Investment Demand and Housing Prices in an Emerging Economy

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Abstract

This paper hypothesizes that the increase in money supply induced by rapid economic growth leads to strong investment demand in the Taiwanese housing market. A threshold model is used to confirm money supply as the key threshold variable. When the growth rate of money supply is below the model's estimated threshold value, household number, income, and user cost of housing capital are significant variables. It appears that service demand and housing supply are essential in creating the linear movement of housing prices. However, when the growth rate of money supply exceeds the threshold value, stock prices and the inflation rate become important. These findings suggest that non-linear movement of housing prices is primarily driven by investment demand.

The behavior of housing prices attracts considerable research attention because the housing market is one of the most volatile sectors of the economy. Studies on housing price modeling are extensive. Early studies attempted to use linear models to analyze housing price behavior and identify relationships between housing price and its determinants. The linear models used in these studies are capable of explaining long-run housing price movement based on the service demand of housing, but excess housing demand often causes considerable short-run non-linear volatility. Worldwide housing prices have displayed asymmetric, cyclical, and significant volatile behaviors. The market in the United Kingdom, for example, experienced four distinct cycles after the 1970s. Chen, Kawaguchi, and Patel (2004) revealed cyclical movements over the past few decades in the Asian real estate markets, including Hong Kong, Singapore, Taipei, and Tokyo. Taipei housing prices in the late 1980s underwent a three-fold increase in three years. In recent years, the market in the United States also experienced an unusually strong real estate boom and subsequent burst due to the subprime crisis.

Because of the frequency of non-linearity in housing prices, some studies have focused on econometric modeling and have attempted to incorporate non-linear characteristics into housing price models. For example, one early study by Hendry (1984) used cubic terms of lagging housing-price variables to capture non-linear

volatility. Hendry (1984) considered non-linear volatility to be caused by excess demand in housing. Hall, Psaradakis, and Sola (1997) used the switching model to describe housing prices with bubble-like behavior. However, most of the early housing studies tended to econometrically model the non-linear movement but not to sufficiently examine the underlying causes behind the non-linear phenomena in housing prices. Some later literature tried to explain the non-linear volatility in housing prices due to excess demand in housing in more detail. Levin and Wright (1997) explain this excess demand based on speculation. Clayton (1996) explains that expectation is the main reason for excess demand. Other studies (Dolde and Tirtigoglu, 2002; Jud and Winkler, 2002; Lastrapes, 2002; Goodhart and Hofmann, 2008; Beltratti and Morana, 2010) also tried to demonstrate that exogenous influence from the macro-economy could be the main cause of the excess demand that results in sharp increases in housing prices.

The previous literature has modeled non-linearity in housing prices and attempted to explain it based on excess demand, but the connection between non-linear econometric techniques and the excess-demand explanation is insufficient and merits further exploration. Some studies, such as Henderson and Ioannides (1983, 1987), Lin and Lin (1999), Arrondela and Lefebvreb (2001), and Cassidy, Dennis, and Yang (2008), have analyzed tenure choice by separating housing demand into service demand and investment demand. Our study attempts to better explain and model non-linear housing price movement in terms of service and investment regimes. Specifically, this paper asks the following major questions. First, does investment demand contribute to non-linear phenomena, such as the threshold effect in the housing market? And what is the key threshold variable for separating service and investment demand regimes? Second, what variables affect housing price movements in service and investment demand regimes? Finally, does a threshold model perform better than a linear model? Our study uses a threshold autoregressive (TAR) to answer these questions.

Our study is related to the existing literature but differs in the following aspects. First, we offer further discussion of the underlying causes of non-linear movement for housing prices (e.g., Hall, Psaradakis, and Sola, 1997; Dolde and Tirtiroglu, 2002; Sun, Sim, and Ho, 2007; Tsai, Chen, and Ma, 2010). Using the threshold model, we empirically separate housing demand into service and investment. This paper extends the explanation of monetary variables to investment demand, which is responsible for the non-linear movement of housing prices (e.g., Darrat and Glascock, 1989; Lastrapes, 2002; Chen, Tsai, and Chang, 2007; Goodhart and Hofmann, 2008; Beltratti and Morana, 2010). Second, we analyze an emerging economy, the economy of Taiwan, where housing prices are increasing rapidly. We chose Taiwan as an extreme case because its housing market demonstrates very strong resistance to worldwide financial crises. This resistance is evidenced by the fact that the Taiwanese housing market remained almost entirely intact during the 1997 Asian financial crisis and the 2007 U.S. financial crisis. We propose rapid economic growth, which induces an increase in the money supply, as the underlying cause of the strong demand for investment in housing. Finally,

this paper provides greater insight into the housing price movement in an emerging economy, especially for Chinese markets. Mainland China has high economic growth and has experienced very strong housing booms in recent years. Hong Kong's real estate prices have recently reached new heights. Our findings indicate that high economic growth will bolster housing assets and that monetary policies will be the essential instruments controlling the housing boom. Our results should help government divisions adjust housing market conditions and avoid the significant housing price fluctuations that make housing difficult to afford.

The remainder of this paper is organized as follows. The next section reviews the literature. Section 3 shows the peculiar characteristics of the Taiwanese housing market. Section 4 describes our housing price model, methodology and data, while Section 5 presents and discusses the empirical results. The concluding remarks and policy implications are contained in the final section.

Literature Review

Service and Investment Demand in the Housing Market

The housing price movement can be characterized by a long-run trend with a degree of short-run variability, which implies that the determinants affect price in two different ways. The upward long-run trend, generally regarded as a product of service demand sustained by determinants such as income and demographic factors, is unable to change rapidly. The stock of dwelling units, which is relatively inelastic with respect to changes in price, also determines the long-run movement of housing prices. Previous studies, such as Giussani and Hadjimatheou (1991), Breedon and Joyce (1992), and Hall, Psaradakis, and Sola (1997), model housing price for long-run and short-run movement. The models consider income, wealth, household number, dwelling stock, and so forth to be long-run variables determining service demand.

Due to the high volatility of housing prices in the short-run, studies have attempted to incorporate non-linear characteristics into housing price models and to explain the underlying causes. Some studies have focused on the behavior of price movements and modeled it using econometric techniques. For example, Hall, Psaradakis, and Sola (1997) used the switching model to describe housing prices with bubble-like behavior. Tsai, Chen, and Ma (2010) also used the switching model and found three volatile states in the U.K. price series. They also found that the magnitude of high price volatility for new and existing housing markets was as much as 14 to 20 times higher than that of low price volatility. Other studies have provided additional theories and explanations for the short-run volatility. Bowden (1980), Hendry (1984), Meen (1990), and others have examined housing prices from the perspective of housing demand because there is strong excess demand in the housing market. To model the excess demand in housing, studies, such as those by Meen (1990, 2002) and Hall, Psaradakis, and Sola

(1997), have used the approach of measuring the user cost of housing capital to capture the influence of excess demand on non-linear housing price movements, while other studies (Clayton, 1996) have used the rational-expectation theory. Although concepts such as user cost of housing capital or rational-expectation theory deriving from future housing price growth may explain some of the rapid adjustments in housing demand, we must discuss some additional theories related to excess demand.

Many studies have examined the theory of housing demand (e.g., Megbolugbe, Marks, and Schwartz, 1991). Some of these studies have discussed demand from the perspective of service and investment (e.g., Henderson and Ioannides, 1983, 1987; Berkovec, 1989; Brueckner, 1997; Lin and Lin, 1999; Arrondela and Lefebvreb, 2001; and Cassidy, Dennis, and Yang, 2008). These studies suggest that owner-occupied housing has both a consumption role in providing housing services and an investment role. Henderson and Ioannides (1983) appear to be the first authors to clearly present a model designed to illuminate the dual role of housing as both a consumption and investment good. Their paper also offers interesting predictions about housing market behavior and the determinants of tenure choice. Berkovec (1989) developed an applied general equilibrium model for analyzing the effects of tax policy on housing consumption and investment. Brueckner (1997) investigated the portfolio choices of homeowners, taking into account the investment constraint proposed by Henderson and Ioannides (1983) that requires housing investment by homeowners to be at least as large as housing consumption. Arrondela and Lefebvreb (2001) presented a model suggesting that the difference between the investment demand for housing and the consumption demand for housing explains decisions to purchase dwellings for owner occupation and for renting. A recent study by Cassidy, Dennis, and Yang (2008) introduced Home Appreciation Participation Notes (HAPNs), an innovative new housing finance tool based on two distinct housing utilities: shelter and investment. The HAPNs allow buyers to purchase the two elements individually. Thus, buyers can focus on purchasing housing units that best fit their shelter needs and invest in housing appreciation to whatever extent is appropriate given their investment portfolio.

