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House prices and household income: Do they move apart? Evidence from Taiwan

Ming-Chi Chen^{a,*}, I-Chun Tsai^b, Chin-Oh Chang^c

^a*Department of Finance, National Sun Yat-sen University, 70 Lien-hai Rd., Kaohsiung 804, Taiwan*

^b*Department of Finance, Southern Taiwan University of Technology, Taiwan*

^c*Department of Land Economics, National Chengchi University, Taiwan*

Abstract

This paper investigates the equilibrium relationship between house price and household income and what causes disruptions of the equilibrium between them. By using data from Taiwan, the traditional cointegration test does not find evidence for a long-run equilibrium between them, but the stochastic break (STOPBREAK) test, which allows temporary shocks during sample periods, does obtain evidence of their equilibrium relationship. Further use of the Perron test on house price to income ratio (PIR) indicates that the PIR appears to have shifted. Finally, examining the causes of their deviation by vector autoregression (VECM) model, it was found that the slow increase in income may just sustain the long-run trend in house prices. Money supply, representing the investment demand variable, should be mainly responsible for deviation between house price and income and the shift of PIR.

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Keywords: Income; House prices; Cointegration; STOPBREAK; VECM

Introduction

The link between house price and income has received a great deal of attention from both researchers and government policy makers. This is especially due to the marked changes in assets price over the past few decades, which have had substantial influence on housing affordability. Theory based on the permanent income hypothesis suggests that aggregate consumption for housing in any particular period is a stable function of the average income over the current cycle. However, this permanent income hypothesis does not appear to be sufficient to explain the fluctuations in house prices. This is because 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 as an asset for investment by which rental income or capital gains are earned. Therefore, housing demand can also be categorized into service demand and investment demand. Income can only explain part of the house prices, and a crisis of housing affordability occurs when increase in income does not catch up with house prices.

*Corresponding author. Tel.: +886 7 5252000x4826; fax: +886 7 5254898.

E-mail address: mcchen@finance.nsysu.edu.tw (M.C. Chen).

In housing literature, it has been suggested that house price and income should have long-run equilibrium relationship, i.e. cointegration (Abraham & Hendershott, 1996; Capozza, Hendershott, & Mayer, 2002). However, deviations are always detected between house price and income over the world so that the housing affordability problem has been an important issue in many countries and is widely discussed. During the past few decades, many countries have experienced rapid increases and high volatility in house prices. On the other hand, growth in income is relatively gradual and appears to be unable to catch up with increased house prices. The United Kingdom (Bramley, 1994), Ireland (Memery, 2001), Japan (Yamada, 1999), and Taiwan (Chang, Kuo, & Lin, 2001) all have experienced problems of affordability in the past few decades. For example, Taiwan's asset price has increased rapidly over the last few years. An unusual phenomenon in Taiwan is that house price rises much more rapidly than family income, and thus the Taiwan housing system is constantly under pressure of affordability problem. For the past 30 years (1973–2002), the actual increase in average house price in Taipei has been 7.0%/annum with a 21.1% standard deviation, indicating a very high rate of increase and extremely large fluctuation in house price. However, household income during the same periods has increased only 4.4% with a 6.2% standard deviation. Generally, the ratio of house price to income (PIR) in Taiwan has been about 4 or 5; however, this affordability index rose from 4 to more than 13 during late 1980s because the house prices jumped threefold.

It seems that there is a conflict of the house price to income relationship between previous studies and the real world situation. A recent study by Gallin (2006) challenges the traditional view of the long-run equilibrium relationship, arguing that the traditional cointegration approach used in previous study has low power. Gallin (2006) uses the panel data test, which is more powerful, for the US and found no evidence of cointegration. This paper attempts to re-examine their long-run equilibrium relationship using a different approach for Taiwan's case to provide some clarification for this argument. It uses both the traditional cointegration test and the stochastic permanent breaks (STOPBREAK, Engle & Smith, 1999) test to analyze possible long-run relationships between house price and income. The study then uses the Perron test (1997) to consider whether housing affordability is a temporary crisis. Then it further investigates the causes of the deviation by using the vector autoregressive (VAR) model. Therefore, three questions are examined in the paper. Are house price and income moving apart? Is the housing affordability crisis passing away? What are the factors that cause deviation between house price and income?

This paper makes a contribution to the growing literature by providing additional evidence in the context of an Asian housing market. Taiwan provides a good case study for a number of reasons. Many countries experienced similar problem of affordability in the past few decades, Taiwan appears to be one of the dramatic cases. Second, little research has examined housing affordability problem from the viewpoint of long-run equilibrium, and thus our results would provide a better understanding of equilibrium relationship between house price and income. Third, Taiwan's housing problem and policies have attracted much attention from policy makers of other developing countries. Other countries may experience similar problem and they can have make better policy reactions from the analysis.

The rest of the paper is organized as follows. The section on Taiwan's housing market gives an overview of house price, income and the housing market in Taiwan and the section on literature review and theoretical discussion discusses some selected literature and outlines our theoretical framework. The section on data and methodology describes the applied methodologies and the data. Estimation results are reported and discussed in the section on empirical analysis, and the last section provides a summary of the main finding and draws some conclusions.

