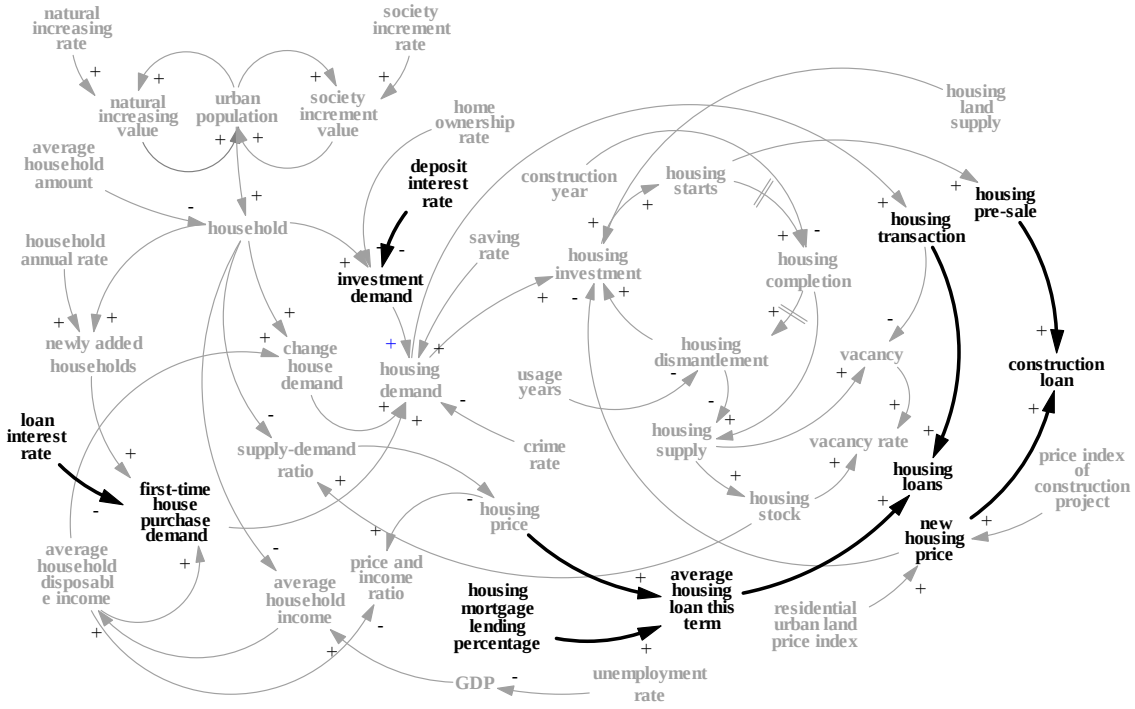


Fig. 6: Causal loop diagram for housing finance sub-system

2. Causal loop diagram for housing market surveillance system

The causal relationship between urban housing and the different variables provides us a tool to understand the market feedback system, which can also form the base of a dynamic system model. This research leverages statistical data from 1991-2008 for Taichung City, taking them as exogenous variables for analysis in accordance with the previous causal feedback analyzed. Taking into consideration the market evolution of the Taichung City housing market and calibration parameters to develop model mathematical equations, the fluctuations of the index variables have a non-linear relationship, utilizing Vensim table function (lookup) processing to establish a system dynamism flow diagram (Fig. 7).

Urban population sub-systems consist of one accumulative factor, two rate factors (natural increase, society increment) and six supporting variables (natural increasing rate, society increment rate, average household amount, newly added households, household increment rate, household). Urban housing behavior is based on households as the basic family unit. Market supply and demand is calculated by the number of households, which