The dual factors influencing housing behavior, consumption and investment, make the analysis of housing purchases quite difficult. Nevertheless, it is better to refer to a model that keeps the two-dimensional aspect of housing (Henderson and Ioannides, 1983). Although many studies have examined tenure choice by considering service and investment factors, few studies have examined the effect of these two factors on demand or housing prices. In the housing sector, especially in many Asian countries, speculative investors are common, and their actions tend to create housing bubbles. There is very strong demand for investment in housing. Examining the effects of these two factors on demand and housing prices provides significant implications for rapidly growing economies, such as those in many Asian countries, in which there is considerable investment in the housing market.

Housing Price Short-run Volatility and Money Supply

The macroeconomy is believed to have a critical effect on asset-price volatility (Gilchrist and Leahy, 2002). Research on the housing market has reported a significant connection with the general performance of the economy and with monetary policy (Darrat and Glascock, 1989; Kim, 1993; Ball, 1994; Maclennan, Muelbauer, and Stephens, 1998; Lastrapes, 2002; Jin and Zeng, 2004; Goodhart and Hofmann, 2008; Beltratti and Morana, 2010). Darrat and Glascock (1989) examined the causal relationship between money supply and real estate return and found that money supply plays an important role in changes in real estate return. Ball (1994) presented a theoretical argument for a relationship between economic growth and urbanization processes, which in turn affect housing prices. Breedon and Joyce's study (1992) incorporated gross financial wealth into their housing price model. They indicated that money supply has a lagged effect on current real estate returns, implying a possible refutation of market efficiency. Kim (1993) also indicated that the housing price in Korea was driven by rapid growth in the money supply. As Maclennan, Muelbauer, and Stephens (1998) indicated, there are both direct and indirect ways by which monetary policy may be transmitted through the housing market.

More recent studies have discussed how the relationship between money supply and asset investment leads to strong housing price fluctuation. Lastrapes (2002) used VAR to estimate the dynamic response of housing prices to money supply shocks and interpreted these responses based on the asset view of housing demand. Jin and Zeng (2004) developed a three-sector quantitative dynamic stochastic general equilibrium model to account for some of the salient business-cycle properties as they relate to service investment and housing prices. The authors found that monetary policy and nominal interest rates play a significant role in the determination of housing prices, as do money shocks by generating remarkably volatile residential investment. Aoki, Proudman, and Vlieghe (2004), Iacoviello (2005), and Elbourne (2008) examined the effects of monetary policy shock on housing markets and confirmed that they do influence housing-prices.

The strong link between money and housing prices appears to exist worldwide. Goodhart and Hofmann (2008) assessed the links between money, credit, housing prices, and economic activity in 17 industrialized countries over the last three decades. They provided evidence of a significant multidirectional link between housing prices, monetary variables, and the macroeconomy. Their results suggest that the link between housing prices and monetary variables is stronger over more recent years and that the effects of shocks to money and credit are stronger when housing prices are booming. Beltratti and Morana (2010) suggested in their analysis of G7 countries that macroeconomic variables, such as interest rates and monetary aggregates, affect housing prices.

Although the above-mentioned studies provide a potential link between housing price short-run volatility and monetary variables, how monetary variables stimulate

investment demand in housing deserves further discussion. While some studies, such as those by Henderson and Ioannides (1983, 1987), Brueckner (1997), Lin and Lin (1999), Arrondela and Lefebvreb (2001), and Cassidy, Dennis, and Yang (2008), specify and analyze housing demand from a service and investment viewpoint, we attempt to explain housing price movement from the viewpoint of investment demand and to enhance the links between investment demand, monetary variables, and housing price short-run volatility by examining Taiwan, where there is strong demand for housing investment.

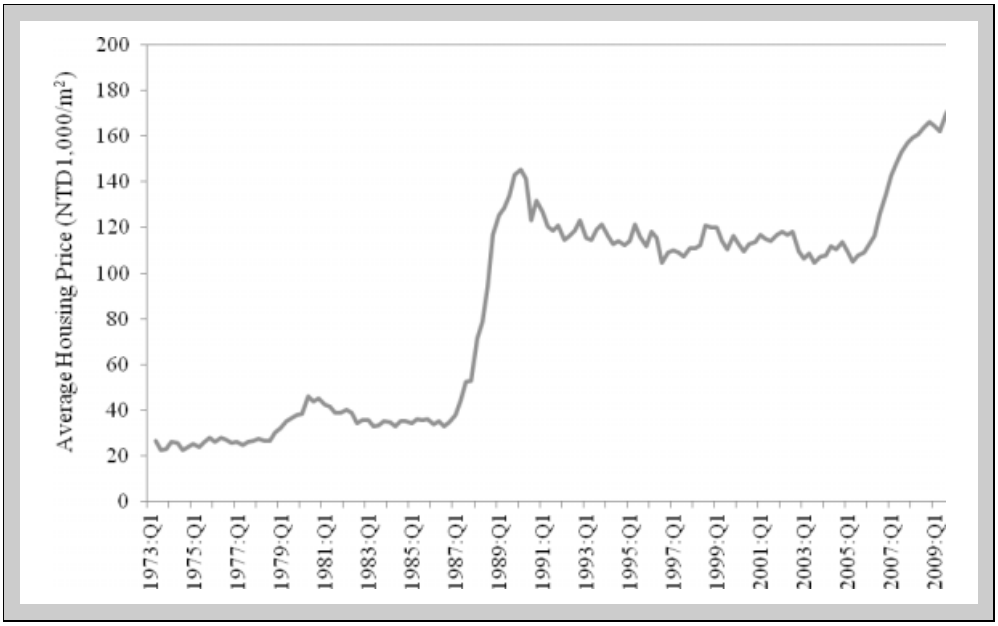
The Characteristics of the Taiwanese Housing Market

Economic Transition in Taiwan

Taiwan's economy underwent a rapid transition and industrialization led by export growth during the post-war period. Economic growth recorded an impressive rate of increase, with an average of 9% per annum during the 1960s and 1970s. Although two oil crises and recessions occurred in the 1980s, Taiwan recovered more rapidly than most other countries, with a peak economic growth rate of 12% in 1987. However, Taiwan's economy began to show signs of maturity, and economic growth began to slow after the 1990s. Because of a conservative financial system, Taiwan suffered little compared with many of its neighbors in the 1997 Asian financial crisis. After 1997, economic growth rates fell below 6%. The global economic downturn, political turmoil, and an increasing amount of bad debt in the banking system pushed Taiwan into recession in 2001, the first full year of negative growth since 1947. Currently, the electronics industry is the most important industry in helping to maintain Taiwan's economic growth. Exports, led by electronics and machinery, generate 70% of Taiwan's GDP growth and have provided the primary impetus for industrialization. This heavy dependence on exports made the economy vulnerable to the downturns in world demand resulting from the U.S. subprime crisis in 2007. However, Taiwan has shown signs of recovery, with an economic growth rate of 13.27% in the first quarter of 2010. Taiwan still runs a large trade surplus, and its foreign reserves are the world's fourth largest behind China, Japan, and Russia.

In addition to the long-run shift in Taiwan's industrial structure, there have been many major financial changes affecting the macroeconomy. Taiwan abandoned its fixed exchange rate regime after 1987. Because of the huge export surplus from the early 1980s, market forces had exerted a strong upward pressure on the exchange rate. After the Central Bank adopted a managed floating exchange rate regime in 1987, the exchange rate began to rise rapidly.[1] Because of this change, the restrictions on capital flows were also lifted, which enabled capital to move freely in the foreign exchange market, resulting in higher speculative movements during this period. In addition, in 1985, ten leading banks in Taiwan announced that their interest rates would be determined individually according to their position and market condition. The financial liberalization and loose monetary

Exhibit 1 | Historical Movement of Real Pre-sale Housing Prices in Taiwan (Taipei Area)



Source: Department of Construction and Planning Administration of the Ministry of the Interior and Taiwan Real Estate Center, NCCU.

policy unleashed investment activity in both the stock and housing markets and may be the primary cause of bubbles in the asset markets. As Agell and Berg (1996) state, financial liberalization has had a direct effect on the consumption choices of households with previously constrained credit and an indirect effect operating via wealth effects created in the housing market.

