A DYNAMIC MODEL OF HOUSING MARKETS AND HOUSE PRICES

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ABSTRACT

Residential property market performances have great impact on the economy as a whole, and models of housing markets and housing prices have been a constant interest in real estate literature. Traditional static models may not be able to describe a special phenomenon in the housing market, the sometimes very rapid change in housing prices over a short term. This study develops a dynamic model for analysing residential housing market behaviour both in the long and short-term. It describes the dynamic effects of changes in aggregate housing demand and supply in the long-term model. In the short-term model, the impacts of demand and supply affects the housing prices, sometimes resulting in rapid changes as illustrated. This model is consistent with traditional housing economic theory. The differences are that it can demonstrate three-dimensional movement and a discontinuous change in housing prices. The study begins with reviewing housing economics and housing price models, followed by the development of a dynamic model of housing markets.

KEYWORDS

Housing market, Housing prices, Dynamic model, Catastrophe, Lagged supply

INTRODUCTION

Evidence suggests that residential property markets play an important role to the macro economy. The construction and property industries in Hong Kong have contributed over 20 percent of GDP since 1982 (Walker, *et al.*, 1995). Property and construction company stocks contributed 25 percent of Hong Kong's stock market capitalization, and over 60 percent (on average) of capital investment expenditure have been in property since 1983 (Newell & Chau, 1996). More than 45 percent of all bank loans are directly tied to properties (Chan, *et al.*, 2001). In Australia, dwelling sales have expanded from $90 billion or 13 per cent of GDP in 1999 to $156 billion or 21 per cent of GDP in 2003 (Ballard, 2004). It was recorded that the residential property sector contributes around

17% of the total GDP in Auckland in 2005 (New Zealand Government, 2006).

Property markets can affect price stability and distort resource allocation. Housing prices can surge to levels incompatible with economic fundamentals, creating bubbles (Chan, *et al.*, 2001) that inevitably collapse. Rising house prices, together with low interest rates and flexible mortgage financing, raise the general level of household income; drive internal consumption and support macroeconomic performance (Zhu, 2003). Rising property values also induce speculative activities, adding further pressure on housing prices. Conversely, falling property prices tend to impose downward pressure on the banking sector by increasing bad debt expenses for property loans, weaken business confidence and economic stability. Property depreciates and investment in property declines. A sudden drop in value causes a large number of properties to become negative-assets for families. Smooth changes in house prices thus help to maintain stable economic growth.

Housing price fluctuations can be driven by macro factors as well as intrinsic characteristics of the housing market itself (Zhu, 2003). It is important to understand the nature of housing price behaviour, and causal relationships between housing prices and the supply and demand for houses. Traditionally, housing price has been studied by models derived from historical data (Ho, 1998). This paper develops a dynamic model with three dimensions to study housing market fundamentals and intrinsic mechanism of property market.

REVIEW OF HOUSING ECONOMICS AND PRICE MODELING

Price formation in neoclassical economics is based on scarcity, utility and production functions and the associated assumption of utility and profit maximisation (Lee, 2003). The durability of housing means that the housing supply is dominated by existing stock (Muth & Goodman, 1989). The predominance of existing housing makes the housing supply quite fixed in the short term. The long time it takes to complete a housing unit (Maclennan, 1982) explains why housing supply usually lags behind demand whenever there is a sudden increase in housing demand (Omar & Ruddock, 2002). Omar and Ruddock (2002) suggest that the policy of housing development should foresee both the long-term and short-term trends in housing demand.

Equilibrium is the main issue of neoclassical theory (Solo, 1993). It is the end point of the

demand and supply mechanism and suggests an interactive system that determines economic changes through time. The stock-flow model widely used in macroeconomic studies of the housing market was motivated by a concern with business cycles and forecasting. In an adjusting stock-flow model, it is assumed there is a perfectly inelastic short-term supply of stock or services. The demand for and inelastic supply of housing services determines the price per unit of housing services. This price interacts with operating costs alternative asset yields, and a risk premium to determine a capital value per unit of housing stock. The capital value relative to the supply price of new stock determines the flow of new construction (Smith *et al.*, 1988).