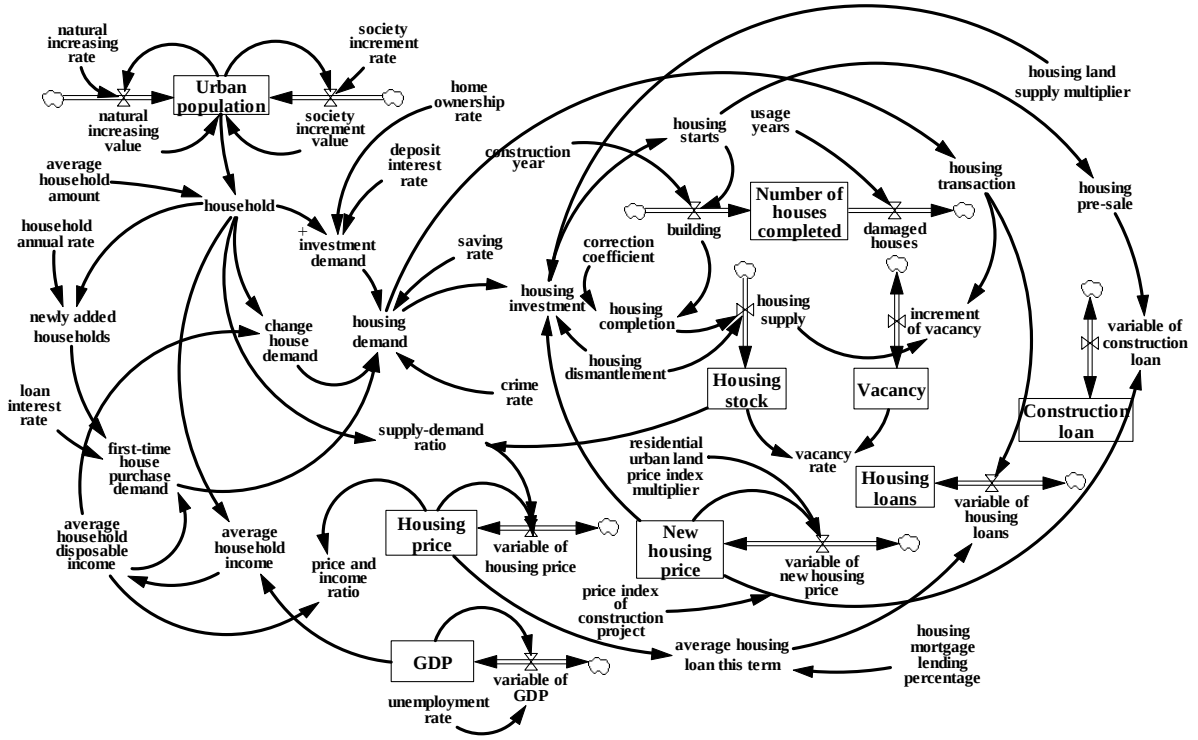


Fig. 7: Causal loop diagram for housing market surveillance system

depends on overall population and household structure. Therefore, there is the need to first understand how urban dwellers grow and household structure changes. The urban population is one accumulative factor (natural increase and society increment) separately affected by natural increasing rates and society increment rates. When determining the urban population, taking Taichung City's data as the example, the average household amount can be used to calculate households and the household annual increase rate can be used to calculate newly added household numbers.

The housing demand sub-system consists of eight supporting variables: investment demand, repeated house purchase demand, first-time house purchase demand, housing demand, average household disposable income, household income, home ownership rate, and supply-demand ratio. According to the overall number of households, new households, home ownership rate, combined with average household disposable income and housing finance sub-system's loan interest and deposit interest rate's impact multiplier, we can calculate first-time house purchase demand, repeated house purchase demand and investment demand and go a step further to consider how the housing economic sub-system is influenced by saving and crime rates.

The housing supply dynamism model includes three accumulative factors (housing stock, vacancy rate, number of completed houses), four rate factors (housing supply, number of houses being built, number of houses being dismantled, number of vacant houses), eight supporting variables (vacancy rate, housing investment, housing pre-sale, housing starts, housing completed, housing dismantled, housing transaction, transaction volume correction number) and three constants (construction year, house lifespan, supply of housing land

influence multiplier). In the system, the most critical point to note is that housing supply has on average a two-year delay. In the model, we need to take into consideration the two-year lag and include it in our model simulation. Only then can the calculation of housing supply volume, housing stock, supply-demand ratio, number of vacant houses and vacancy rate be accurate.

The housing economic sub-system includes three accumulative factors (GDP, housing price, new housing price), three rate factors (GDP change rate, housing price change, new project price changes), five supporting variables (price index of construction project, saving rate, unemployment rate, crime rate, price and income ratio) and one constant value (residential urban land price index multiplier). Using the unemployment rate to predict GDP and using the GDP distribution rate to estimate average household disposable income, we can estimate new housing prices; with the price index of construction project and residential urban land price index multiplier, we can estimate housing price change from housing demand sub-system's supply-demand ratio; and with average household disposable income we can calculate the price and income ratio. The simulated GDP, housing price and new housing price become representative of the housing demand market change index.

The housing finance dynamism model includes two accumulative factors (housing loans, construction loan), two rate factors (housing loans change, construction loan change) and four variable factors (deposit interest rates, loan interest rates, mortgage lending percentage, current house loan amount). The loan interest rates and deposit interest rates will determine overall demand volume. Mortgage lending percentages will adjust to housing price to determine if the current purchase mortgage amount is high or low and will go a step further to affect housing loans. Construction loans are affected by the housing economic system's new housing price to become the housing finance observation quantitative index.

Regarding the dynamic system model's effectiveness, Coyle & Exelby (2000) and Sterman (2002) agreed that it is critical that we need to keep testing the results and cross-check with the actual quantitative data to test model validity, confirm model behavior characteristics, showcase actual behavior characteristics and point out the effectiveness of the system dynamism model including modeling objectives, structure behavior and parameter confirmation.

Confirming index parameters means to compare modeling parameter value and actual system value. Hopefully this action will help the model's behavior to be logical and fulfill actual system behavioral characteristics. Therefore, this research leverages 18 years of statistical data from 1991 to 2008 for analysis, simulating average errors to confirm the model's effectiveness. The city's housing dynamic market modeling system sets the accumulative factor as targets and via a parameter test (Table 3), average error value needs to be less than 2%. All observation index average errors need to be 0.34% and below and finally fulfill the "Error < 5% is 70% of index, each single index error cannot be higher than 10%" requirement. If so, it will be accurate to present the model as a close replication of Taichung City's urban housing market actual situation and give an accurate prediction.