The Historical Movement of Housing Prices in Taiwan

Housing is an important sector of Taiwan's economy. However, it is also one of the most volatile sectors.[2] Over the last few decades, Taiwan has experienced sustained long-term growth in housing prices and recurrent fluctuations around its growth path. Over the past 37 years, the real average annual price increase in the Taipei area was 1.54%, as seen in Exhibit 1, and the standard deviation was almost 6.67%. Housing prices in Taipei, in real terms, show a clear upward trend. The price increases in Taipei have been inevitable because the falling supply of houses has been accompanied over the years by an increasing demand for home ownership. The surplus of continuous export has resulted in wealth accumulation, evidenced by both increased income and monetary growth. Consequently, the upward long-run trend has been fueled by demand and sustained by rising income, as well as by demographic factors accounting over time for the increase in value

and the supply of housing. Historically, it can be argued that long-term housing prices in Taiwan are largely influenced by demographic pressure, the availability of land, income, and accumulated wealth.

In the short-run, however, the housing market behaves more like an asset market with strong investment demand. Fluctuations in Taiwanese housing prices may be among the most dramatic in the world; at one point, housing prices tripled in a three-year period. Over the past forty years, Taiwanese housing market has gone though four boom periods: 1972–74, 1978–80, 1987–89 (Chen and Patel, 2002; Chen, Kawaguchi, and Patel, 2004), and from 2004 to the present, as shown in Exhibit 1. The housing price boom (Taipei area) in the early and late 1970s was caused by an oil embargo that led to high inflation in goods and construction costs. Rapid economic growth from trade surplus inducing increases in the domestic money supply is believed to be a complementary factor. The boom of the late 1980s is thought to have been caused by increases in the money supply due to financial liberalization and loose monetary policies with the background of rapid economic growth. The housing market went into a very long 13-year recession after the third boom and then began to rise again after 2004. This boom was basically fueled by low interest rates, which gave business conglomerates and speculators leverage to play the market. This record low interest rate environment may prolong the bubble-to-burst cycle. Another cause is the closer trade ties with China that have increased investors' expectations. Therefore, based on the experience of the Taiwanese housing market, the money supply associated with investment demand appears to be an essential component of housing booms. Many Taiwanese studies (Chen and Patel, 1998, 2002; Chen, Tsai, and Chang, 2007) suggest that money supply causes speculation in the housing market.

Housing Price Model, Methodology, and Data

The Basic Model: Linear Baseline Specification

In the traditional neo-classical approach, housing price models follow a simple standard reduced-form approach that analyzes housing prices from the demand and supply sides. A typical housing market model, followed by Malpezzi and Maclennan (2001), Jud and Winkler (2002), and Chen and Patel (2002), can be specified as following the three-equation model:

$$HD_t = f(Ph_t, HHN_t, Y_t, USERC_t, MS_t, SPI_t). \quad (1)$$

$$HS_t = g(Ph_t, CC_t). \quad (2)$$

$$HD_t = HS_t. \quad (3)$$

For this housing-market model, specified by Chen and Patel (2002) for the Taiwanese housing market, the stock demand for new houses (*HD*) is influenced by the housing price (*Ph*), household number (*HHN*), household income (*Y*), user cost of housing capital (*USERC*), money supply (*MS*), and alternative investments such as stocks (*SPI*). Supply for housing is a function of factors influencing real estate developers to construct new houses, including housing prices (*Ph*) and construction costs (*CC*).

Substituting for *HD* and *HS* in equation (3) from equation (1) and (2) leads to the expression of the reduced-form linear equation for housing prices with further consideration of the increasing supply of new houses (*S*) and inflation rate (*Inf*) as the control variables.

$$Ph_t = \alpha_0 + \underset{(+)}{\alpha_1 HHN_t} + \underset{(+)}{\alpha_2 Y_t} + \underset{(?)}{\alpha_3 S_t} + \underset{(+)}{\alpha_4 CC_t} + \underset{(+)}{\alpha_5 USERC_t} + \underset{(+)}{\alpha_6 MS_t} + \underset{(?)}{\alpha_7 SPI_t} + \underset{(?)}{\alpha_0 Inf_t} + u_t. \quad (4)$$

In this equation, some variables are related to long-run movement in housing price and service demand, such as household number, income, and housing supply. Other variables, such as money supply and stock price, are more closely tied to investment demand. The household number (or population) is directly related to the potential demand for houses. An increase in household number leads to a rightward shift of the demand curve and causes housing prices to rise. Income is another important determinant of a household's ability to buy a house; higher income results in a higher ability to buy. The user cost of housing is the capital capture cost of service weighed against the opportunity for capital gains. A basic measure of user cost is the after-tax mortgage interest rate minus expected capital gains. While the user cost should have a positive value, negative values occur when the rate of housing prices increases beyond the mortgage interest rate and other associated costs. The user cost should have a negative relationship with housing prices. Because an expansion in the money supply increases the general price level of goods, many studies have indicated that housing price is driven by rapid growth in the money supply. In addition, an increase in the money supply will enable households to invest in the housing market and allow banks to increase loans to households and developers. This should lead to a rise in housing prices, given that real assets are normally perceived to be a relatively safe investment and offer a better inflation hedge than other financial assets (Chen and Patel, 2002). With regard to the effect of the stock price index, however, there is no consensus on the relationship between stock price returns and housing price returns. Some researchers support the existence of a connection between stock price returns and housing price returns (e.g., Li and Wang, 1995), whereas others claim that stock and housing remain separable and a connection does not exist (e.g., Geltner, 1990).

Some studies have shown mixed results (e.g., Wilson and Okunev, 1999). Because the prior literature has generated mixed results, we leave the relationship between stock and housing returns open for empirical examination in this paper. In addition, the impact of inflation on housing prices is uncertain. Hoesli, Lizieri, and MacGregor (2008) mention that the empirical results of the relationship between inflation and real estate returns are mixed. While there is some evidence that directly owned private real estate provides a partial hedge against some components of inflation, securitized real estate is often shown to exhibit the same negative relationships found in stock market research, particularly with respect to unexpected inflation. Finally, taking the supply side into consideration, an increase in construction costs for builders usually causes a decrease in the housing supply, which in turn leads to higher housing prices. Therefore, the effects of construction costs on housing prices are expected to be positive. For housing supply, it is presumed that although an imbalance may exist in the short run, demand equals supply in the long run. If there is overbuilding in one period, the oversupply will cause house prices to increase. Therefore, increasing the supply of new houses has a negative relationship with housing prices.

The Threshold Model for Service and Investment Demand

Investment Demand Theory behind the Taiwan Housing Price Movement. The fixed housing stock has attributes of an investment asset. The housing investment decision is based on the return on housing capital relative to the returns on assets competing for inclusion in the wealth holder's portfolio. The availability of credit in the economy and for households must be taken into account. For the effect of the money supply, many studies discussed above have indicated that housing prices are driven by the rapid growth of the money supply because its expansion leads to an increase in the general price level of goods. In addition, an increase in the money supply enables households to invest in the housing market and banks to increase loans to households and developers, which in turn contributes to an increase in housing prices.

As noted above, housing prices in Taiwan are greatly affected by increases in the domestic money supply (DMS). When there is a rapid expansion in the money supply, households find it relatively easy to borrow funds to invest in the housing market. In addition, real assets are generally perceived to be a relatively safe investment and offer a better inflation hedge than other financial assets. As stated previously, the rapid economic growth in Taiwan has led to a continuous trade surplus, which has accumulated into a large amount of foreign exchange. In an open economy like Taiwan's, the broadest term of money supply (MS)[3] can be represented by:

$$MS = FR + DMS, \tag{5}$$

where FR is the foreign exchange reserves.

Taiwan's foreign exchange reserves are an accumulation of its continuous trade surplus from the wealth created from export-led economic growth. Although Taiwan has a small economy, its foreign exchange reserves have been ranked among the largest in the world for the past several decades. In 1992, Taiwan's foreign exchange reserve was ranked second, its highest rank. Its 2009 reserve of US$3480 ranks fifth in the world. The foreign exchange reserves are an underlying force behind the money supply for housing price increases in Taiwan.