The Taiwan's housing market

Historical development of the Taiwan housing market

Taiwan's economy has experienced rapid industrialization, urbanization and export expansion in the post-war period. The continuous export surplus results in both income growth and monetary growth. The growth in income certainly increases the demand for houses; however, this increase in residential demand is likely to be relatively moderate. Because of high population density and limited land supply, houses in Taiwan are relatively expensive. In addition, the financial system in Taiwan is relatively underdeveloped, so households have to rely to a large extent on personal savings for purchasing houses. On the other hand, monetary

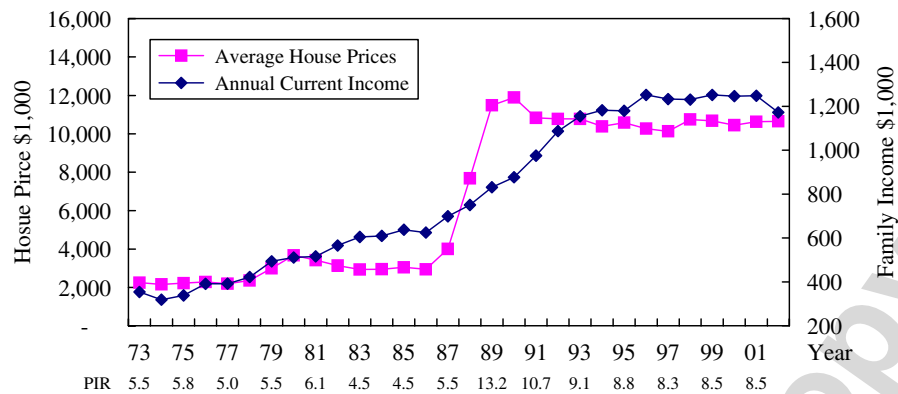


Fig. 1. Taipei house prices and income.

expansion will also raise demand for houses because it enhances the banks' ability to extend credit to the housing sector. Although real estate is in competition with other assets, it is normally perceived to be a good investment and a better inflation hedge than other assets. Moreover, because there are very few investment instruments and the relevant opportunity cost of housing is better than other assets in Taiwan, thus the housing market offers a favorable investment opportunity.

Fig. 1 shows the historical house price and income in Taipei. There were three boom periods: 1972–1974, 1978–1980 and 1987–1989 in the housing market of Taiwan (Chen, Kawaguchi, & Patel, 2004). The rise in house price in Taipei, its first boom, in the early 1970s was commonly seen to have been caused by the oil embargo. The sudden increase in oil prices led directly to high inflation in most commodities as well as construction costs. Money supply is believed to be a complementary factor. The trade surplus causing foreign money expansion leads to increases in domestic money supply. A second boom involved the increase in oil price in the late 1970s, which again resulted in increased costs on the supply side and expectation of price increases on the demand side. The third boom in house prices is thought to be brought about by the great increase in money supply in the late 1980s. Inflation rate was stable in this period.¹ The primary reason behind the increase in money supply was continuing high economic growth around 12–13%, as it was during Taiwan's previous boom periods.

Because Taiwan is an extreme case where the rate of increase in house prices has been relatively high in comparison with income, these indicate a higher housing cost burden for households in Taipei and the burden is getting heavier and heavier. Owing to the booms in the housing market, there have been several cyclical fluctuations in house prices relative to income in the early 1970s, late 1970s and late 1980s. Fig. 1 shows the price of a typical house (apartment), annual household income and their ratio in Taipei area. Over this 30-year period, the lowest ratio (4.5:1) occurred in 1986 and the highest ratio (13.2:1) occurred in 1989. As can be seen, the highest ratio was almost three times that of the lowest ratio. After experiencing a house price peak in the late 1980s, they subsequently tended to decline after a big jump and income caught up with house prices.

Table 1 compares the ratios of several selected Asian cities.² As in western countries the PIR are generally between 4 and 5, the ratios for these Asian cities are generally higher. The PIRs for these cities for selected years are between 6 and 13. Hong Kong is more dramatic, with 16.3 in 1997 and 6.7 in 2002. These Asian cities are all highly populated, causing a fundamentally high PIR ratio. These ratios are volatile because these cities all experience house price fluctuation but income growth is steady.

Aspects of the Taiwan housing market resulting in high PIR

There are several possible underlying causes behind the Taiwan's high PIR. First, high population density is the fundamental reason for the Taiwan's high PIR, as in other Asian cities. Secondly, the Chinese traditional

¹Inflation is an important factor of house price boom before 1980, but is not the major concern for house price in Taiwan in recent years (Chen & Sing, 2006).

²This table involved an international comparison of PIR. However, no claim can be made for full comparability since PIR calculated in each country reflects that country's standards.

Table 1
Comparison of house price to income ratio in selected cities

	Beijing ^a	Hong Kong ^b	Taipei	Tokyo ^c
1987	NA	NA	13.2	7.4
1992	8.1	NA	10.7	8.2
1997	13.3	16.3	8.3	6.9
2002	6.7	6.7	8.5	5.9

^aBased on the selling price of residential building based on new houses. *Source*: Lau and Li (2006).

^bBased on the average price of private domestic premises. *Source*: Hong Kong Monthly Digest of Statistics.

^cBased on average price of new condominium. *Source*: Japan Real Estate Institute.

preference to own property could be another reason. One characteristic of Taiwan's housing market is a comparatively large number of owner-occupied dwellings and a relatively small rental sector. Taiwan had a relatively high owner-occupied rate of about 65% in the 1960s, and this rate increased to more than 80% in the 2000s, corresponding with a decline in private-rental rate of less than 10%. Third, housing policy is considered as low priority in Taiwan's development agenda, with public housing comprising less than 5% of the total housing in the markets. Inefficiency of government housing policy can also be seen from the delayed action taken in the late 1980s when property prices jumped threefold in a 3-year period. Fourth, financial liberalization and loose monetary policy in the late 1980s might have caused the PIR to shift even higher. Domestic monetary growth has been considered as an important factor in explaining the house prices fluctuations in Taiwan. The common explanation for the dramatic jump in house prices in the late 1980s is the rapid increase in the money supply induced by the liberalization of foreign exchange³ and interest rates.⁴ The financial liberalization and lower interest rate since, which affected both aggregate demand and private consumption, thus appears to be responsible for the shift of PIR.