Early research estimated variations of a basic two-equation stock-flow model. According to DiPasquale and Wheaton (1994), the demand for owner-occupied housing was modeled as depending on exogenous variables, such as demographic characteristics and real permanent income, the real price level of housing, the annual user cost of financing that price, and the alternative cost of renting.

The traditional assumption in the stock-flow model is that markets clear quickly and, at any time, prices adjust to equate the demand for housing with the existing stock. Thus, equilibrium price levels are determined in each period as a function of the selected variables. DiPasquale and Wheaton (1994) have suggested three innovations for the stock-flow theory: 1) Gradual price adjustment. The stock-flow model assumes that the housing market clears quickly. However, they found strong evidence to suggest that it takes several years for the market to clear. Therefore, rapid price adjustments may not be rational. 2) Expectation. They found that current prices will be positively related to recent past prices with backward-looking expectations. 3) Housing prices, new construction, and the land market. In the traditional model the supply of new housing is based on land and land prices depend on the stock of housing, not on the flow or the level of building activity.

DEVELOPMENT OF A DYNAMIC MODEL OF HOUSE PRICES

The study begins by setting the general assumptions for a dynamic neoclassical model. Next the structure of demand and supply are illustrated to show how price determination can be explained. The price elasticity of demand and supply will also be explained.

General assumptions

The model assumes that the housing market is competitive, and housing products are homogeneous (Muth, 1960). The behaviour of households and developers is rational and constant. House prices adjust until they reach an equilibrium where the quantity demanded is equal to the quantity supplied. Buyers and sellers in the housing market may or may not be in touch each other. Real estate agents connect buyers and sellers in the market. There is a sound financial credits system that allows households to get into the housing market (Chan, 1999). Households and developers go freely into the housing market to purchase and sell. Householders seek to maximise their utility derived from expenditures for both housing and non-housing related goods and services (Maclennan, 1982). Developers pursue profit maximisation. The existing housing stock plus additions to that housing stock are determined by developer behaviour in search of profits (DiPasquale, 1999) after consideration of development costs (Megbolugbe & Cho, 1993).

Demand for houses includes consumption and investment demand (Reichert, 1990). Scarcity of land makes housing prices appreciate (Tse, 1998) making some households speculate in future increases (Ho, 2000). Total housing supply or housing stock consists of a new supply of housing units and existing housing units (DiPasquale & Wheaton, 1994). The available unites include hoarded houses, unsold new houses, vacant houses, and second-hand houses for sale (Chan, 2003). This is a dynamic process of new supply. The decision to construct new supply is adjusted depending on the quantity demanded (DiPasquale, 1999). The housing market is always in equilibrium in the long term, but adjusts in the short term (Maclennan, 1882). Housing prices are determined only by quantity supplied and demand variables. A stable steady state is achieved from the interaction between supply and demand.

Figure 1 is a dynamic model that illustrates the housing market mechanism. The ordinate indicates housing price at equilibria. The abscissa indicates total housing demand and supply.

D = the curve of owner-occupied houses demanded at each equilibrium price.

S = the curve of total available supply of houses at each equilibrium price.

Q_d = Owner-occupied quantity demanded at each equilibrium level, i.e., $q_{d1,2,3.}$

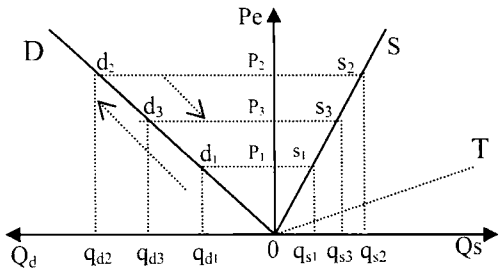

Figure 1 A dynamic model of housing market and house prices

Q_s = quantity supplied at each equilibrium level, i.e., $q_{s1,2,3}$, which include hoarded houses, unsold new houses, vacant houses, and second-hand houses for sale.