3. Sensitivity Analysis

Table 3: Housing Market Statistics of Taichung City

Year	Item	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average error
Urban population	Historical Value	774197	794960	816601	832654	853221	876384	901961	917788	965790	940589	983694	996706	1009387	1021292	1032778	1044392	1055898	1066128	0.00%
	Simulated Value	774197	794960	816601	832654	853221	876385	901962	917790	965791	940590	983694	996699	1009380	1021285	1032771	1044384	1055889	1066119	
	Difference	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
GDP	Historical Value	57715	62244	66537	71454	76090	80881	86212	90134	100811	95314	98622	103195	106806	113378	118096	123763	130822	130890	1.82%
	Simulated Value	57715	61966	66460	71280	76361	81283	85828	90497	100775	95727	105821	109498	113023	116742	120803	125378	130245	135423	
	Difference	0.00%	0.45%	0.12%	0.24%	0.36%	0.50%	0.45%	0.40%	0.04%	0.43%	7.30%	6.11%	5.82%	2.97%	2.29%	1.30%	0.44%	3.46%	
Housing stock	Historical Value	219808	236637	261611	303029	333890	355039	365495	366839	376532	372139	394840	398880	402395	406830	411308	428715	437805	445429	0.00%
	Simulated Value	219808	236637	261612	303030	333891	355041	365497	366841	376536	372141	394843	398884	402399	406835	411312	428715	437806	445392	
	Difference	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	
Housing price	Historical Value	436	596	511	507	508	476	474	472	461	485	398	437	384	437	495	547	574	635	0.51%
	Simulated Value	436	595	512	508	510	479	477	475	464	488	402	437	388	440	498	552	577	633	
	Difference	0.00%	0.17%	0.20%	0.20%	0.39%	0.63%	0.63%	0.64%	0.65%	0.62%	1.01%	0.00%	1.04%	0.69%	0.61%	0.91%	0.52%	0.31%	
New housing price	Historical Value	444.3	514.1	482.8	603.2	681.4	599.8	656.4	680.7	864.1	665.8	834.5	726.1	735	877.5	827.5	1067.8	1996	1560.1	0.03%
	Simulated Value	444.3	514.13	482.7	603.1	681	599.6	656.2	680.5	863.8	665.6	834.2	725.81	734.78	877.2	827.2	1067.4	1995.4	1559.6	
	Difference	0.00%	0.01%	0.02%	0.02%	0.06%	0.03%	0.03%	0.03%	0.03%	0.03%	0.04%	0.04%	0.03%	0.03%	0.04%	0.04%	0.03%	0.03%	
Housing loans	Historical Value	667269	888471	1032875	1373730	1696043	2002590	2289903	2420346	2651772	2539707	2623276	2768188	3038881	3482662	3962936	4352855	4628776	4732762	0.00%
	Simulated Value	667269	888475	1032878	1373731	1696048	2002601	2289915	2420359	2651783	2539723	2623287	2768201	3038901	3482687	3962962	4352881	4628803	4732789	
	Difference	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Construction Loan	Historical Value	117655	272427	630816	714803	629356	517044	553191	612298	558510	591918	507837	418809	420936	508638	670132	846545	1056878	1063936	0.00%
	Simulated Value	117655	272428	630818	714804	629357	517044	553191	612298	558511	591919	507836	418809	420936	508637	670132	846545	1056879	1063937	
	Difference	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	

Note: The accumulative factor in the system did not take into consideration the vacancy and the number of completed houses; the vacancy needs a 10-year official data point, which is not available. Therefore it will not be taken into consideration. the number of completed houses is a simulated parameter and therefore also not included in the discussion.

In this research, sensitivity variable calculation and analysis are undertaken to discover how variables are influencing the system and to understand the main reasons behind the influence by dividing the parameters into proactive and passive groups – an "Influence - Response Matrix" (Kano Noriaki, 1999) – to observe how policies cause direct impacts on the market. Proactive variables include the system's exogenous variables which are 15 indexes; the passive group includes 8 accumulative factors plus the supply-demand ratio, vacancy rate, price and income ratio totaling 11 indexes. By combining the proactive and passive parameters, 2,970 data points are created, leading to 165 types of change relationships. This research undertakes a 10% change on each proactive variable for testing, so as to observe the impact on passive variables. This impact will be a good indicator if the impact is positive or negative. Each exogenous proactive variable change will be cross-checked with original simulated data, while taking an 18-year difference as the constant value. With 18 years of data, simulated data will be cross-checked; this evaluation method gives no change 0 points; if the change is lower than 1/8, it will be given one point; for values between 1/8-1/4, two points will be given; for values higher than 1/4, three points will be given.

The results showed that the proactive group of variables influences the model to a greater extent (Table 4). The variables that cause the greatest impact are unemployment rate, price index of construction project and loan interest rate. For the passive group of variables, the four biggest influencers are housing price, price and income ratio, supply-demand ratio and vacancy rate; the higher the sensitivity, the more complicated the impact will be. Overall, housing economic policy is the most relevant to urban housing market development, and housing finance is secondary. This research takes sensitive indexes such as unemployment, price index of construction projects, loan interest rates, etc., as the base of the simulated model, while taking housing price, price and income ratio, supply-demand ratio, vacancy rate, etc., to evaluate policy effectiveness.

Table 4: Sensitivity analysis (variable-response matrix)

Variable	Urban population	GDP	Housing Stock	Vacancy	Housing Price	New housing price	Housing loans	Construction Loan	Supply-demand ratio	Vacancy rate	Price and income ratio	AS
Natural increasing rate	1	0	1	1	3	0	2	3	3	1	3	**18**
Society increment rate	2	0	1	2	3	0	3	3	3	2	3	**22**
Average household amount	0	0	2	3	3	0	3	3	3	3	3	**23**
Household annual rate	0	0	3	3	3	0	3	3	3	3	3	**24**
Home ownership rate	0	0	2	3	1	0	2	3	3	3	1	**18**
Housing land supply	0	0	3	3	3	0	3	3	3	3	3	**24**
Construction Year	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	**8**
loan interest rate	0	0	3	3	3	0	3	3	3	3	3	**24**
Housing Mortgage lending percentage	0	0	0	0	0	0	0	0	0	0	0	**0**
Savings rate	0	0	1	1	3	0	1	1	1	1	3	**12**
Unemployment rate	0	3	3	3	3	0	3	3	3	3	3	**27**
Crime rate	0	0	3	3	3	0	1	3	3	3	3	**22**
Residential urban land price index	0	0	1	2	3	2	1	3	2	2	3	**19**
Price index of construction project	0	0	2	3	3	3	2	3	3	3	3	**25**
PS	**3**	**3**	**26**	**31**	**35**	**5**	**28**	**35**	**34**	**31**	**35**	

Note: 1. AS: Influence variable, AS=Σ Column value, represents the added value of proactive variables. 2.PS: Response value, PS = Σ Column value, represents the added value of passive variables.