Literature review and theoretical discussion

House price, income and affordability

House prices have boomed worldwide again over the last 10 years. The early boom in house prices was led by the UK and Ireland in the second half of the 1990s, with Australia catching up in 2000. In the 2000s, more and more countries saw house prices rise strongly, including the most of the European Union, South Africa, and subsequently the US and New Zealand. Because of this boom, house price has attracted much research to investigate its determinants. For example, Roche (2001) analyzes whether house prices in Dublin are driven by market fundamentals or by speculation. Meen (2002) investigates the time-series behavior of house prices for both the US and the UK. Meen (2002) found that the behavior has differed over time in these two countries but the same housing theory can explain behavior in both countries. Zhou and Sornette (2006) examine whether the price bubble busted in the US and found the turning point of the bubble would probably occur around mid-2006.

Although the house prices have boomed in these countries, household income has risen relatively slowly, which causes the PIR to jump, with a resulting affordability problem. Many studies (Abraham & Hendershott, 1996; Capozza et al., 2002; Malpezzi, 1999; Meen, 2002) consider that house price is linked to income by a stable long-run relationship. They may drift apart temporarily, but their tendency is to return to their long-run equilibrium. However, Gallin (2006) proposed a different view of their relationship, arguing that traditional cointegration tests are known to have low power, particularly in small samples. Gallin instead

³After Taiwan Central Bank began to adopt a managed floating exchange rate regime in 1987, the exchange rate began to rise rapidly, from NT\$36 = US\$1 to NT\$25 = US\$1 from 1987 to 1989. Foreign exchange control was also abolished in 1987. The restrictions on capital flows were also lifted and this enabled capital to move freely in the foreign exchange market, which resulted in higher speculative movements during this period.

⁴After 1985, interest rates for banks in Taiwan can be determined by banks individually according to their own position and market condition.

used a panel-data test for unit roots and cointegration since it is more powerful than the standard time-series counterparts. Using both US national data and a panel of 95 metropolitan area over 23 years, Gallin found no evidence of cointegration, implying that house price and income are moving apart. This study seems to suggest we should pay more attention to the affordability problem.

House price is the most important determinant of the affordability of home ownership. Rising home prices pose problems to prospective homebuyers in accumulating the down payment of new homes, which is generally stated as a percentage of the house price. Rising prices also raise the required monthly mortgage payment for mortgage loan of a given type; as a result, buyers must have higher incomes to meet the qualifying criteria (Linneman & Megbolugbe, 1993). Housing affordability is an important topic that is widely discussed worldwide. For example, Bramley (1994) suggested that the UK housing system experienced an affordability crisis in the late 1980s and early 1990s, which was manifested in several distinct ways, and similar to the experience in some other countries. A combination of circumstances led to this crisis, including changes in demography, income distribution, housing supply and tenure, but financial deregulation was particularly important. Gyourko and Linneman (1993) in the USA investigated how the affordability of single-family housing has changed by analyzing whether a home of a given quality from the past 30 years is now more affordable for a household similarly situated to the one that occupied the home then. Yamada (1999) examined the crisis in Japan and indicated that housing affordability decreased as a result of rapid inflation in land prices, thus reducing the number of people who qualified for home ownership. Memery (2001) also suggested that Ireland experienced an affordability crisis because of exceptional economic growth in the 1990s. This was due to failure of successive Irish government to develop an integrated housing policy to cope with rising house prices. The lack of affordable accommodation is now one of the key factors limiting Ireland's continued economic growth. Moore and Skaburskis (2004) analyzed increasing affordability burdens in the Canadian housing market, finding that the affordability problem affects almost all classes of households in Canada, but the problem is most concentrated for those with low incomes. Lau and Li (2006) examined the Beijing housing market, finding high PIR that leads to a housing affordability problem.

As indicated in the above section, Taiwan is an extreme case where the rate of increase in house prices has been relatively high in comparison with income, leading to an affordability problem. Whether Taiwan has a relatively higher PIR ratio compared with other developed countries or what is the reasonable PIR in Taiwan has been an academic research issue. For example, Hsieh (1996) examined the interrelationship of house price, affordability, tenure choice and ownership rate. That study indicated that the affordability problem has been deteriorating because the PIR decreased steadily over the period 1960–1975, but increased sharply thereafter. Chang et al. (2001) investigate what was a reasonable PIR for different household income distributions in Taiwan. They suggest that Taiwan has a higher PIR of 4–6 compared with 2–4 in developed countries. They also suggest different household income distributions in Taiwan have different PIRs, and because of the lack of low-price housing, the affordability problem for low-income households is getting worse. These studies seem to suggest that Taiwan's affordability problem is increasing.

In a rapid growing economy, economic growth will certainly push the income and house price to rise. However, it is questionable that house price will climb faster than income in the long run because houses will eventually become unaffordable. For example, Japan experienced high asset appreciation in the 1980s when house prices rose much faster than income. However, after the bubble burst, the house price dropped almost 50% so that income finally caught up. It seems that crisis of housing affordability often occurs but may not last long.

Theoretical framework for empirical analysis

Previous studies usually presume that there exists a stable relationship between house price and income. Renaud (1989) and Malpezzi (1990, 1999) analyze house price and income by positing a long-run equilibrium ratio between typical house prices, P , and income, Y :

$$\frac{P^c}{Y^c} = k, \quad (1)$$

where k is the above-mentioned PIR.⁵ An equilibrium price is defined as one from which there is no systematic tendency to depart, conditional on the values representing market conditions. However, there is no reason to believe that k is the same for all market conditions, or that for any of the usual reasons that the relationship above could not be stochastic. Letting t denote the time periods under consideration, we can rewrite the equilibrium condition for a representative market as

$$\frac{P_t^c}{Y_t^c} = k_t = Z\delta + \eta_t, \quad (2)$$

where Z is a vector of market condition and other determinants of k , δ is the vector of corresponding parameters, and η is a well-behaved error term.