The Threshold Model. The empirical equation (4) represents the conventional linear housing price model. However, recent literature has suggested that the relationship between housing price and its determinants does not follow a single pattern. The TAR model is used to examine the non-linear interaction between the housing price and its determinants. As discussed, we hypothesize that service and investment demand causes different housing price behaviors and may have a threshold effect on housing prices.

Applying the TAR model to housing prices, the empirical TAR model can be formulated as follows:

$$ph_t = \begin{cases} A_1' X_t + u_t & \text{if } x_t < \gamma, \\ A_2' X_t + u_t & \text{if } x_t \geq \gamma, \end{cases} \tag{6}$$

where X_t is a matrix that denotes the explanatory variables and x_t is the threshold variable where γ is the threshold parameter. The error u_t is assumed to be independent and identically distributed, with a mean of zero and finite variance $\sigma^2(u_t \sim iid(0, \sigma^2))$. The empirical model is $y_t = A_1' X_t + u_t$ when $x_t < \gamma$ and $y_t = A_2' X_t + u_t$ when $x_t \geq \gamma$. We can also rewrite equation (5) as follows:

$$y_t = A_1' X_t \cdot D_1 + A_2' X_t \cdot D_2 + u_t, \tag{7}$$

where $1(\cdot)$ is the indicator function defined in terms of the threshold parameter γ as $D_1 = 1(x_t < \gamma)$ and $D_2 = 1(x_t \geq \gamma)$. In sum, the observations are divided into two ''regimes'' depending on whether the threshold variable x_t is smaller or larger than the threshold value (γ) and the regimes are distinguished by differing regression coefficients, A_1 and A_2.

X_t is a matrix including the main housing price determinants, such as household number (*HHN*), household income (*Y*), housing supply (*S*), construction cost (*CC*), user cost of housing capital (*USERC*), money supply (*MS*), stock price index (*SPI*), and inflation (*Inf*) in the equation (4). According to this process, when the regression equation (4) is under a two-regime TAR system, our empirical model[4] can be expressed as:

$$\begin{aligned} Ph_t = {} & (\alpha_{10} + \alpha_{11}HHN_t + \alpha_{12}Y_t + \alpha_{13}S_t + \alpha_{14}CC_t \\ & + \alpha_{15}USERC_{t-1} + \alpha_{16}MS_t + \alpha_{17}SPI_t + \alpha_{18}Inf_t) \cdot D[x_t \leq \gamma] \\ & + (\alpha_{20} + \alpha_{21}HHN_t + \alpha_{22}Y_t + \alpha_{23}S_t + \alpha_{24}CC_t + \alpha_{25}USERC_{t-1} \\ & + \alpha_{26}MS_t + \alpha_{27}SPI_t + \alpha_{28}Inf_t) \cdot D[x_t > \gamma] + u_t. \end{aligned} \tag{8}$$

Under the threshold point (γ), housing prices show linear behavior. However, above the threshold point (γ), housing prices behave non-linearly, possibly because of investment demand.

Tests of Threshold Effect

When equation (8), the TAR model, is estimated, we should first test if there are threshold effects. Previous studies sometimes subjectively split the sample to conform to the needs of their research issues. However, this division will cause a slight defect of the model setting and the sample splitting error. To avoid this subjective partition, our TAR models divide the sample according to the classified standards of the CUSUM and Chow breakpoint test.

The CUSUM Test. The CUSUM test (Brown, Durbin, and Evans, 1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical bounds. The test finds parameter instability if the cumulative sum goes outside the area between the two critical bounds. The CUSUM test is based on the statistic:

$$W_t = \sum_{s=n}^{t} \frac{w_s}{\hat{\sigma}_w}, \tag{9}$$

for $t = n, n + 1,...,T$, where w_s is the recursive residual, and $\hat{\sigma}_w$ is the standard error of the regression fitted to all T sample points. If the β vector remains constant from period to period, then $E(W_t) = 0$. But if β changes, then W_t will tend to diverge from the zero mean value line. The significance of any departure from the zero line is assessed by reference to a pair of 5% significance bounds with $\theta = 0.94$[5], the distance between which increases with t. The 5% significance bounds are found by connecting the points ($n - \theta\sqrt{T-n}$, $n + \theta\sqrt{T-n}$) and ($T - 3\theta\sqrt{T-n}$, $T + 3\theta\sqrt{T-n}$). Movement of W_t outside the critical lines is suggestive of coefficient instability.

The Chow Breakpoint Test. Intuitively, if we divide the sample into two subsamples, they should have the same characteristics without a structural change. The idea of the Chow breakpoint test is to fit the equation separately for each

subsample to test whether there are significant differences in the estimated equations. A significant difference indicates a structural change in the relationship. For example, we can use this test to examine whether the regression function for the housing price is the same before and after the threshold effect. The test may be used with least-squares and two-stage least-squares regressions. To carry out this test, we partition the data into two or more subsamples, each of which must contain more observations than the number of coefficients in the equation so that the equation can be estimated. The Chow breakpoint test compares the sum of the squared residuals obtained by fitting a single equation to the entire sample with the sum of squared residuals obtained when separate equations are fit to each subsample of the data. The *F*-statistic is based on the comparison of the restricted and unrestricted sum of the squared residuals, and in the simplest case involving a single breakpoint, is computed as:

$$F = \frac{(SSR_R - SSR_U)/(p + 1)}{SSR_U/(T - 2(p + 1))} \sim F(p + 1, T - 2(p + 1)), \qquad (10)$$

where SSR_R is the restricted sum of squared residuals, SSR_U is the sum of squared residuals from subsample, T is the total number of observations, and $p + 1$ is the number of parameters in the equation. This formula can be generalized naturally to more than one breakpoint. The *F*-statistic has an exact finite sample *F*-distribution if the errors are independent and identically distributed normal random variables.

Description of Taiwan Data

Our study analyzes the housing price and its determinants in Taiwan over the period from 1975 to 2009. There are several housing price series, such as pre-sale housing prices, the Sinyi housing price index, and the Cathay housing price index. We adopt new pre-sale housing prices (average unit price per pin of house) in the Taipei area provided by the Department of Construction and Planning Administration of the Ministry of the Interior[6] for the period from 1972 to 1999 and thereafter extended by the Taiwan Real Estate Center for 2000 to 2009. Although these data were computed based on the weighted-average method[7] and the other two sets are quality adjusted, the pre-sale price data are available over the longest period in Taiwan and are also widely used in academic research. Our housing price data consist of 140 quarterly observations for a period from 1975: Q1 to 2009:Q4.

For the other variables, the population (household number), income (household income), housing supply (housing permits), and construction costs (construction cost index) are from the Statistics of Taipei and Taipei County. The other determinants, money supply (M2), interest rate (mortgage interest rate), stock

Exhibit 2 | Definition of Variables

Variable	Definition
$\Delta \ln Ph_t$	Real housing prices growth rate in Taipei area.
$\Delta \ln HHN_t$	Household number growth rate in Taipei area.
$\Delta \ln Y_t$	Real household income growth in Taipei area.
$\Delta \ln S_t$	Housing starts growth rate in Taipei.
$\Delta \ln CC_t$	Real construction cost growth rate in Taipei.
$USERC_t$	User cost of housing capital represented by real interest rate minus real housing price growth rate.[8]
$\Delta \ln MS_t$	Real money growth rate represented by M2.
$\Delta \ln SPI_t$	Real stock price index growth rate.
$\Delta \ln CPI_t$	Inflation rate represented by annual rate growth of Consumer Price Index.

prices (stock price index) and Consumer Price Index, are collected from the *Taiwan Economic Journal* (TEJ). The variables, measured in nominal terms such as housing price, income, money supply, interest rate, stock-price index, and construction-cost index, are deflated by the Consumer Price Index. All of the variables are converted to natural logarithms with the exception of the interest rate. Detailed definitions of the variables are shown in Exhibit 2.

Panel A of Exhibit 3 reports descriptive statistics for eight variables, while Panel B presents their correlation matrix. The highest correlation is between the growth of household income and money supply, at 0.756 (absolute value). To avoid the multicollinearity problem of the empirical model, we use the variance inflation factor (VIF), the results of which are shown in Exhibit 4. Because all of the individual VIFs are below the critical value of 10 and the average VIF is 2.05, the potential for multicollinearity of the empirical regression is eliminated.