4. Scenario Analysis

This research leverages a goal-oriented simulation analysis method to set clear policy goals and strategy to be deployed (Legasto & Maciariello, 1980). With a complete and healthy housing finance environment, we can enhance citizens' house purchase capability and guarantee that urban housing resources are utilized as effectively as the government policies have set them up to be. After observing the simulated model, it was found that the loan interest rate, unemployment rate, construction engineering materials price, hybrid strategy deployed, supply-demand ratio, price and income ratio and vacancy rate are critical factors of influence for housing price behaviors. This test will test, with no noise interference, the system's internal variable reaction under exogenous variable influence stimulation and what the resulting behavior characteristics are so that strategic planners will be able to leverage the results and go a step further to develop effective strategies.

(1) Scenario Analysis of Single Strategy

Strategy 1: Increase housing loan interest rates to improve the housing financing environment

To address the economic crisis and reduce citizens' mortgage interest burden, the Executive Yuan in 1990 set up the "NT$120 billion Youth Welfare House Loan and Credit Guarantee Program," and the "NT$200 billion Welfare House Purchase Program." Later, the government also rolled out the "NT$200 billion Welfare House Purchase Loan," "Low interest Housing Subsidy Mortgage Loan," and, since early 2009, the "Start a Family with Peace of Mind - Youth Program" and other types of house loan programs. These government subsidy policies strive to stimulate the urban housing market and since then, Taiwan has seen the longest period of ultra-low interest rates. Bank loan interest was 9.6% in 1993, 2.29% in 2005 and 2.754% in 2008. Until now, construction financing, citizen house purchase and home improvement loans exceeded 20% of all capital the government has put aside; the fact that such a significant amount of money is pumped into a single industry has caused serious market imbalance. In 2011, mortgage loan interest rates will be adjusted to 3.5% (s1) and 5.5% (s2) for model simulation purposes.

As the housing market supply exceeds demand, the original model's housing supply-demand ratio is moving towards the positive direction and is also increasing. Together with increased interest rates, it became very expensive to buy houses; housing demand and supply then showed reduction, creating shocks in the housing supply-demand ratio evaluation. Its impacts are stronger in controlling housing supply-demand. The s1 model's adjustment is within acceptable range by the people, but the effect is not obvious. S2, under high house demand, not only faces severe pressure in housing supply, but investors will also start to feel motivation to invest again, and thus they have to adjust their strategies quickly to leverage the fluctuation and reduce housing volume supply drastically. In 2013, housing supply and demand volume will plummet, housing supply-demand ratio in 2016 is reduced to 1.25%, and the loan interest rate is adjusted to 5.5%. This means that it is an effective method for ensuring quick improvement to supply-demand ratio (Fig. 8).

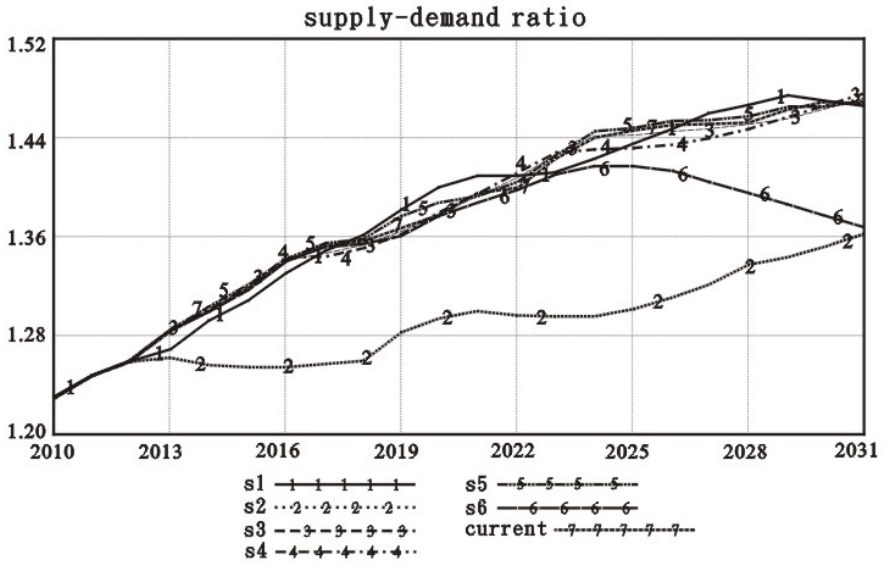


Fig 8: Scenario results of housing supply-demand ratio for single strategy

Interest rate adjustment has caused house purchase cost to increase. Housing demand volume and supply volume has shown phased changes. As housing supply and demand face a time lag, there is a temporary increase in the vacancy rate; however, supply and demand quickly responded to the shock. In 2013 onwards, vacancy rate shows a downward trend; s2 as compared to s1 has a bigger impact on housing vacancy rate. Influence degree and differences are bigger (Fig. 9).