P_e = the equilibrium housing price, i.e., $P_{1,2,3}$.

T = the time period at each equilibrium level, i.e., $t_{1,2,3}$..

The total housing stock (Q_T) in the market thus equates to the owner-occupied demand for houses plus the house supply, i.e., $q_d + q_s = Q_T$ at each equilibrium period. Owner-occupied demanded for houses in the market would increase constantly as population grows in the long term. The supply of houses increases in order to meet the demand for houses. The total stock of houses therefore increases as well as house prices in the long term. i.e., $q_{d1} + q_{s1} = Q_{T1} < q_{d2} + q_{s2} = Q_{T2}$.

The Effects of Demand Changes in the Market

Demand is the relationship between prices and the quantity of goods consumers buy. The effective housing demand is the amount of housing for which the population is willing and able to pay. The effective housing demand for private housing is volatile and has been affected in the past by the market supply and market allocation mechanism.

Potential buyers have been divided into two subgroups: owner occupiers who buy and sell houses for personal use, and speculators and property developers who make money by selling and buying property (Roehner, 1999). Individuals view housing not merely as a consumption good, but also as an investment good (Case & Shiller, 1988; Dusansky & Wilson, 1993). Hence, uncertainty and expectations play a crucial role in housing demand models, as expectations of future prices influence current consumption, including housing choice and future consumption. Figure 2 illustrates the effects of demand changes in the market.

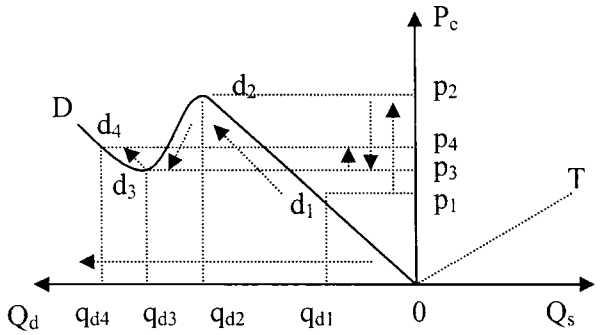

Figure 2: Effects of owner-occupied housing demand changes in the market

At the start, owner-occupied demanded for houses is at point q_{d1}, when price p_1, intersecting at d_1. The decision to buy or rent depends on affordability and household income. Household income thus plays a major role in determining demand for houses. Income not only influences the ability of a household to afford the continuing cash flow for housing, but influences a household's lifetime wealth prospects (Pozdena, 1988). The consumption and investment benefits and capital gains from purchasing houses, means that housing demand increases to q_{d2}, when house prices increases to p_2, intersecting at d_2. Connecting d_1 and d_2 gives the demand curve D. In the short term, continuous increases in house prices reduce the household's ability to afford housing. Price decrease to p_3 when demand for houses decreases in the third period to q_{d3}. The decline of demand for houses can be caused by external elements, such as a financial crisis, lost confidence in property investment, increased mortgage rate and so on. House prices adjust with market demand for houses. The demand curve thus is a nonlinear curve. In the long term, the total owner-occupier demand for houses Q_d is increasing gradually because population increases.

The housing market system can be derived by the shape of owner-occupier demand and supply curves. Fig. 3 illustrates the shape of owner-occupier demand curve from D to D_1. This change indicates how much owner-occupier demand fall as price increases, ceteris paribus. Most scholars have found that housing is relatively price inelastic. The price elasticity estimates are between -0.5 and -0.8 for the US housing market (Carline 1973; Lee, 1977; Hanushek and Quigley, 1982). In the UK market, the corresponding results are between -0.4 TO -0.7 (Meen, 1996; King, 1980; Ermisch, *et al.*, 1996). The short-run elasticities were considerably smaller.