Stationary time series are required for our study. The Dickey and Fuller (1979, 1981) tests and the Phillips-Perron (1988) test[9] were employed to examine the hypothesis of a unit root among all of our variables in this study. The results of the unit-root tests in Exhibit 4 show that the null hypotheses of a unit root are all rejected. All of the variables are stationary.

Empirical Results

The premise of this study is that economic growth is fundamental for the money growth that increases housing prices in Taiwan. We use the multivariate Granger causality technique for the preliminary test of this premise. Next, we use the threshold model to test our theory that investment demand contributes to the

Exhibit 3 | Descriptive Statistics and Variance Inflation Factors

Variables	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis
Panel A: Descriptive Statistics							
$\Delta \ln Ph_t$	0.0129	0.0116	0.2505	−0.1331	0.0514	1.0548	6.8241
$\Delta \ln HHN_t$	0.0082	0.0068	0.0171	0.0016	0.0042	0.6159	2.1367
$\Delta \ln Y_t$	0.0093	0.0072	0.0674	−0.0276	0.0197	0.7853	3.3602
$\Delta \ln S_t$	0.0009	0.0174	0.2329	−0.1328	0.0875	0.6685	3.0081
$\Delta \ln CC_t$	0.0023	0.0006	0.1045	−0.0712	0.0269	0.5709	4.4746
$USERC_{t-1}$	0.0602	0.0693	0.1787	−0.2213	0.0598	−1.2604	7.1092
$\Delta \ln MS_t$	0.0257	0.0272	0.1192	−0.0456	0.0328	0.4221	3.1152
$\Delta \ln SPI_t$	0.0186	0.0136	0.9648	−0.7753	0.2174	0.0451	6.8205
$\Delta \ln CPI_t$	0.0129	0.0116	0.2505	−0.1331	0.0514	1.0548	6.8241

Panel B: Variance Inflation Factors

	$\Delta \ln HHN_t$	$\Delta \ln Y_t$	$\Delta \ln S_t$	$\Delta \ln CC_t$	$USERC_{t-1}$	$\Delta \ln MS_t$	$\Delta \ln SPI_t$	$\Delta \ln CPI_t$
VIF	2.1550	3.3610	1.0972	1.2506	1.1281	3.0940	1.0436	3.2680

Exhibit 4 | Results of Unit Root Tests

Variables	Augmented Dickey-Fuller Test	Phillips-Perron Test
$\Delta \ln Ph_t$	−8.585***	−9.425***
$\Delta \ln HHN_t$	−5.265***	−14.065***
$\Delta \ln Y_t$	−3.975***	−11.591***
$\Delta \ln S_t$	−4.259***	−4.182***
$\Delta \ln CC_t$	−4.947***	−10.856***
$USERC_{t-1}$	−6.126***	−6.674***
$\Delta \ln MS_t$	−3.332**	−12.697***
$\Delta \ln SPI_t$	−12.727***	−12.761***
$\Delta \ln CPI_t$	−2.826*	−11.668***

Note: The null hypotheses of the Augmented Dickey-Fuller Test and the Phillips-Perron Test are that the series is non-stationary with a unit root. The 1%, 5%, and 10% critical values are −3.4782, −2.882, and −2.578, respectively.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

Exhibit 5 | Multivariate Granger Causality Tests (Block Exogeneity Wald Tests)

Null Hypothesis	χ^2-Statistic	Prob.
For Housing Prices		
ΔGDP does not Granger Cause ΔPh	2.339	0.126
ΔM2 does not Granger Cause ΔPh	3.347*	0.067
For Economic Growth		
ΔPh does not Granger Cause ΔGDP	2.714*	0.099
ΔM2 does not Granger Cause ΔGDP	27.276***	0.000
For Money Supply		
ΔPh does not Granger Cause ΔM2	2.449	0.118
ΔGDP does not Granger Cause ΔM2	4.755**	0.029

threshold effect in the Taiwanese housing market. We then employ a robust test to confirm the empirical analysis and to estimate the threshold point for separating service and investment demand into two systems. Finally, we examine respectively which variables affect housing price movements in service and investment demand regimes, and we compare the performance of linear and threshold models.

Preliminary Test of the Effects of Economic and Money Supply Growth on Housing Prices

We have proposed that economic growth causes money supply growth, which in turn causes housing prices in Taiwan to increase. We use the multivariate causality test to examine this relationship. The results, shown in Exhibit 5, suggest that the economic growth rate (ΔGDP) and real money supply growth rate (ΔM2) Granger cause each other, and the real money supply growth rate Granger causes housing prices. Although we do not find that economic growth directly causes changes in housing prices, we do find that economic growth causes real money growth and real money growth causes housing prices. These results support our assertion, and we examine the housing price determinants in the next section.

Does Investment Demand Contribute to the Threshold Effects in the Taiwanese Housing Market?

To avoid the configuring problem from the pectoral gauge in the number of the threshold variables, this paper uses the CUSUM test, which can efficiently determine whether the data have the threshold effect based on their characteristics. As the first step in testing for the existence of threshold effects, we estimated the regression models with all of the explanatory variables. We rearranged every

explanatory variable as a possible threshold variable in every regression model. Finally, we chose the suitable threshold variable and threshold parameter according to the CUSUM test. If the plot of CUSUM statistics (cumulative deviation errors of one-step-ahead prediction from the recursive regression) stays within the critical bounds of the 5% significance level, the null hypothesis that all coefficients in the regression are stable cannot be rejected. If either of the lines is crossed, the null hypothesis of coefficient constancy can be rejected at the 5% level of significance. In other words, the threshold effects are evident. The plots of the CUSUM test in Exhibit 6 show that with the exception of real money growth, all variables have no indication of this effect. This result suggests that real money growth is our threshold variable and confirms our hypothesis that the investment-demand variable is responsible for the non-linear volatility in housing prices. This result further supports the results of previous studies, such as Ball (1994), Maclennan, Muelbauer, and Stephens (1998), Lastrapes (2002), Aoki, Proudman, and Vlieghe (2004), Iacoviello (2005), Elbourne (2008), Goodhart and Hofmann (2008), and Beltratti and Morana (2010), that money supply shocks macroeconomic activity.

Are the Test Results Robust?

We explore the robustness of our CUSUM results by considering alternative variables as threshold variables in the regression model. From the plots of CUSUM tests for all other alternative variables in Exhibit 7, we find that only money supply exceeds the critical bounds of the 5% significance level. Therefore, we reconfirm that money supply is the threshold variable for housing prices.

Where Does the Threshold Point Showing Strong Investment Demand Occur?

When we examine the CUSUM test of money supply in Exhibit 6, we find the variation for some samples exceeds the line of critical value. This finding shows coefficient instability and suggests the existence of structural change. To reconfirm the location of non-linear change, we sort the data by the money supply and test the sample at each point by the Chow breakpoint test, as suggested by Hansen (2001). Tracking down the *F*-statistics of each Chow test plotted in Exhibit 8, we find that there are many significant *F*-statistics in the latter half of the sample, especially in the 120th sample, which has the largest *F*-statistic (3.64). Therefore, we choose this point as the threshold point and the corresponding value (5.85%) as our threshold value for our housing price model.

We proceed to construct both the housing price linear model and the TAR model shown in Exhibit 9 using the real money supply growth rate as a threshold variable with the threshold value (r) approximately equal to 5.85%. For comparison purposes, the first column displays estimates for a linear specification that ignores