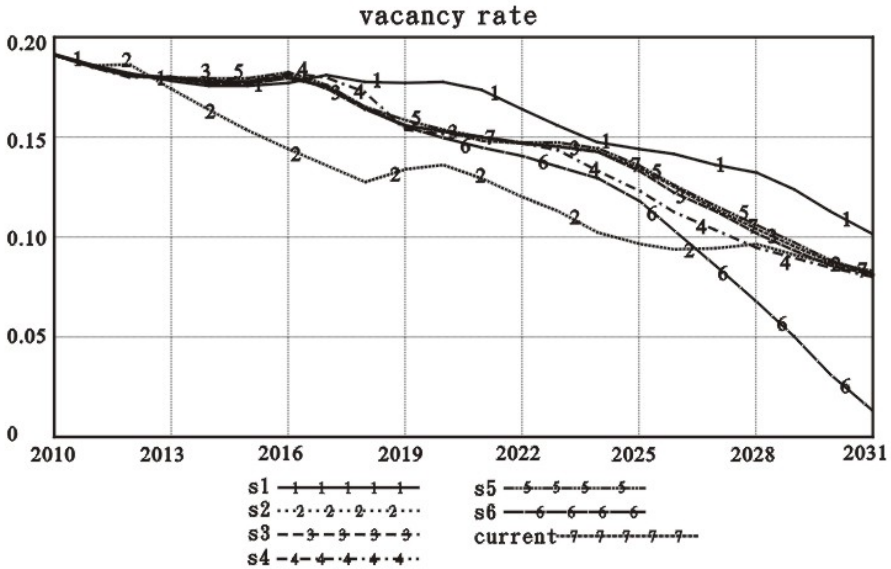


Fig 9: Scenario results of vacancy rate for single strategy

After the interest rate is increased, supply faces a time lag. To achieve sales volume, the market resorted to reducing the housing price; s1 interest rate increase is limited, and thus not strong enough and its impact not that apparent; while s2 increased the interest rate to 5.5%, the price and income ratio in the short term shows bigger reduction; this means that it is a more drastic increase of interest loan and in the short term improves price and income ratio more quickly and leads to more drastic downward change. This indicates that a higher

adjustment of interest rate in a short time can improve price and income ratio. However, in the long term if we deviate from the housing supply and demand equilibrium law, housing demand and supply is under long-term shrinkage; from 2025 onwards, the ratio will adjust upwards. In 2028 development trends will be similar to the original model (Fig. 10).

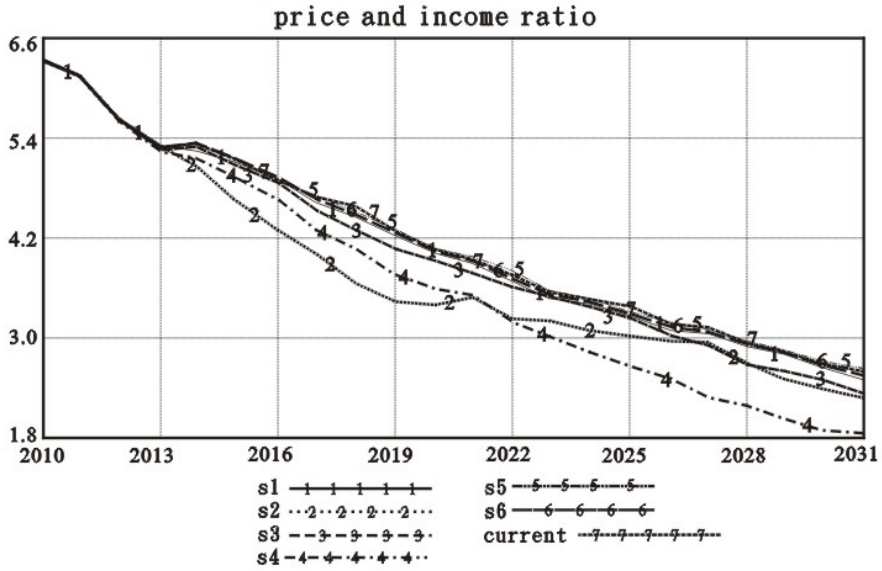


Fig 10: Scenario results of price and income ratio for single strategy

In the original model, where there is more supply than demand, housing prices will show a downward reduction trend. S2 reduces the interest rate to 5.5%, severely repressing house purchase cost increase and housing demand volume, thus achieving the sales volume goal. When supply faces a reduced housing price, it also shows drastic reduction; in 2019, price is reduced to NT$4.835 million/household. Subsequently, similar to the original model, a bigger and more drastic difference method was developed (Fig. 11).

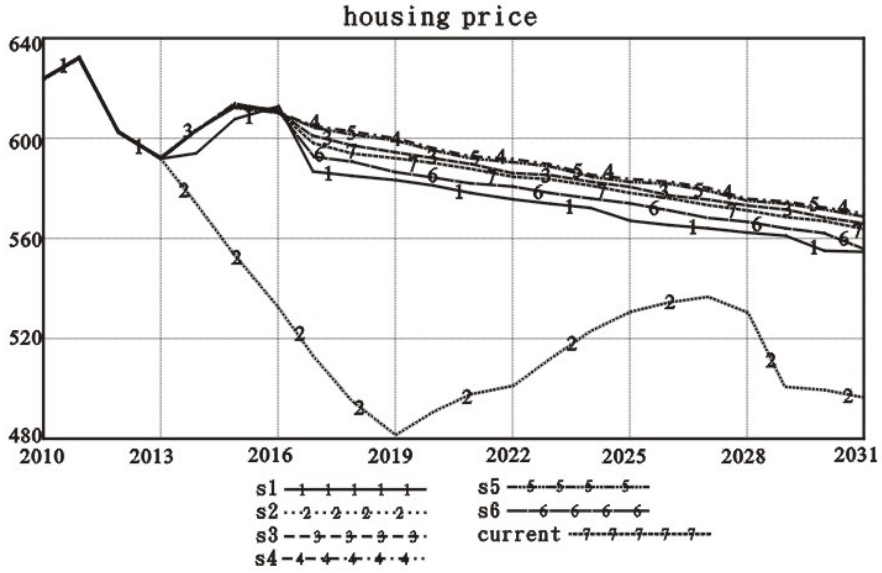


Fig 11: Scenario results of housing price for single strategy

Strategy 2: Reducing unemployment rate, increasing citizen house purchase capability

As for economic development, local overall unemployment rates and economic growth generally go in different directions. Before 1995, it was maintained at about a 1.5% low, but later started to increase; in 2009, the unemployment rate was 5.74%, which made Taiwan the country with the highest unemployment rate among the four Asian tigers (National Statistics, RO.C Taiwan, 2010). This created for the past 10 years low economic development (-2.53%~5.98%, 3.36% on average) and low GDP growth rate (-2.52%~6.25%; on average 2.66%) in Taiwan. Economic growth has been slow, repressing citizen house purchase capability and leading to the set up of the "House purchase pain index-Price and income ratio." Since 2005, Taichung's unemployment rate has varied between 4% to 4.7%, and the price and income ratio climbed from 5.65% to 7.56%. The United Nations' "City index guide" mentioned that when cities of developing countries have a price and income ratio of 1: (4-6), it is favorable. This research took 2011-2015's unemployment rate as 0.1% (s3) and 0.3% (s4), which decreased respectively and then subsequently maintained at 3.7- 2.7% to monitor housing market changes.