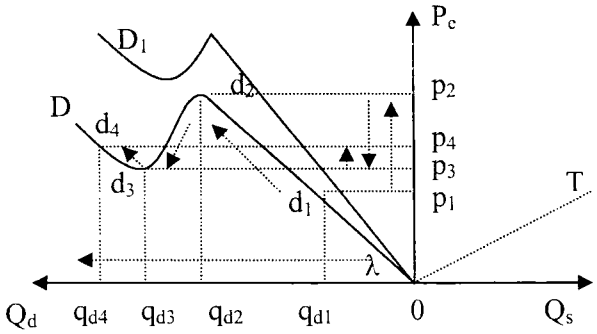

Figure 3: Effects of slope changes for owner-occupied housing demand curve

The Effects of Supply Changes in the Market

Housing supply arises from hoarded houses, unsold new houses, vacant houses, and second-hand houses for sale and represents the rate at which new supplies enter the market (Maclennan, 1982). Limited supply in local markets can exaggerate house price movements, but in the long term, a high level of demand for housing leads to an expansion in house building and an increase in the available market supply.

Housing supply is determined not only by the production decisions of builders but also by the decisions by owners of housing concerning conversion of existing stock (Dipasquale, 1999). Baer (1986) argues that improvements to the existing stock have increased over time, increasing the share of the additions to the stock. The stock of housing units in any period is equal to the stock carried over from the previous period and houses completed during that period, plus conversions and renovations minus demolitions. In equilibrium, the existing stock is just sufficient to satisfy the demand for housing, and there is no incentive for builders to complete further new houses (Nellis & Longbottom, 1981). Supply side factors, including vacancies, housing starts, and the interest rate, have played a marginal and in some instances even a counterintuitive role in price movements (Ley & Tutchener, 2001). Most studies of supply focus on the influence of prices, costs of construction, time lags, and political changes. Galaster (1996) suggests three distinct categories of supply: unchanged existing dwellings, modified existing dwellings, and newly constructed dwellings. The last two represent competitive modes by which suppliers respond to changes in market conditions. Figure 3 describes the effects in the market.

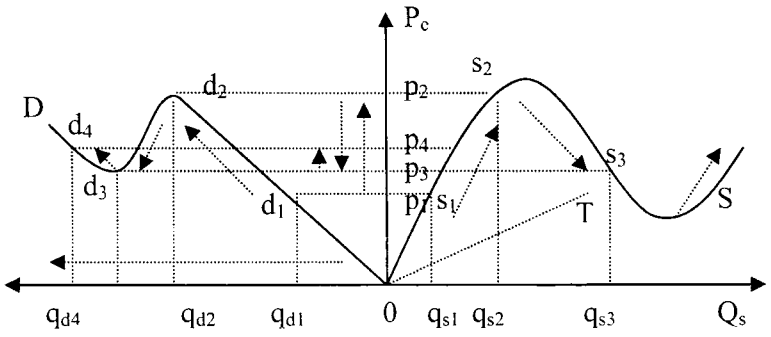

Figure 3: Effects of house supply changes in the market

The supply of housing is the number of houses available in the market at a given price, holding constant other factors that influence suppliers decisions, such as costs and government intervention. At the beginning, housing supply is at point of q_{s1} in Figure 3 when the price is p_1, intersecting at s_1. In period 2 available houses in the market increase to q_{s2}, to meet the increased owner-occupier demand, when house price increases to p_2, intersecting at s_2. Connecting s_1 and s_2 gives the supply curve S. When house prices decrease to p_3, house supply increases in period 3 to q_{s3}. The supply curve thus is a nonlinear curve. In the long term, house prices increase as the total supply of houses increases to Q_s. In the short term, house prices increase as because of the construction lag; fewer houses are available for sale due to owner-occupiers.

The shape of the supply curve can be changed to indicate different effects on the housing market. Assume there is a lagged supply, and the slope of the supply curve changes from S to S_1 (Figure 4). The price elasticity of housing supply measures the responsiveness of housing production to its selling price. Muth (1960) and Follain (1979) found no statistically significant relationship between outputs and price, because there is perfectly elastic supply. However, Stover (1986) produced consistent results with infinite supply elasticity. DiPasquale and Wheaton (1994) argued that Muth's stock adjustment model is more in tune with recent housing microeconomic models. They estimated a price elasticity of construction in the range of 1.0 to 1.2. These results indicate that the stock adjusts very slowly to its new long-term equilibrium through new construction. Similarly, Whitehead (1974) suggested that the elasticity of housing supply is around 1.2. Peng and Wheaton (1994) studied Hong Kong housing data and suggested that housing construction is no less elastic, and that the price elasticity for the supply for new units is 1.11.