Exhibit 6 | Result of CUSUM Tests for the Existence of Threshold Effects

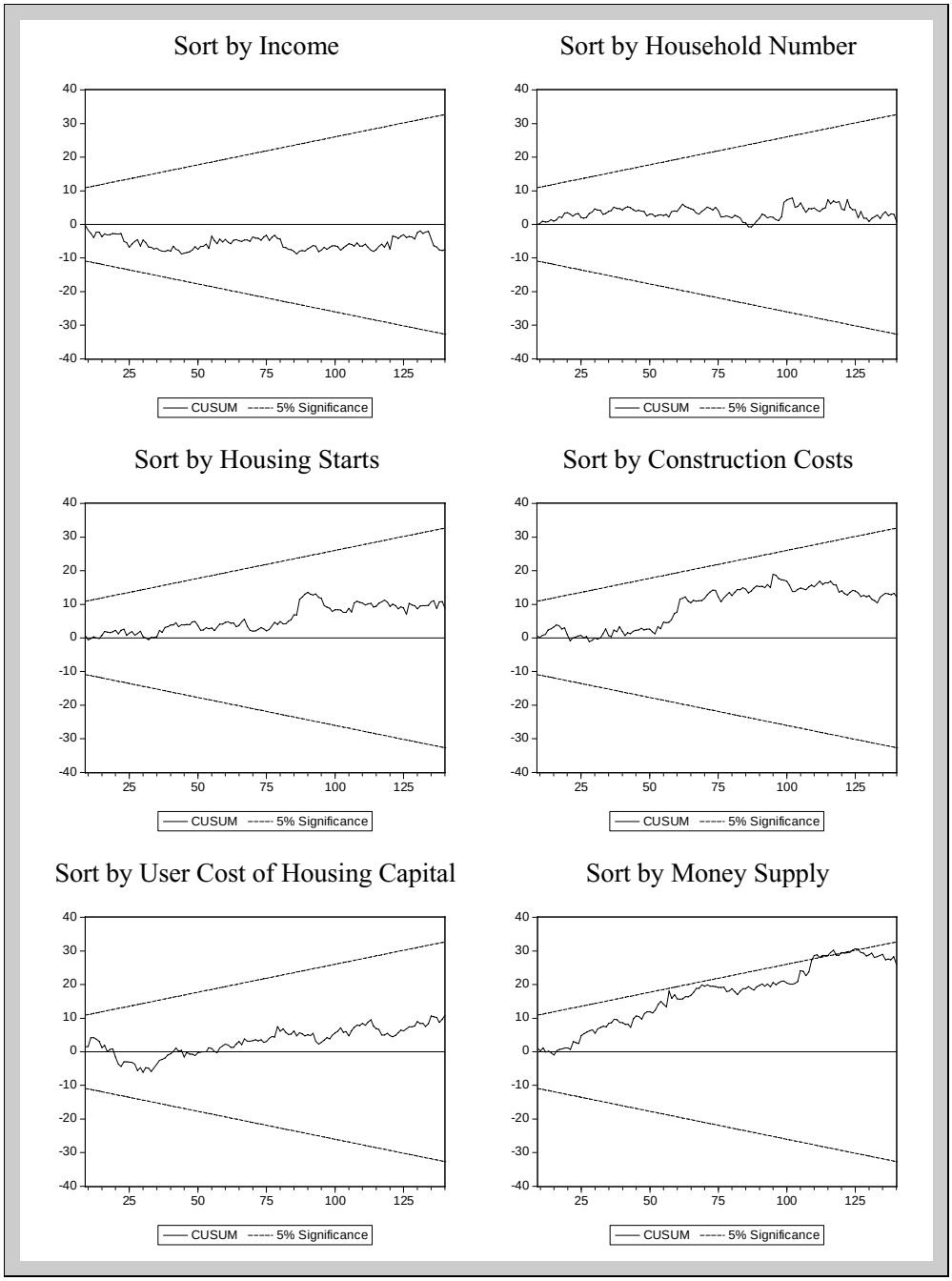
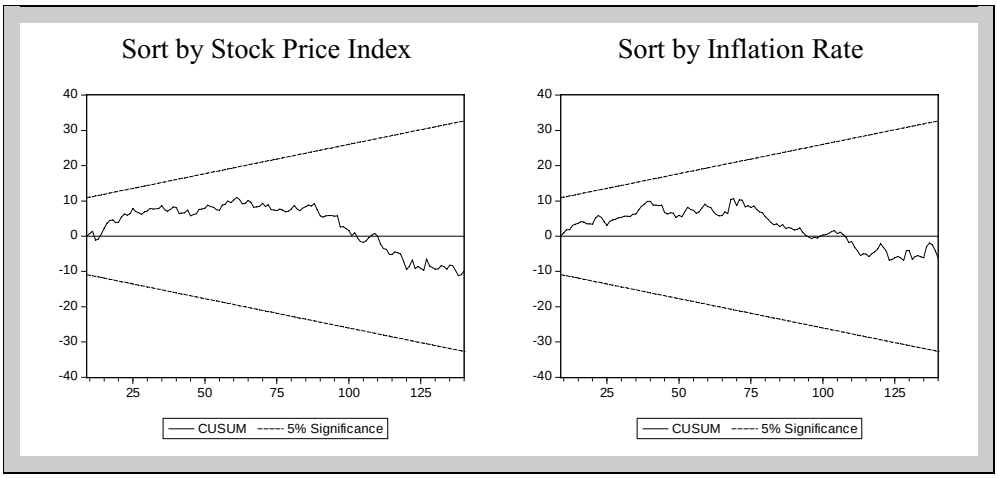


Exhibit 6 | (continued)
Result of CUSUM Tests for the Existence of Threshold Effects



the threshold effect. The remaining columns provide the estimates of the TAR model. The results of the linear model in the first column indicate that household number, user cost of housing capital, and stock price index have significant influence on the housing price growth. The signs of these variables also coincide with the theoretical housing price change. This result is consistent with previous housing studies and is similar to an empirical study for Taiwan (Chen and Patel, 2002). The housing-supply variable is not significant, which may be due to housing-supply inelasticity.

The second and third columns in Exhibit 9 show the estimates from the TAR model in which real money growth is the threshold variable. When D_2 in equation (4) is equal to 1, the real money growth has increased more than 5.85% per quarter compared with the previous quarter, and housing prices begin to show non-linear behavior. In contrast, when D_2 is equal to 0, the real money growth has increased less than 5.85%, indicating that housing prices still behave linearly. The explanatory power (adjusted R square) of the linear model is around 31.8%. By considering the threshold effect, the explanatory power increases to 39.6%. Moreover, both AIC and SBC suggest that the model should be selected with the threshold effect. To assess the forecasting ability of these two models, we forecasted housing prices as a one-step-ahead zone, using the last eight quarters of the sample period in both the linear and the threshold model. The mean absolute percentage error (MAPE) of the threshold model is smaller than that of the linear model for both in-sample and out-of-sample. This finding suggests that the threshold model outperforms the linear model.