Two strategies that reduce unemployment rate caused average household disposable income to increase; when house purchase ability is increased, housing demand increases along with the housing supply and demand volume. Therefore, it possesses a pull influence. When there are slight changes in housing supply-demand ratio and vacancy rate (see diagram 8 and 9), housing price also increased a little (see diagram 11). With price and income ratio reduced, s4 has better results, presenting greater reduction. From 2013 to 2031, the ratio is reduced to 1.81, showing that a greater reduction of unemployment rates can strengthen house purchase ability; in other words, it is a good strategy to reduce the "house purchase pain index." (Fig. 10)

Strategy 3: Control construction materials price change, stimulate effective resource utilization

The price index, also known as the product price index, is an index that calculates prices of a particular product or service on a particular day and is a very good indication of standard price changes for a particular period of time. Therefore, when a product or service changes price, the price index will also become different. Urban housing price is affected by construction costs and urban land price; the change is directly reflected in a new housing price. This research used the construction engineering price index as a base, observing 2004 as the base index change. The results showed that the construction engineering material price index from 81.6 in 2006 increased to 122.13 in 2008. In five years, the index saw an average growth of 8%, kicking off the prices of newly built housing to increase from NT$7.35 million/household to NT$19.96 million per household. This led to overly expensive housing for citizens and increased their burden tremendously. This research used the method of increasing the construction engineering price index to observe housing market change. Similar to the original model, annual increased growth rates of 4% (s5) and 8% (s6) are implemented to simulate the model.

For S5, as product and service price change becomes acceptable by citizens, housing supply-demand ratio is maintained and the effect is not obvious. S6's annual growth rate is 8%, representing that housing cost has become more expensive for citizens, thus restraining

housing demand and causing housing supply volume to slowly decrease. In 2020, housing supply-demand ratio showcases obvious reduction, representing that higher price growth has a very obvious effect on housing supply-demand ratio's long-term improvement (Fig. 8).

The vacancy rate change in s5 is caused by a subtle price adjustment, so, the impact is limited. The resulting development trend is quite similar to the original model and so the improvement effect is not too obvious. S6 had significant increase in housing price, thereby severely restraining housing demand and reducing supply volume. In 2010, the vacancy rate showed obvious reduction and in 2031 was revised to 1.53%, which represents that a higher price growth impacts vacancy rate more effectively in the long run (Fig. 9).

S5 and s6 showed that when housing cost increases, it impacts new housing projects and then affects new housing prices. New housing prices increase from NT$78.44 million/household to NT$205.14 million/household in 2031. To curb housing demand, housing supply also needs to be reduced. However, when transactions of new housing projects are reduced, it means that housing (including new houses and old houses) price change is not big (see diagram 11). Price and income ratio only showed slight fluctuations (Fig. 10).

Overall, housing supply-demand ratio is affected (as in s2) when there is significant increase of loan interest rates. When there is a high price growth rate (as in s6), impact is more obvious in the long term. Vacancy rate, in the short run, is affected when interest rate change is more obvious (again as in s2). In the long run, the high price index growth is more effective (as in s6). Price and income ratio in the short run is more apparently affected by high increases in loan interest rate (as in s2); in the long run, a strong reduction of the unemployment rate (as in s4) showed a greater impact. Housing price is very much affected by a large adjustment of the interest rate (as in s4); construction engineering material prices also play an important role in adjusting and controlling the market, as they will affect the prices of new houses. Its impact on overall housing prices is limited.

Under the single-scenario hypothesis which simulates different polices, the simulated results showed that adjusting loan interest rate, unemployment rate and construction engineering material prices will result in different supply-demand ratios, price and income ratios and vacancy rates. Therefore, different housing price policy goals can ensure that urban housing resources are effectively utilized to a certain extent and help increase citizens' ability to purchase their own homes. This is what the government's subsidies and policies are for, but we must also take into consideration that no one policy can satisfy our goals. We need to implement various policies to ensure that we can achieve as many goals as possible.

(2) Scenario analysis of joined strategy

"Urban housing market" refers to the overall urban housing transaction relationship, where there is a need to leverage market strategies to balance the housing market demand and supply relationship. Single strategy modeling cannot simulate real-life situations which

resemble a multi-system behavior. The research will now discuss multi-faceted government policies and how these policies improve system effectiveness.

To reinforce the guarantee that urban housing resources are well-utilized, the citizens' ability to purchase houses is improved and the housing finance environment developed. This research used 2011 as the base year and divided the strategies into two groups – joined strategy simulation and policy evaluation.

Joined strategy 1: To help develop a housing finance environment, citizens' ability to purchase houses and guarantee urban housing resources is well-utilized.

This strategy hypothesizes that construction materials price increase by 4% each year and is complemented by a loan interest rate of 5.5%, and the unemployment rate within 5 years was reduced by 0.3% and then simulated by 2.7% method (cs1). Reducing the unemployment rate, however, can strengthen house purchase ability, and can influence housing demand and supply. As engineering materials price increase is common, a price index increase of 4% is in the acceptable range. Both parties' influence on the supply-demand ratio is not very obvious, but if the interest rate is adjusted to 5.5%, the influence on house purchase costs quickly increase and citizen's housing demands decrease, enabling housing demand overall to reduce. To address the time lag, after 2013, an adjustment is made quickly to address the problem, significantly reduce housing supply volume and creating housing supply-demand ratio reduction (Fig. 12).