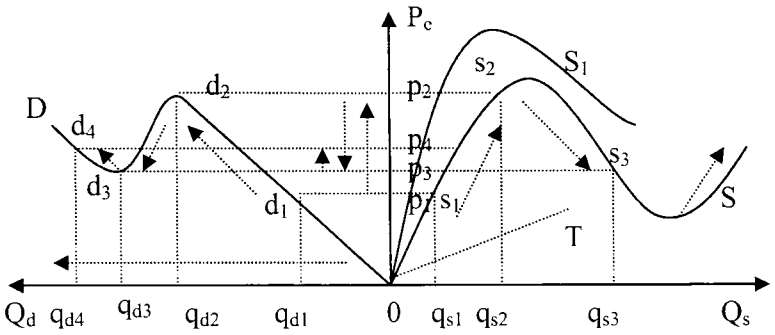

Figure 4: Effects of lagged supply change supply system

Given owner-occupier demand, when the number of available houses changes, the effect is house price changes (Figure 5). Figure 6 shows the supply structure in the market. s_3 indicates that there is a monopoly structure in the housing market, house price can increase considerably. The smaller s_1 represents the competitive structure in the housing market.

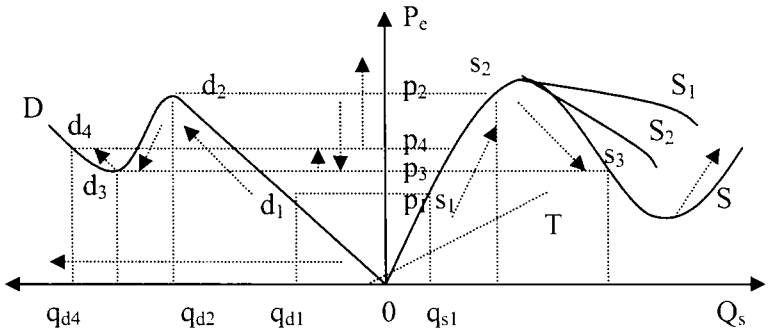

Figure 5: Effects of changes of number of house supply at a period

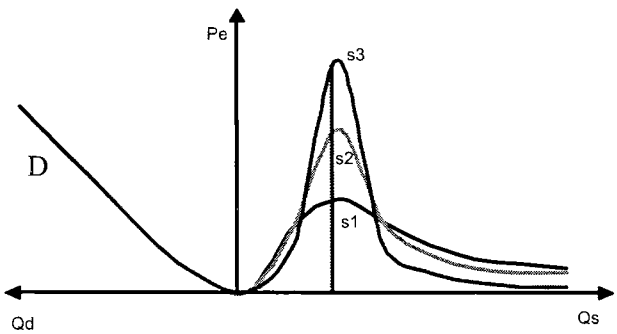

Figure 6: Effects of changes of supply structure

The Effects of House Prices

The owner-occupier demand and supply of houses is an integrated system in a housing market. The essence of economic theory is that demand and supply act together to

determine the equilibrium in static situations. If there is a shift in supply or demand in a comparative static condition, a new equilibrium is yielded (Maclennan, 1982; Harvey, 1998; Bumas, 1999). The important conclusion is that price increases are caused by shortages only and price decreases are caused by surpluses.