This stable equilibrium relationship (k) is often altered under impacts from other factors, such as supply-side shortage, increase in investment demand or shocks incurred by government policies. Because of cyclical behavior of house price and stable increase in income, these two variables usually deviate in a certain time frame, resulting in crisis of affordability. To understand what are the factors that influence the change in PIR(k), it will be necessary to carefully review the house price determinant models.

In the neo-classical approach, demand for housing is a function of factors such as demography, income, house price, user cost and availability of substitutes. Supply for housing in the short run is inelastic, but in the long run, supply is a function of the factors influencing real-estate developers to construct new houses. They include price, construction costs, land costs, interest rates and seasonal factors. The principal determinants of house price are those variables that influence the demand for and supply of houses. Although income is a determinant of house price, the long-run equilibrium equation for house price is usually specified as a function of demographic factors, income, construction cost and interest rate, as we can see from many studies like Hendry (1984), Drake (1993), Holly and Jones (1997), Malpezzi (1999) and Meen (2002). This suggests that the k may not always maintain equilibrium because there are other variables disrupting the equilibrium.

As suggested by Chen and Patel (2002), the long-run equilibrium equation for Taiwan house price (Ph) is

$$Ph_t = c + \alpha_1 PY_t + \alpha_2 HC_t + \alpha_3 CC_t + \varepsilon_t, \quad (3)$$

where PY is the household income, HC the housing completion, and CC the construction cost.

However, Chen and Patel (2002) also pointed out that the housing market in Taiwan is characterized by an investment demand, which is induced by the rapid expansion of money supply. When there is a rapid expansion in money supply, households will either use the money on hand, or borrow to invest in the housing market. Real estate is generally perceived to be a good investment and a better inflation hedge than financial assets. Moreover, the dramatic jump in house prices in the late 1980s followed a rapid increase in the money supply (35%, 25%, and 20% increases in 1986, 1987, and 1988, respectively), induced by the financial liberalization. The monetary growth has been considered to be an important factor for explaining the increase in house price in Taiwan. Therefore, the house price equation are modified as

$$Ph_t = c + \alpha_1 PY_t + \alpha_2 HC_t + \alpha_3 CC_t + \alpha_4 MS_t + \varepsilon_t, \quad (4)$$

where MS denotes money supply.

⁵The measure of housing affordability is at best ambiguous (Linneman & Megbolugbe, 1993). Although the conventional public policy indicator of housing affordability in the US is the percentage of income spent on housing, many studies still relied on the home price-to-income ratio. This ratio provides a direct and easy measurement for housing affordability. From this ratio, we can argue that if housing affordability is deteriorating, this ratio will change. If the crisis persists, the PIR will shift to another level. If the crisis is temporary, the PIR should return to its original level. This is because house price and income should reach equilibrium in the long run.

Data and methodology

Data description

This study analyzes house price, income and other determinants from the period of 1973Q3 to 2002Q4. It uses average unit price⁶ (per pin) of new pre-sale house in Taipei area from the Department of Construction and Planning Administration of the Ministry of Interior because this data is the longest available in Taiwan.⁷ Then multiplying the average price per pin by the average area per household in Taipei yields the average price of houses. The income data were collected from current household receipts from the statistics of Taipei Municipality. Housing consumption is generally presumed to be a function of permanent income, but permanent income is not observable. Permanent income is proxied using the Almon polynomial approach (see Sargan, 1980).⁸ Other determinants such as money supply, housing completion and the construction cost index were obtained from various government statistics. The variables, measured in nominal terms, such as house price, income, money supply and construction cost index, are deflated by the consumer price index.

Methodologies for testing long-run relationship

To examine the long-run relationship between house price and income, for the study we first used the traditional cointegration test on house price and income. If this equilibrium relationship does not exist, then it further examines how the equilibrium relationship changes using STOPBREAK test (Engle & Smith, 1999) which can be utilized to see whether they have temporary deviation. The study further tests the stability of PIR by using unit test. The typical unit root is weak in detecting structural change in the time series. Therefore, the Perron test (1997) is used to examine whether the PIR has changed its level.

Cointegration, STOPBREAK and Perron's test

The Engle and Granger (1987) and Johansen (1988) cointegration methodologies have been well established and widely applied in economics and finance literature. According to Engle and Granger (1987), two series integrated in the order d , $I(d)$, are cointegrated, if the linear combination of the two series, $[Y_t = \beta X_t + u_t]$, results in a residual, u_t , that is stationary in less than order d . The results hold if there are no short-term shocks that will destabilize the equilibrium in the system. When economic shocks cause permanent and transitory shifts to equilibrium, the long-term impact of the shocks is time varying or stochastic. Engle and Smith (1999) proposed a STOPBREAK approach for modeling a class of processes that incur random structural shift at random intervals. They conjectured that a pair of variables may move together for periods of time and jump apart occasionally. Engle and Smith (1999) called this process temporary cointegration. This STOPBREAK test provides a useful framework for testing the long-run relationships between variables, which allows for temporary deviation of the series as a result of shocks.

Engle and Smith (1999) defined the simplest form of the STOPBREAK process for a time series y_t as follows:

$$y_t = m_t + \varepsilon_t, \quad t = 0, 1, \dots, T, \quad (5)$$

where $m_t = E[y_t | I_{t-1}]$ is a time-varying conditional mean, and ε_t is the error term.

$$m_t = m_{t-1} + q_{t-1} \varepsilon_{t-1} = m_0 + \sum_{i=1}^t q_{t-i} \varepsilon_{t-i}, \quad t = 1, 2, \dots, T, \quad (6)$$

where $q_t = q(\varepsilon_t) \in (0, 1)$ s.t. $E[q_t \varepsilon_t | I_{t-1}] = 0$.