Exhibit 7 | Robustness of CUSUM Test for the Existence of Threshold Effects

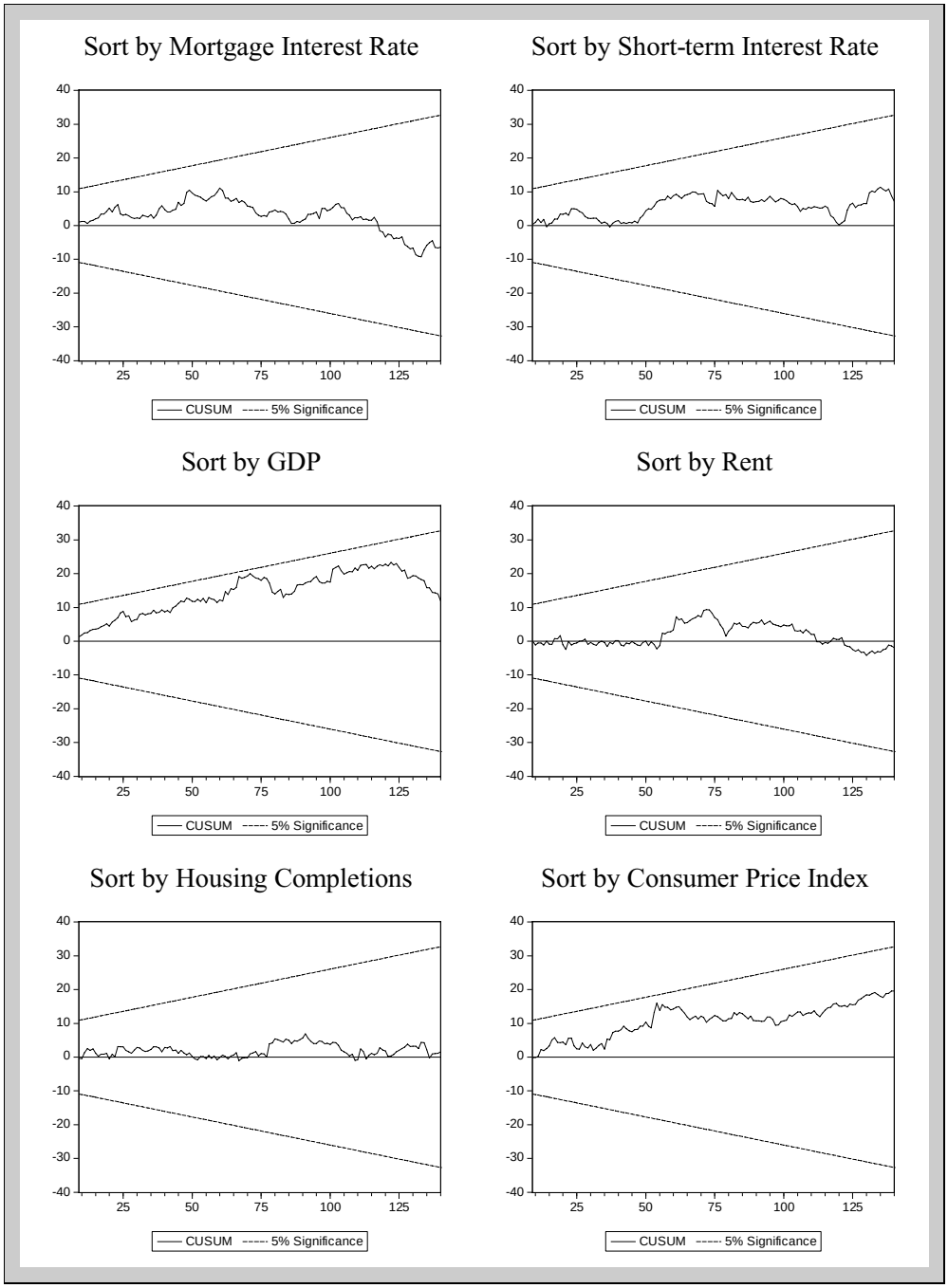
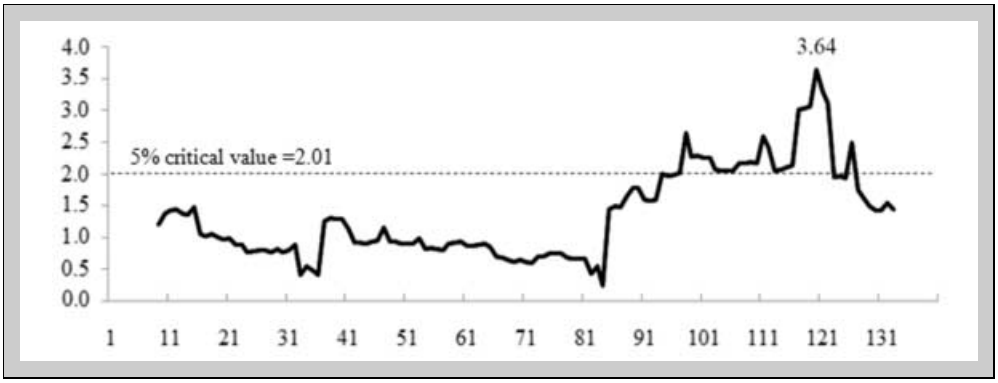


Exhibit 8 | Moving Test of Chow Breakpoint



Which Variables Affect Housing Price Movements in Service-Demand and Investment-Demand Regimes?

The threshold value of the real money supply growth rate, estimated at 5.85%, divides the data into two subsamples. Exhibit 10 shows that there are more samples below the threshold (nearly 85% of the observations) than above it. Therefore, this subsample can be considered the ''general'' regime, in which service demand and supply cost are responsible for housing price growth. We refer to the 15% of observations with a high real money supply growth rate as the ''investment-demand'' regime. When people hold extra money, investment alternatives and expectations become important to investors in the housing market, which is dominated by investment demand.

The threshold value of 5.85% can be considered a triggering reference for the non-linear movements of housing prices. Exhibit 10 shows that the real money supply growth rate closely traces the non-linear movement of housing prices in Taiwan. Most values above the 5.85% threshold are from before 1992, when housing prices displayed strong non-linear movement during the second (1978–1980) and third booms (1987–1989). The second boom, for example, is responsible for half of the observations (six seasons) of real money growth over the threshold value of 5.85%. The real money growth rate was especially high, at 11.37%, during the fourth season in 1977. The real money growth rate was also high during the second and fourth seasons of 1978 (7.97% and 9.36%, respectively). During the third boom, the real money growth rate reached a high of 10.01% during the fourth season of 1986. After 1990, real money growth rates were not as high as in early periods, and housing prices did not display obvious non-linear movement. Nevertheless, real money growth rates trace the path of housing price movement. One of the important changes in the monetary environment was the financial liberalization in the late 1980s, during which Taiwan begin to experience a low interest rate that decreased the cost of

Exhibit 9 | Results of Linear and TAR Model

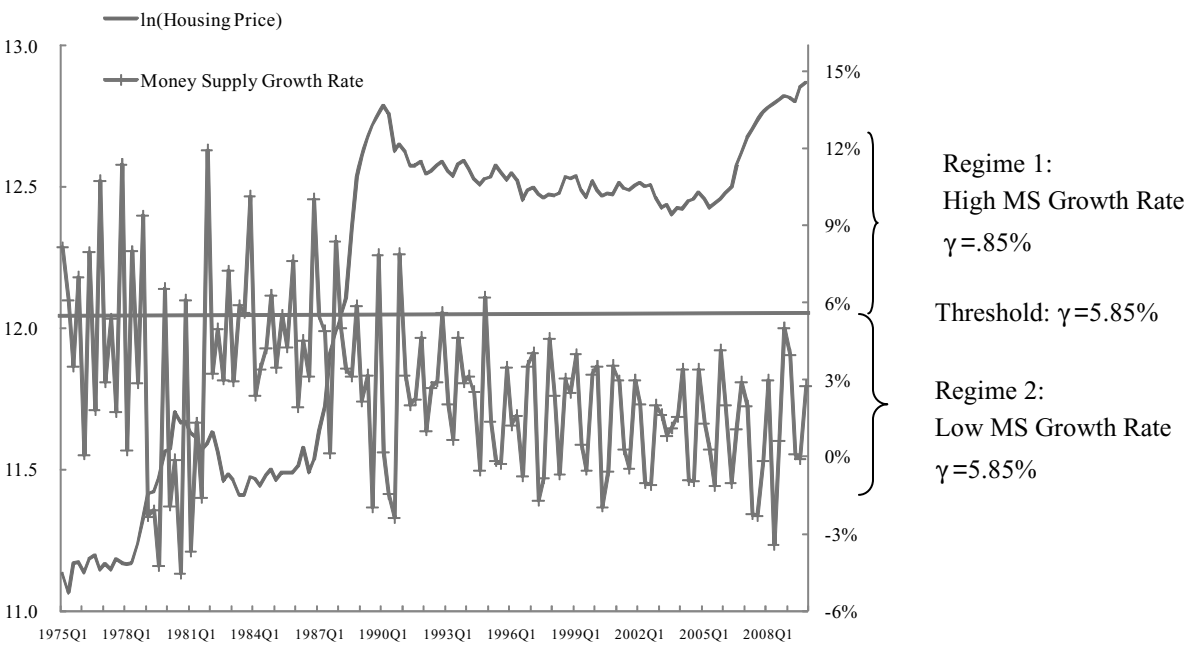
Explanatory Variables	Linear Model	Threshold Model: Low MS Growth Rate $\gamma = 5.85\%$ ($D = 0$)	Threshold Model: High MS Growth Rate $\gamma = 5.85\%$ ($D = 1$)
Constant	0.010	0.003	0.017*
	(0.009)	(0.009)	(0.010)
$\Delta \ln HHN_t$	2.660**	4.964***	
	(1.254)	(1.363)	
$\Delta \ln Y_t$	0.533	0.735**	
	(0.336)	(0.350)	
$\Delta \ln S_t$	0.026	0.080*	
	(0.043)	(0.045)	
$\Delta \ln CC_t$	0.046		
	(0.150)		
$USERC_{t-1}$	−0.362***	−0.418***	
	(0.064)	(0.067)	
$\Delta \ln SPI_t$	0.036**		0.098**
	(0.017)		(0.038)
INF_t	−0.351	−0.686*	−1.288**
	(0.344)	(0.349)	(0.532)
$\overline{R}^2$	0.318	0.396	
Sum of ε^2	0.238	0.209	
F-statistic	10.267	12.379	
AIC	−3.426	−3.540	
SBC	−3.258	−3.351	
Forecasting Error			
In Sample *MAPE*	0.217	0.216	
Out of Sample *MAPE*	0.191	0.149	

Note: Standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

purchasing or investing in a house. Low interest rates also boosted the mortgage market. Taiwan's mortgage market was estimated to be approximately 41% of the GDP as of the end of 2009, up from 29% in 2003. The recent boom in the housing market is fueled by low interest rates, which give business conglomerates and speculators leverage to play the market.