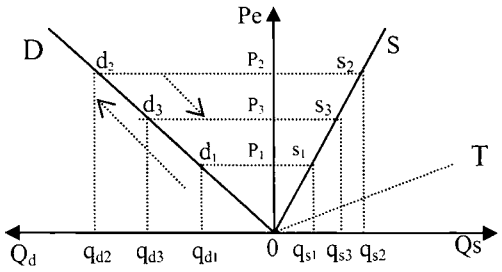

Figure 7: The dynamic model of house market in the long-term

The developed dynamic model can describe not only the mechanism and fundamental system of a house market, but also long-term and short-term phenomena. Figure 7 shows the system behavior in the long-term.

Assume everything else constant, the owner-occupier demand will increase in the long term. This is because population and income increase over time. As a result, the owner-occupier demand curve shall be linear and upward sloping in the long-term model. Similarly, as the total stock of houses increases, available houses for sale will increase. It is suggested that the house market has a cycle averaging 7 years (Bank of New Zealand, 2005). In the short term, increased household numbers have a minimal impact on house prices. It is external effects such as lack of confidence in the local economy and housing market, increased unemployment and events like financial crises that influence households' decisions to buy or sell. A large change in owner-occupied demanded changes the demand curve so that it becomes nonlinear as the effect of house prices changes. The supply curve is nonlinear in the short term because of lagged supply from new construction and excess supply from hoarding houses, unsold new houses, vacant houses, and second-hand houses for sale. Figure 8 depicts the dynamic model for the short-term housing market.

To understand the impact on housing prices, four phases are defined according to the discussion above, namely: the stable, the bubble, the unstable and catastrophe phase.

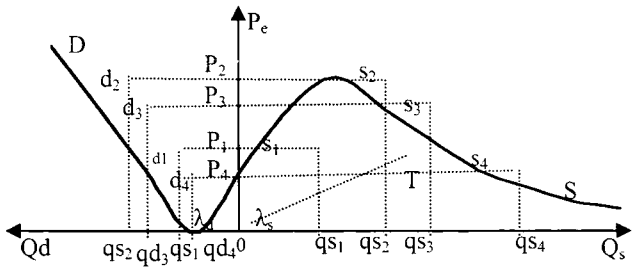

Figure 8: The dynamic model of house market at the short term

The Stable Phase (P_1):

This is a stable equilibrium phase in which housing prices move from one equilibrium to another. Figure 8 shows an equilibrium price level where equilibrium quantity and portion of vacant units are at point "d_1-P_1-s_1".

According to neoclassical economics, markets will respond to changes in demand and supply. An increase in demand for housing will push the price upward because housing supply is inelastic in the short-term (Kauko, 2001). The increase in prices will provide producers with a stronger incentive to speed up construction of houses and units (Gwartney, *et al.*, 2000). In this phase, the housing price has a stable adjustment at a given level of housing supply in the short-term. In the long-term, housing supply is smoothly adapted for the changes in demand. Vacant units are proportionate to the total housing stock at a suitable ratio and the housing price remains stable.

The Bubble Phase (P_2)

This phase indicates an unstable equilibrium position at the level of "d_2-P_2-s_2". The characteristic of this phase is that the price goes up consistently. Accompanied with an increase in household income, demographic elements and economic conditions, people expect house prices to increase. When the price has not reached the expected level, demand for housing consistently increases; and with it, house prices. In the short-term, new housing supply can not match the rapidly increasing demand for housing (Tse, 1997). The price will be under further pressure if the purchasers can see benefits of some speculation. Good economic prospect and high return from property create positive feedback. The deviation from equilibrium is large. Positive feedback may come from high expectations, over-confidence, imitative behaviour and hoarding between investors (Johansen & Sornette, 1999). Such positive feedback provides the fuel for the

development of speculative bubbles, the so called bubbles phase. A rapid increase in houses for sale in this phase is a warning of disruptive price changes.