⁶Median price should be more representative for a typical house price but the Department of Construction and Planning Administration of the Ministry of Interior only provides average prices.

⁷The data for the period from 1973Q2 to 1999Q1 were collected from the Department of Construction and Planning Administration of the Ministry of the Interior and the data after 1991Q1 were collected by the study. The average prices were computed using the weighted average method.

⁸It is defined by $A_n(Y_t) = 2/(n+1) \sum_{i=0}^n (n-i) Y_{t-i}$ for $i = 1, 2, \dots, n$ where $A_n(\cdot)$ is the restricted Almon polynomial, and Y is the disposable income.

The above STOPBREAK process is a process where shock effects are permanent and determined endogenously in the process. If $\tilde{q}_t = 1$, the realized process at time t is a random walk. If $\tilde{q}_t = 0$, the conditional mean will be a constant, the long-run forecast for y_t will not deviate from the mean value of \tilde{q}_t .

When a pair of time-series variables, such as income Y_t and house price X_t , is involved, the general STOPBREAK process can be specified as follows:

$$A(L)B(L)(Y_t - X_t\delta) = z_{t-1}A(L)\varepsilon_t + (1 - z_{t-1})B(L)\varepsilon_t, \\ t = 1, 2, \dots, T, \quad (7)$$

where $A(L) = 1 - \alpha_1L - \alpha_2L^2 - \dots - \alpha_pL^p$, $B(L) = 1 - \beta_1L - \beta_2L^2 - \dots - \beta_pL^p$, L is the lag operator, z_t denotes the measurable function of information up to t , and ε_t is an innovation term.

If $\delta = 0$, $B(L) = 1 - L$, $A(L) = 1$, the model complies with the simplest form of the STOPBREAK process. Alternatively, if $\delta \neq 0$, then we can say that both the income and house price series establish only temporary cointegration effect, where the two series jump apart occasionally and revert back to the equilibrium relationship in the long run. To test the persistence of the STOPBREAK process, let us assume that $q_t(\gamma) = \varepsilon_t^2 / (\gamma + \varepsilon_t^2)$, and the processes in (5) and (6) can be rewritten as follows:

$$\Delta y_t = \frac{-\gamma \varepsilon_{t-1}}{\gamma + \varepsilon_{t-1}^2} + \varepsilon_t. \quad (8)$$

According to Eq. (4), the random walk null hypothesis can be tested as [$H_0: \gamma = 0$], against the alternative hypothesis, [$H_1: \gamma = \bar{\gamma}$]. Engle and Smith (1999) found a locally best test sufficient to test the null hypothesis $H_0: \varphi = 0$ against a negative alternative using t -tests, where φ can be estimated using the following regression:

$$\Delta y_t = \varphi \frac{\Delta y_{t-1}}{\bar{\gamma} + \Delta y_{t-1}^2} + \mu_t. \quad (9)$$

Engle and Smith employed this STOPBREAK model to test the relative stock prices to see if the two stocks move together.

Unit root tests are generally used to examine stationarity in time-series data. Dickey and Fuller (1979, 1981) tests are the most common techniques to detect stationarity. However, this test is weak when structural change occurs. Perron (1989) proposed a unit root test allowing for a structural break, but this test has been generally criticized for treating the time of break as exogenous (i.e., the time of break is known a priori). Therefore, Perron (1997) further developed unit roots test with three alternative models that consider the breakpoint as endogenous, so the date of possible change in either intercept or slope is not fixed a priori. The first model proposed by Perron that allows a shift in the intercept is

$$y_t = \mu + \theta DU_t + \beta t + \delta D(T_b)_t + \alpha y_{t-1} + \sum_{i=1}^k c_i \Delta y_{t-j} + e_t,$$

where T_b denotes the time at which the change occurs; DU_t is the dummy variable for a mean shift; $DU_t = 1$ if $t > T_B$, and 0 otherwise; $DT_t = t - T_B$ if $t > T_B$, and 0 otherwise. The null hypothesis that $\alpha = 1$ is tested using the t -statistic. The break point is chosen such that the t -statistic for testing $\alpha = 1$ is minimum. Perron (1997) suggests a general-to-specific procedure to determine the lag order.

Therefore, by using the cointegration and STOPBREAK tests, the long-run equilibrium relationship between house price and income can be examined. To further understand their relationship, we test PIR by using the Perron (1997) test of unit root to see whether the level has shifted.

Tests of factors disrupting the equilibrium

After equilibrium test of house price and income, the analysis proceeds with the test of the factors disrupting the equilibrium using a dynamic VAR model first proposed by Sims (1980) and later modified as vector autoregressive error-correction models (VECM) due to development of the cointegration theory. For a VECM

Table 2
Test of long-run equilibrium between house price and income

<i>Part 1: Johansen's cointegration test (trace test)</i>			
Hypothesized number of CE(s)	Likelihood ratio	5% critical value	
None	9.76	12.53	
At most 1	1.16	3.84	
CE: cointegration equation			
<i>Part 2: Test of STOPBREAK process</i>			
	<i>t</i> -statistic	TR ² (<i>p</i> = 5)	TR ² (<i>p</i> = 10)
Statistics	4.07*	18.86*	27.24*
Critical value: 5%	−2.07	11.07	18.31

Null hypothesis: $W_t \sim$ random walk; Alternative hypothesis: $W_t \sim$ STOPBREAK process. Critical values are provide by Engle and Smith (1999).

*indicates significance of the statistic.

system, the generalized equations could be formally represented as follows:

$$\Delta y_t = \gamma_y \mu_{t-1} + \sum_{p=1}^n \alpha_p \Delta y_{t-p} + \varepsilon_t, \quad (10)$$

where y_t are 5×1 vectors of endogenous variables for house price, income, money supply, housing completion and construction cost. For the cointegrated series, the error correction term, μ_{t-1} , represents the speed of adjustment toward the long-run values.