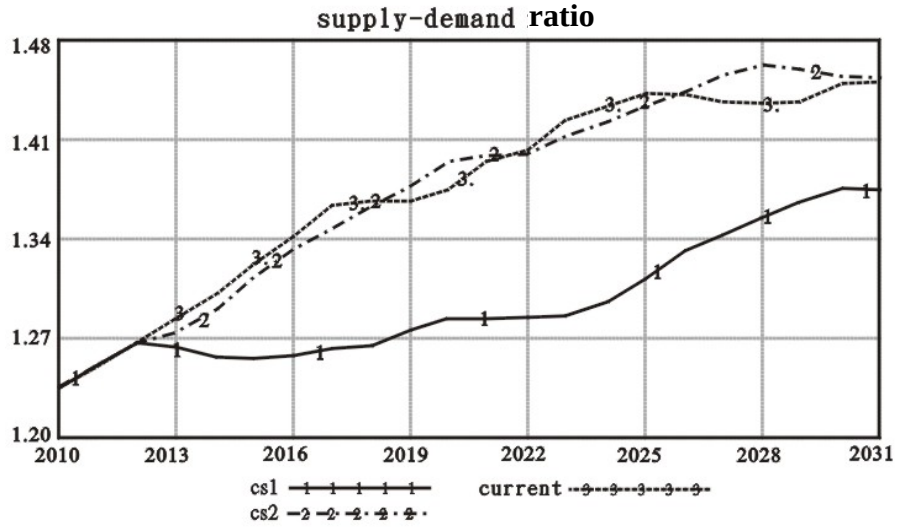


Fig 12: Scenario results of supply-demand ratio for joined strategy

As the unemployment rate at -0.3% reduction and the price index growth of 4% are not big adjustments, housing supply and demand behavior is not that great, and therefore vacancy rate is not much affected either. When the loan interest rate has been adjusted to 5.5%, the house purchase cost quickly increase and thus housing supply and demand evolve quickly; the increase of interest rate is more sensitive to adjustments in housing supply. The end results are that there is a more restricted supply in the market in the long-run and vacancy rates are reduced. When all three variables are applied, vacancy rate in 2013 represents a quicker reduction trend (Fig. 13).

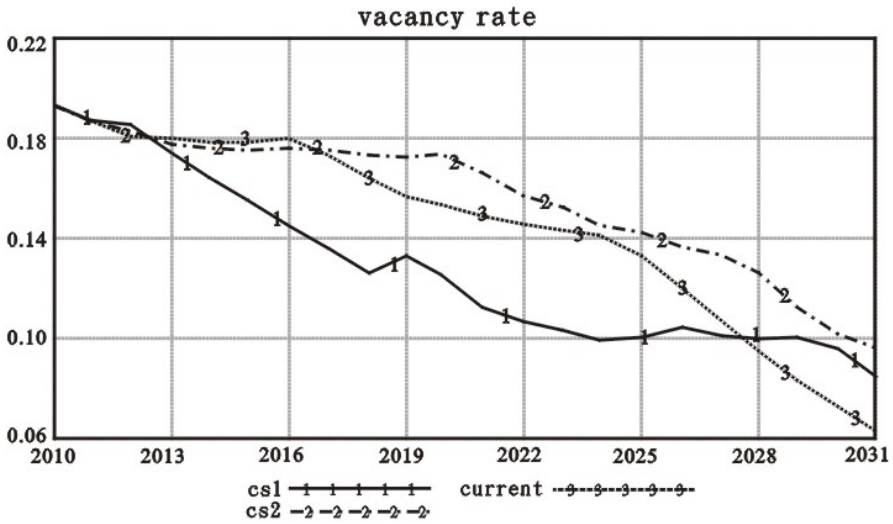


Fig 13: Scenario results of vacancy rate for joined strategy

Under cs1 scenario, as unemployment rate is reduced by 0.3%, average household disposable income increases, helping citizens' house purchasing ability to increase in leaps. Housing demand is expanded, the price and income ratio reduced in all aspects, the loan interest adjusted to 5.5%, and the price and income ratio in the short run reduced. This restrained price and income ratio price index by 4%. When original housing price did not change, price and income ratio in 2013 showed rapid reduction and in 2031, the ratio is reduced to 1.60 (Fig. 14).

Fig 14: Scenario results of price and income ratio for joined strategy

When unemployment rate is reduced by 0.3% and price index is increased by 4%, though this situation created a slight increase in housing prices, the loan interest rate increase to 5.5% will have a stronger influence on housing supply and demand; this eradicates excess housing, reducing housing prices and leading to overall decreases in housing prices in the market. In 2019, housing prices are reduced to NT$4.835 million/household (Fig. 15).