The Unstable Phase (P_3)

The situation becomes critical when price bubble continues to grow due to speculative activities. It becomes critical when the average state of the price system become hyper-sensitive to a small disruption, *i.e.* different parts of the system become highly correlated. Critical points can be identified to show singularities asociated with bifurcation and catastrophe theory (Johansen, *et al.* 2001). Such singularities are produced by i) usual householders behaviour (performance today based on past data affects the future); ii) unusual householders behaviour (speculation); iii) construction lags; and iv) nonlinearity of the system. These mechanisms produce tragedy. Catastrophes occur from external stimulation (Fernandes, 1998). Any external phenomenon, such as changes in local economic conditions, a global economic slow-down, increases in unemployment or changes in the financial system may create a housing price catastrophe in the vulnerable system. In this phase, housing demanded decreases in company with increased lagged supply. House prices decrease.

The Catastrophe Phase (P_4)

In the housing market, the main reasons for a price crash may be misinformed expectations and speculation (Kim & Kim, 1999). People review the past and current behaviour of housing prices in the market and constantly adjust their expectations about the future, based on new information (Cho, 1996). Some households purchase property for investment when they expect a rise in housing prices. The continuous rise in housing price provides an environment that earns profits for short term speculators. Price speculation involves buying or selling with the expectation of a future price change (Levin & Wright, 1997). The speculative activities create bubbles in which the housing prices exceed the real value of property (Ho, 2000). Alternatively, if the housing price falls rapidly when the bubble breaks because of external factors, negative feedback occurs from households. Because of the downturn in expectations, many households withdraw from the housing market and monitor the housing price movement. Some speculators will leave the market by selling their property as quickly as possible at a marginal price, to avoid loss. This behaviour further increases the supply and puts more pressure on prices.

At higher price levels, housing demand reduces; some households exit the market after making profits by selling property. The higher housing price makes some speculators pause to observe the market trend. Housing price decreases as demands falls. Most importantly, there is a lag in the supply of construction, which means that the previous level of supply continues even after the fall in demand. The lagged supply adds pressure and lowers the householders' expectations of future housing prices. The housing supply increases and the supply curve becomes nonlinear. When the price drops down to P_3 and supply to s_3 (Figure 8), the point at the same slope of λd, which is the same level as vacant units but with the opposite sign of λs at s_3. Housing price catastrophe occurs at this point. Different slopes leads to different effects in price. The cobweb theorem indicates an effect of the change in current price and housing supply in the opposite direction (Hua & Chang, 1999). This happens because of construction lagging behind housing supply. Rapidly increasing housing demand encourages housing supply. At a new equilibrium position, new supply increases rapidly as demand decreases. The total housing stock at this point is qd_3-qs_3.

It is described as the catastrophe phase because there are disrupting changes in housing prices. s_3 is an unstable solution because of "the crowd effect", which fuels collective behaviour when households interact and imitate (Gwartney, *et al.*, 2000). Demand for housing decreases, price drops further to P_4 from P_3, *i.e.* the housing price appears as discontinuous from s_3 to a new stable state, s_4, a new and stable equilibrium position in the unstable system. The unstable conditions may change to a stable condition again because the supply may readjust down when there is a downward trend of housing prices. House supply starts to reduce and the speed at which housing demand falls slows down and the change in housing prices becomes smoother. At a lower lever of housing prices, supply reduces and demand increases smoothly. Both housing demand and supply return to a stable situation. The price becomes comparatively stable, but at a lower lever before it starts to recover.

In reality the catastrophe change in housing price is much more complicated than the simple form described above. However, even this simple form reveals a system of behaviour of the housing market and the principles and relationship of the equilibrium. It identifies unstable changes in housing prices as a result of housing supply exceeding the owner-occupier demanded for houses.

SUMMARY AND CONCLUSION

The research has developed a dynamic model for housing markets and prices. The derivation of owner-occupied demand and the supply curves was discussed. Both long term and short-term effects of the model are explained. The model demonstrates the fundamental mechanisms operating in housing market systems. It demonstrates that discontinuous housing prices can occur in a non-linear system where housing price fluctuation is determined by rapid increases or decreases in owner-occupied demand accompanied by a rapid decrease or increase in housing supply caused by the lag in the supply... The system was explored in four phases: stable, bubble, unstable, and catastrophe. At any time, the housing price movements depend on the stability of the system and sudden changes in housing prices are intrinsic properties of the system.

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