The variance (forecast error) decomposition can be used to characterize the dynamic behavior of the VAR model. The above equation is rather difficult to describe in terms of α_i coefficients; while the variance decomposition technique suggested by Sims (1980) is useful in the VAR framework for testing the sources of variability. The variance decomposition breaks down the variance of the forecast error for each variable into components that can be attributed to each of the endogenous variables. We use the approach of Pesaran and Shin (1998)⁹ to estimate the variance decomposition.

Empirical analysis

Do house price and income deviate from each other?

The study first performs unit root tests for the house price, income and other variables in Eq. (1). The augmented Dickey–Fuller (ADF, Said & Dickey, 1984) test and also the Phillips and Perron (1988) test both confirm that all these variables are I(1) (see Appendices A and B for details).

The hypothesis is that house price and income should attain a long-run equilibrium relationship. This hypothesis is tested using traditional cointegration tests (Johansen, 1988). Table 2 presents the results of Johansen's cointegration analysis for house price and income. According to the trace test, the null hypothesis of no cointegration, i.e., $r = 0$ cannot be rejected when the calculated statistics are smaller than their critical values at the 5% significance level. This cointegration test implies the nonexistence of a common stochastic

⁹The VAR model is routinely carried out using the "orthogonalized" impulse responses, where the underlying shocks to the VAR model are orthogonalized using the Cholesky decomposition method. This method assumes that the system is recursive and the estimations of impulse response function and variance decomposition are orthogonalized so that the covariance matrix of the resulting innovations is lower triangular. Therefore, the Cholesky decomposition method is criticized as an arbitrary method for attributing a common effect and changing the order of the equation may dramatically change the impulses. An alternative approach, the generalized impulse response analysis, which is invariant to the ordering of the variables in the VAR has recently been proposed. In contrast to the Cholesky decomposition method, the generalized impulse responses are unique.

Table 3

Test of stationarity for price to income ratio (PIR)

Part 1: Augmented Dickey–Fuller t-test for PIR

<i>t</i> -statistic	–2.988* (lag 4)
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Part 2: Perron test for PIR

Break date (TB)	1987:01	Y_{t-1}	DU_t	DTb_t
<i>t</i> -statistic		17.301**	5.157**	–1.662*

*Significant at the 5% level.

**Significant at the 1% level.

trend, suggesting that there is no stable long-run equilibrium relationship between them. This conflicts with many previous studies (Abraham & Hendershott, 1996; Capozza et al., 2002; Malpezzi, 1999; Meen, 2002) that long-run equilibrium should be found between house price and income, but supports Gallin's (2006) viewpoint. However, this could be because the traditional cointegration test is unable to detect their long-run equilibrium when a strong disturbance occurs. Therefore, the study continues to test our hypothesis using the STOPBREAK test.

The time-varying stochastic shocks are now allowed for variables' long-run equilibrium in the STOPBREAK model. The *t*-statistics of the STOPBREAK tests are summarized in part 2 of Table 1. The *t*-statistic significantly rejects the null hypothesis, suggesting that house price and income do have a STOPBREAK relationship. This provides evidence that house price and income do have a long-run equilibrium relationship although sometimes they deviate because of temporary shocks. The temporary deviation may be caused by factors such as strong investment demand or short-run shortages of housing supply, as discussed below.

Continuing to test stability of the house PIR, we use the Perron test (1997) to examine stationarity of the PIR. From Table 3, the ADF test rejects unit root in PIR, which means the PIR ratio is a stationary series. This appears to suggest PIR is stable and affordability is not deteriorating. As indicated above, ADF was weak when structural change occurred. The Perron test is further used and it indicates that PIR is a stationary I(0) series but there is a break point in the constant for the first quarter 1987. The coefficients for DU_t and DTb_t are significant at the 0.05 level, which suggests PIR has changed. The positive DU_t indicates a shift of PIR. This Perron test appears to suggest affordability deteriorated after 1987. This time point is coincident with the financial liberalization in this period.

These results imply that house and income may deviate from each other but will finally return to equilibrium level. There are temporary disturbances disrupting them and also cause a structural change in their relationship.

Why do they deviate from each other?

In order to further understand why house price and income drift apart, the study tests how other variables disrupt their equilibrium using the house price long-run equilibrium Eq. (4) and VECM Eq. (10). The empirical results are reported here after carrying out a two-stage cointegration estimation process.¹⁰ It uses the variance decomposition to measure the short-run variations in house price induced by shocks emanating from income and other three variables. The variance decomposition estimates over the last 24 quarters are summarized in Table 4.

The results indicate that disturbance originating from house price itself inflicted the greatest variability on future prices: it contributes up to 93% variability one quarter ahead, approximately 88% four quarters ahead.

¹⁰In the first stage, cointegration tests are performed to determine the long-run relationships among the variables in Eq. (4). Using the Johansen (1988) multivariate cointegration test methodology, we found significant evidence of cointegration among them. After the cointegration relationship is identified, the VAR model for the variables would include the one period lagged cointegrating vector in the dynamic VECM system. Stage two of the analysis involves estimation of the VECM models.