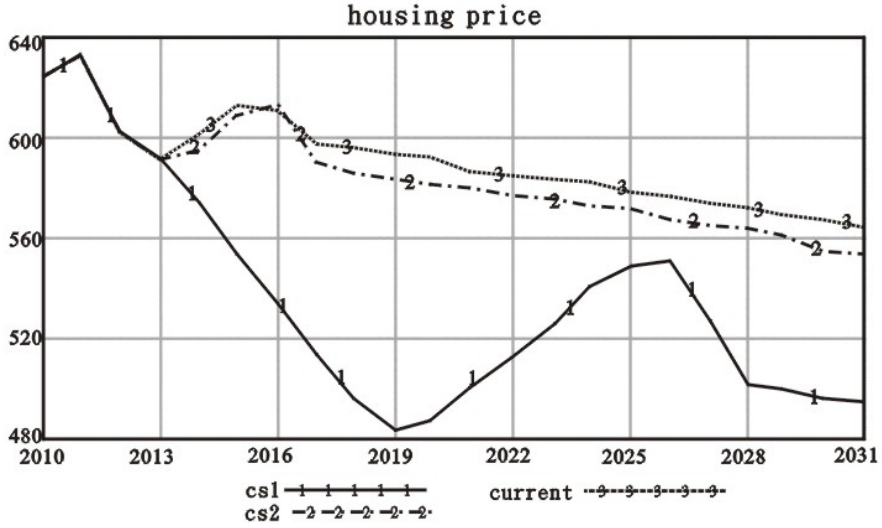


Fig 15: Scenario resualts of housing price for joined strategy

Joined strategy 2: To help develop the housing finance environment, elevate citizens' house purchase ability, and guarantee that urban housing resources are well-utilized

This strategy hypothesized that construction engineering material prices increase by 8%, complemented with a stronger loan interest of 3.5%. The unemployment rate has a 0.1% reduction within 5 years and then simulated by 3.7% method (cs2). These actions reduced overall housing demand and supply, thus reducing the housing demand-supply ratio in the short run. The unemployment rate, with a 0.1% reduction, affects citizens' ability to purchase houses. The price index is also increased by 8%, and housing demand is reduced in general, thus leading to a short-term reduction of the housing supply-demand ratio, but in the long run, there is only a slight market fluctuation (Fig. 12).

When the loan interest rate is increased to 3.5%, the vacancy rate in the short term will be reduced. The price index grows by 8% and leads to a decrease in housing demand, but it is a more effective strategy than reducing unemployment rates as a strategy towards house purchase ability. From 2017, the vacancy rate is higher than the original model (Fig 13).

When the unemployment rate is reduced by 0.1%, the loan interest rate is increased to 3.5% and the price index grows by 8%. These variables do not impact price and income ratio that much; they cause a slight reduction of the price and income ratio (Fig. 14). When the loan interest rate is increased to 3.5% and prices grow by 8%, the changes lead to slight changes in the housing price. However, when the unemployment rate is reduced by 0.1%, there is a slight impact. When applied in conjunction with the three variables, their effects write each other off, and housing price therefore only fluctuates slightly (Fig. 15).

Under the joined environment model, though many different types of policies influence it, the system in the end showcased that behavior trends are more effective than single scenario simulations. The loan interest increase can effectively restrain the housing demand increase; the unemployment rate control can strengthen house purchase ability, complemented by construction materials price control, enabling new prices to gradually increase when the three

variables effectively reduce Supply-demand ratio, Vacancy rate, Price and income ratio and Housing price. In ensuring that urban housing resources are well-utilized, elevating citizens' house purchase ability and helping develop housing finance policy goals, the simulated results of cs1 with its more gradual price fluctuation under higher loan interest and lower unemployment rates are a better and more effective policy as compared to cs2.

Conclusion

The urban housing market is a critical component of Taiwan's economic development system. It plays a very important role in determining the evolvement of Taiwan's economic situation, urban planning goals and the various urban policies to be implemented. Therefore, if we research, test and simulate policy models from an urban perspective, we are in a better position to understand what variables or geographical properties affect the urban housing market. We will also be able to find out the interaction mechanism, response strength, frequency and sustainability of the different variables so that the government is better able to select, designate and actualize the most effective programs, effectively controlling the urban housing market, increasing our urban competitiveness and realizing our vision of a better living environment.

To guarantee that urban housing resources are effectively utilized in the urban housing market, increase citizens' ability to purchase their own houses and create a more healthy housing finance environment, the dynamic urban housing model can quickly simulate different strategies so that we are more capable of understanding and predicting the future housing market and its development. The research also showed that strategy simulation is possible and that it can be done in a scientific way that is also highly adaptable to real-life situations. The research has reached the following conclusions:

1. Multi-collaboration can be systematically applied in the dynamic urban housing market research

The urban housing market is a multi-segment market that is non-linear, highly complicated and has time lag. Using a systematic engineering infrastructure that boasts engineering techniques and chemistry components (systems and sub-systems) and through the Fuzzy Delphi law and results derived from expert questionnaires and consultations, we can build an unbiased, professional index system that utilizes a dynamic system model to simplify what could have otherwise been a very complicated process. The different indexes used in the study can also give answers to what the variables' causal feedback relationships and influence differences are, and then through these responses evaluate policy effectiveness and help urban planners build a probable infrastructure to monitor the urban housing market.

2. Joined strategy model is a better evaluator of government housing policies than a single-strategy model

Loan interest rate increase, unemployment rate reduction, and product and service price index are each separately deployed in the single-strategy model to achieve different levels of changes in the supply-demand ratio, price and income ratio, vacancy rate, housing prices, etc. The model is also able to differentiate the long-term and short-term impacts, but it is not effective as a tool to survey policy effectiveness. The joined environment model consolidates

all variable influences and develops a cluster effect. Under internal conduction and multiplier effects, it is a better guarantor that urban housing resources are effectively utilized, citizens' house purchase ability is enhanced and the urban housing environment is developed healthily.

3. Policy optimization needs to consider policy objectives and the feasibility of limited resources

When urban housing policies are seeking optimization, goals need to be clearly established through a dynamic system model, leveraging a causal and logical process to discover the policy leverage points that can improve system behavior. Through the simulation of government policies and preferred implementation methods, under normal circumstances, multi-policy strategy is a more effective strategy. However, as the resources are limited when evaluating the resource origin's limitations and are difficult to implement, it becomes necessary that we consider our existing facilities before we can achieve the goal of evaluating policies better.

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