The estimated threshold model in Exhibit 9 suggests that when the real money supply growth rate is below the threshold value, household number, income,

Exhibit 10 | Real Money Supply Growth Rate and the Threshold Value



housing supply, user cost of housing capital, and the inflation rate have significant effects on the housing price growth rate. Service demand and supply cost seem to be responsible for housing price growth in this condition. As a result, the settlement of housing prices appears to depend on service demand and consumer considerations, which means that the housing market should be a consumers' market. However, when real money growth is high, only stock prices and inflation rates are influential. As suggested by previous studies (e.g., Gyourko and Keim, 1992), real estate and stock markets should be positively correlated because a large part of a company's value is tied up in real estate. Therefore, it appears that when people hold extra money, investment alternatives and expectation become important to investors in the housing market because investment demand dominates. This speculative activity leads to a structural change in the fluctuation of housing prices that then behave in a relatively volatile manner (i.e., nonlinearly). Therefore, in this situation, it appears that the housing market should be an investors' market, in which the housing market is driven by investment demand.

Conclusion

Housing is a multi-dimensional commodity that can be regarded both as a durable consumer good offering a flow of services such as shelter and an asset for investment by which rental income or capital gains are earned. Traditionally, Chinese people have had a propensity to invest in property, and Taiwan has a relatively high rate of owner occupancy and stronger investment demand. These factors cause an upward trend and volatile fluctuations of housing prices. Therefore, capturing the manner of the fluctuations is of great interest to the government, scholars, and industry. Whereas many previous housing studies have suggested non-linearity in housing price behavior in different regions or countries, the primary purpose of this paper is to examine a non-linear phenomenon: the threshold effect. We hypothesize that investment demand is the main cause of the non-linear behavior in housing prices and test this hypothesis using the threshold model. We extend the explanation of monetary variables to investment demand, which is responsible for the non-linear movement of housing prices in Taiwan. We first use the CUSUM and Chow tests to determine whether threshold effects exist, which variable causes this threshold effect, and in which situations this effect occurs. We then apply a threshold model to determine the threshold value and estimate this housing-price TAR model accordingly.

We analyze the investment demand for Taiwanese housing prices using determinants including household number, income, housing supply, construction cost, money supply, user cost of housing capital, stock prices, and the Consumer Price Index. Money supply was determined via the CUSUM test to be the key threshold variable. We construct both a linear model and a TAR model for the housing price, the latter of which uses the real money supply growth rate as a threshold variable, with a threshold value approximately equal to 5.85%. The TAR

model performs better than the linear model and exhibits higher explanatory power. When real money growth is relatively low, household number, income, housing supply, user cost of housing capital, and inflation rate have significant effects on the housing price growth rate. Service demand and supply cost are responsible for housing price growth. However, when real money growth is relatively high, only stock price and inflation rate exhibit significance in the model. Investment alternatives and expectations also become more important to investors in the housing market, suggesting that housing price is driven by investment demand.

Our findings have some policy implications, especially for an emerging economy. Over the past several years, many Asian countries, such as China, Hong Kong, Singapore, Korea, India, and Taiwan, have experienced considerable trade surplus, foreign direct investment or inflows of capital from investors betting on currency gains. These factors often stimulate an economy into an overheated condition and increase housing prices. China's economy, for example, has continued to grow rapidly over the past several years, exhibiting an economic growth rate higher than 10%, which stimulates housing prices. China's economic bubble during this period has been driven by an annual growth rate of the money supply of more than 20%. In 2010, China's foreign-exchange reserves amounted to $2.85 trillion, the highest in the world. The Chinese government has attempted to keep money supply growth under 17% to cool down the economy and the housing market. The situation in China is very similar to that of the Taiwanese housing boom in the late 1980s, during which money supply growth and foreign exchange reserves reached new highs. Although the Chinese Central Bank is acting to slow the growth of the money supply and to raise the rate on local currency deposits, the rapidly growing economy makes it difficult to maintain the money supply at the desired level, and the money supply continues to increase almost 10% every quarter. Singapore is also in a difficult situation as it too tries to bring down housing prices. The tightening measures appear to apply to only a fraction of real estate investors. Singapore, like Taiwan and other parts of the world, is in a very low-interest-rate environment. The nation's money supply continues to grow rapidly, increasing by almost 20% over the past two years. Global investors are confident about the strength and stability of Singapore's economy and are driven to sell their home currencies and park their funds in Singapore, adding to the nation's money supply. The Monetary Authority of Singapore (MAS) has recently stated that it will allow the local dollar to gradually strengthen in the hope that this will alleviate the pressures of imported inflation. As a result, the money supply increase created by economic growth stimulates investment demand and increases housing prices. Our findings on the threshold model for the Taiwanese housing market can be applied to housing markets in other parts of the world, especially in the case of emerging economies in which investment demand is relatively strong.

Raising the interest rate has often been used by the Taiwanese government to dampen housing price inflation. An increased requirement for bank reserves has also been used to produce a multiple contraction of the money supply. The results

of our analyses reconfirm that the money supply plays an important role in housing price behavior. Although the government can use interest rates to put a brake on the housing market when prices rise too quickly, housing prices in Taipei have recently begun to rise quickly again, causing serious affordability problems. Although governments can use monetary policy to adjust the housing-market conditions and prevent significant changes in the housing market, government should be cautious when using monetary policy as a tool. A tight monetary policy reduces not only housing investment but also other interest-sensitive investments, such as stocks. Therefore, attention needs to be paid to developing a monetary policy that responds to the overall economic stability rather than one directed specifically at the housing market.

Endnotes

[1] From NT$36 = US$1 to NT$25 = US$1 from 1987 to 1989.

[2] According to the National Wealth Statistics 2009, the gross value in Taiwan was NT$161.8 trillion. Land ranked the first at 40.0%, and buildings and construction were second at 24.6%. The assets structure in net value was topped by land at 50.5%, followed by buildings and construction at 20.8% and overshadowing net foreign assets at 14.9%.

[3] In Taiwan, money supply is categorized into three kinds: M1, M1B (narrow money), and M2 (broad money). M1 includes currency in circulation and sight deposits. M1B includes M1, time (or savings) deposits at banks with unrestricted access. M2 includes M1B, fixed-term deposits and accounts at nonbank institutions (time deposits, NCDS, time saving deposits, foreign currency deposits, foreign exchange proceed deposits, foreign exchange trust funds and CDS in foreign currency held by enterprises and individuals, the bank debentures, saving bonds and Treasury bills issued by CBC and held by the public). Therefore, this paper uses the changing rate of M2 as the proxy of money growth variable.

[4] We use an adaptive expectations measure for the user cost of the housing-capital variable (USERC), in which the housing-price expectations are being formed at time $t - 1$. Therefore, the user-cost terms must be lagged by one period.

[5] When significance level is 1%, $\theta = 1.143$.

[6] It was the Taiwan Real Estate Center engaged in housing price data construction for the Department of Construction and Planning Administration of the Ministry of the Interior for the period of 1972 to 1999. Taiwan Real Estate Center continues to extend the data series using the same methodology and sources.

[7] The pre-sale house prices are the prices of new houses prior to construction supplied by house building companies and are collected and published by property-related journals every month. The pre-sale house prices are the primary data sources for tracking long-term historic house prices. These data are quite representative for the new housing market since almost all the pre-sale prices of new houses on the market are collected. The data contain only a few attributes such as floor, types (like flats, houses, etc), location, and average floor prices per-pin (ground floor and other floor), which is not sufficient for hedonic methodology to fix quality. To improve heterogeneity problem, this series use pure apartment and the weighted-average method to control location and floor.

[8] Bourassa and Peng (2011) analyze Taiwan homeownership and indicate that income and property taxation of owner-occupied housing appear to be relatively light, with

deductibility of some mortgage interest, preferential tax treatment of capital gains, no taxation of imputed rents, and low property tax rates. Hence we ignore the taxes when calculating the user cost of housing capital since the taxes are not important in the Taiwanese housing context.

[9] A problem with the Dickey-Fuller test is that it assumes that the errors are statistically independent and have a constant variance. Thus, we also use the Phillips-Perron (1988) test, which allows the disturbances to be weakly dependent and heterogeneously distributed, to confirm the results.

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