Table 4
Variance decomposition of house prices

Quarter	ΔPh (%)	ΔMS (%)	ΔPY (%)	ΔCC (%)	ΔHC (%)
1	93.0	5.8	5.3	7.5	1.8
2	91.9	6.5	5.5	7.5	2.1
3	91.6	5.7	7.0	6.4	2.1
4	88.4	10.9	7.5	6.3	2.0
5	87.7	11.4	7.9	6.3	2.2
8	84.7	12.8	7.5	6.0	4.5
12	81.0	12.8	8.0	6.7	6.6
16	80.0	12.9	8.2	7.1	6.6
20	79.9	13.0	8.3	7.1	6.6
24	79.8	13.0	8.3	7.2	6.6
Average	82.6	12.0	7.9	6.8	5.6

The proportion of variance remains high (79%) even after 6 years (24 quarters). This result indicates that current changes in house price influence heavily people's expectation of future price changes. Two demand-side variables account for about 19.9% of variability and two other supply-side variables account for 12.4% in 24 quarters on average. Money supply prevails over all other variables influencing house price variability and has 50% more shock than income. Income contributes 7.9% of the variance, the second largest, on house price in our system. This result reflects that, with a background of rapid economic growth, the investment demand had a stronger effect than service demand in the short run on the demand for housing. The third largest source of house price variance appears to be construction cost, which accounts for approximately 6.8% of the variance. Construction cost is a fairly important component of new housing cost that is quite variable over short periods due to changes in material and labor costs. The final variable in the model, housing completion, contributes the smallest house price variance (5.6% of the total variance). This is not surprising because of the short-run inelasticity in housing supply. In terms of the total variance from these four determinants, money supply and two other supply-side variables account for 75% while income accounts for the remaining 25%.

A number of important points emerge from these results. First, monetary variables have been very important for the behavior of Taiwan house prices. Over the past few decades, foreign trade surplus has resulted in rapid domestic monetary growth which has raised asset values in Taiwan. On the other hand, an increase in income does not necessarily cause an instant surge in housing demand because the timing of home purchases are long-term decisions affected by many factors. Furthermore, financial liberalization and loose monetary policy in the late 1980s stimulated the aggregate demand for housing via the multiplier mechanism which raised the house prices above the level they would otherwise have attained. This caused PIR to shift to a higher level after the late 1980s. Second, Taiwan's housing market is characterised by a lot of speculative activities. However, there was no aggregate house price index for reference in Taiwan until the 1990s. Consequently, the government did not take any action until after house prices had jumped threefold in the late 1980s, resulting in the PIR ratio jump. Third, although the supply of public housing may slow down house price increases and is the main instrument for housing policy in Taiwan, the low priority given to the housing sector in the government policy makes the public housing supply quite sluggish. This has proved to be quite unsuccessful because the policy has only satisfied the needs of a very small fraction of households. Finally, given that Taiwan's housing market is imperfect and inefficient, a diligent investor in Taiwan housing market could reap abnormal profits by using a trading rule mainly based on the observed behavior of house prices. However, any existing abnormal return may also gradually disappear as an increasing number of investors begin to utilize available information leading in turn to a more efficient market. Therefore, house price and income should finally return to equilibrium.

Conclusions and suggestions

This paper attempts to investigate the long-run equilibrium relationship between house price and income. Taiwan is used as a case to analyze whether house price and income are drifting apart and what are the factors

that cause such deviation. To examine the long-run relationship between house price and income, the study first used the traditional cointegration test for house price and income. Since this equilibrium relationship does not exist, it then examined how the equilibrium relationship changes using STOPBREAK test, which can show whether the deviation is temporary. It also tested the stability of PIR by using the Perron test. Finally, VECM is utilized to further investigate the causes of their deviation.

Many previous studies suggested that there exists a long-run equilibrium between house price and income, although Gallin (2006) suggested the opposite view. This paper re-examines their relationship by different methods and to clarify this conflict. From the empirical results of Taiwan's data, no cointegration relationship is found. This could be that house price is much more volatile than income so that the cointegration test cannot find their equilibrium relationship. In contrast, the STOPBREAK model, which allows for temporary shock during sample periods, does obtain an equilibrium relationship between house price and income. However, the Perron test for unit root indicates that PIR had a break point in 1987 and shifted to a higher level. This time point is coincident with the financial liberalization in Taiwan for this period. These results imply that house and income may deviate from each other but will return to equilibrium level in the long run. However, the disturbances also have caused a structural change in their relationship. The final test of VECM suggests that money supply contributes 50% more shock to house price than to income. Money supply and two other supply-side variables account for 75% of the total variance among the four determinants, while income accounts for the remaining 25%. These confirm that monetary variables have been very important for the short-run behavior of Taiwan house prices and increase in income only support the long-run trend in the house prices.

The findings have the following implications. Taiwan's deviation of house price and income was caused by a short-term increase in investment demand induced by increased money supply. The structural change in PIR is also related to increased money supply due to financial liberalization and loose money policy. Governments should pay more attention to monetary policy in order to adjust the housing market condition and prevent significant changes in the housing market. Although the findings suggest that the ratio between house price and income will finally return to an equilibrium level, it may take quite a long time to recover, as in the case of Taiwan, due to inefficiency in the housing market. Therefore, if housing affordability becomes very serious, the government should act more quickly to intervene with policies to help the ratio recover sooner.

Appendix A

Tests for stationarity is shown in Table A1.

Appendix B. Data definition and sources

- CC Taipei construction cost index (1991 = 100). Averaged from monthly data. Source: Commodity Price Statistics Monthly in Taiwan Area of the Republic of China.
- CPI Consumer price index (1991 = 100). Averaged from monthly data. Source: Commodity Price Statistics Monthly in Taiwan Area of the Republic of China.

Table A1

Variables in level	Ph	PY	CC	HC	MS
ADF test	-1.51	-0.47	-2.48	-2.03	-0.56
PP test	-0.99	0.40	-2.36	-2.72	-0.69
Variables after differenced	Δ Ph	Δ PY	Δ CC	Δ HC	Δ MS
ADF test	-3.17*	-4.52*	-4.38*	-5.94*	-4.85*
PP test	-8.01*	-6.94*	-8.19*	-5.23*	-6.33*

*Significant at the 5% level.

- HC Floor area of permit for occupancy (housing completions) for new residence, m^2 . Interpolated from annual series. Housing completions for Taipei county from 1973 to 1980 are calculated by assuming a fixed proportion of housing completions for the Taiwan area in 1980. *Source*: Urban and Regional Development Statistics, Republic of China
- MS Money supply (M2). Sum of M1B and quasi-money. Averaged from end of month figures. *Source*: Financial Statistics Monthly, Taiwan District, the Republic of China
- Ph Average pre-sale listing house prices, NT\$1000/Ping. *Source*: the Department of Construction and Planning Administration of the Ministry of Interior.
- PY Household permanent income in Taipei city and county. Estimated from household current receipts (disposable incomes, denoted Y) by Almon polynomial ($A_3(Y)$) after interpolated from annual data. *Source*: The Statistical abstract of Taipei Municipality and Taipei County Statistics.

References

- Abraham, J., & Hendershott, P. (1996). Bubbles in metropolitan housing market. *Journal of Housing Research*, 7, 191–207.
- Bramley, G. (1994). An affordability crisis in British housing: Dimensions, causes and policy impact. *Housing Studies*, 9(1), 103–123.
- Capozza, D. R., Hendershott, C. M., & Mayer, C. J. (2002). *Determinants of real house price dynamics*. NBER working paper 9262.
- Chang, C. O., Kuo, K. E., & Lin, V. (2001). Reasonable housing prices in, Taipei—Demand side analysis. *Journal of Housing Studies*, 10(1), 51–66 (in Chinese).
- Chen, M.-C., Kawaguchi, Y., & Patel, K. (2004). An analysis of the trend and cyclical behaviours of house prices in the Asian markets. *Journal of Property Investment and Finance*, 22(1), 55–75.
- Chen, M. C., & Patel, K. (2002). An empirical analysis of determination of house prices in the Taipei area. *Taiwan Economic Review*, 30(4), 563–595.
- Chen, M. C., & Sing, T. F. (2006). Common structural time series components in inflation and residential property prices. *Journal of Real Estate Portfolio Management*, 12(1), 23–36.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time-series with a unit root. *Journal of the American Statistical Association*, 74, 427–431.
- Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time-series with a unit root. *Econometrica*, 49, 1057–1072.
- Drake, L. (1993). Modelling UK house prices using cointegration: An application of the Johansen technique. *Applied Economics*, 25, 1225–1228.
- Engle, R. F., & Granger, C. W. J. (1987). Cointegration and error correction: Representation, Estimation, and testing. *Econometrica*, 55(2), 251–276.
- Engle, R. F., & Smith, A. D. (1999). Stochastic permanent breaks. *The Review of Economics and Statistics*, 81(4), 553–574.
- Gallin, J. (2006). The long-run relationship between house prices and income: Evidence from local housing markets. *Real Estate Economics*, 34(3), 417–438.
- Gyourko, J., & Linneman, P. (1993). The affordability of the American dream: An examination of the last 30 years. *Journal of Housing Research*, 4(1), 39–72.
- Hendry, D. F. (1984). Econometric modelling of house prices in the UK. In D. F. Hendry, & K. F. Wallis (Eds.), *Econometrics and quantitative economics*. Oxford: Basil Blackwell.
- Holly, S., & Jones, N. (1997). House prices since the 1940s: Cointegration, demography and asymmetries. *Economic Modelling*, 14(4), 549–565.
- Hsieh, L. M. (1996). *Housing price, affordability, tenure choice, ownership rate and their interrelationship*. Report of National Science Council Project (in Chinese).
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12, 231–254.
- Lau, K. M., & Li, S. M. (2006). Commercial housing affordability in Beijing, 1992–2002. *Habitat International*, 30, 614–627.
- Linneman, P., & Megbolugbe, I. (1993). Housing affordability: Myth or reality? *Urban Study*, 29(4), 369–392.
- Malpezzi, S. (1990). Urban housing and financial markets: Some international comparisons. *Urban Studies*, 27(6), 971–1022.
- Malpezzi, S. (1999). A simple error correction model of house prices. *Journal of Housing Economics*, 8, 27–62.
- Meen, G. (2002). The time-series behavior of house prices: A transatlantic divide? *Journal of Housing Economics*, 11, 1–23.
- Memery, C. (2001). The housing system and the Celtic Tiger: The state response to a housing crisis of affordability and access. *European Journal of Housing Policy*, 1(1), 79–104.
- Moore, E., & Skaburskis, A. (2004). Canada's increasing housing affordability burdens. *Housing Studies*, 19(3), 395–413.
- Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica*, 57(6), 1361–1401.
- Perron, P. (1997). Further evidence on breaking trend functions in macroeconomics variables. *Journal of Econometrics*, 80, 355–385.
- Pesaran, M. H., & Shin, Y. (1998). Generalised impulse response analysis in linear multivariate models. *Economic Letters*, 58(1), 17–29.
- Phillips, P., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75, 335–346.
- Renaud, B. (1989). *Affordable housing, housing sector performance and behavior of the price-to-income ratio: International evidence and theoretical analysis*. Paper presented to the Center of Urban Studies and Urban Planning, University of Hong Kong.

- Roche, M. J. (2001). The rise in house prices in Dublin: Bubble, fad or just fundamentals. *Economic Modelling*, 18, 281–295.
- Said, S., & Dickey, D. (1984). Testing for unit roots in autoregressive-moving average models with unknown order. *Biometrika*, 71, 599–607.
- Sargan, J. D. (1980). The consumer price equation in the post-war British economy: An exercise in equation specification testing. *Review of Economic Studies*, 47, 113–135.
- Sims, C. (1980). Macroeconomics and Reality. *Econometrica*, 48, 1–48.
- Yamada, Y. (1999). Affordability crises in housing in Britain and Japan. *Housing Studies*, 14(1), 99–110.
- Zhou, W.-X., & Sornette, D. (2006). Is there a real-estate Bubble in the US. *Physica A*, 361, 297–308.

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