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# 人口老化對於亞洲新興市場房價的影響

# Does Aging Affect Real House Prices?

# The Evidence from Eight Emerging Asian Economies

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# Abstract

There are increasing studies examining the relationship between population aging trend and real estate prices. The theoretical background is “Life Cycle Hypothesis” proposed by Modigliani and Brumberg (1954), and Ando and Modigliani (1963). The hypothesis argues that “Aging Phenomenon” will cause the retired generations to sell more assets than the assets purchased by working generations. This thus will result in asset market having excess supply and inevitably dampening assets prices. Since most Asian economies are facing aging issues, yet on the other hand, their economies are also growing, this paper will shed light on whether aging will affect real asset prices in Asia.

Unlike previous studies which focused on developed economies, this paper investigates the impact of aging on real house prices in eight Asian economies during 1988-2011. I apply Takats (2010) to find out the link between growth rate of old age dependency ratio and the return of real house prices in China, Hong Kong, Indonesia, Malaysia, South Korea, Singapore, Taiwan and Thailand.

This paper examines that population aging will negatively affect real house prices, and total population will positively affect real house prices, after controlling several macroeconomic factors, including GDP per capita, unemployment rate, real interest rate, foreign direct investment and land supply index. The result is quite robust owing to several measures of aging and different estimation methods. I also find that there will be positive house price premiums for wealthier economies with higher degree of economic freedom and better institutional environment. This will help mitigate the downside influence on real house prices.

Moreover, this paper uses data from UN Population Prospectus to project the

potential decline in house prices in next 25 years. Among eight sample countries, the house price is expected to fall on average about 1.34 percent annually. Specifically, the estimated partial aging effect on house prices is the severest in China, about -4.14 percent per annum; the house price in Hong Kong, on the other hand, is unaffected by population aging.

Given the rapid surge of economic growth in emerging Asia, we prove empirically that aging does negatively affect real house prices. This negative relationship would not only help investors to take account of the potential country-specific demographic risk, but also warn policy makers to reconsider their population policy.

Keywords: Population Aging, House Prices, Emerging Asian Economies.

# 論文摘要

人口老化是否會對於房價造成負面衝擊？這個問題是家戶、不動產業者、學者以及政府官員所關心的議題。近年來，越來越多的文獻探討房價以及人口老化程度之間的關係。前人的研究已經證明，已開發國家的人口老化現象會造成未來房地產價格的下降。背後的理論基礎源自於 Modigliani and Brumberg (1954)以及 Ando and Modigliani (1963)所提出的「生命周期假說」（Life Cycle Hypothesis），說明投資人在工作年齡的儲蓄是用來提供退休時所需，而退休後的投資人會逐漸消耗先前累積的金融資產。因此，當一個社會老年人口相對於工作人口的比例上升時，勢必會使得資產市場產生超額供給，進一步造成價格下跌的狀況。

新興經濟體近來成長快速，但同時社會內部也面臨人口老化的問題。本文試著以亞洲八個新興經濟體作為樣本，利用 1988 年至 2011 年，共 24 年的資料，探討新興國家人口老化與房價之間的關係。利用 Takats (2010)的方法，以扶老比(Old Age Dependency Ratio)當作人口老化的代理變數，總人口當作另一個人口因素。在控制其他總體經濟變數包括人均 GDP、失業率、外國直接投資、土地供給以及實質利率之下，本研究發現扶老比與實質房價有顯著負向的影響；總人口與實質房價則有顯著正向的影響，說明人口因素與房價之間存在顯著關連性。此研究結果在不同的代理變數以及估計方法之下，均呈現穩健的結果。除此之外，經濟自由度高以及較富裕的國家享有一定程度的房市紅利，可減緩部份人口老化所帶來的負面衝擊。

最後，本研究利用聯合國人口預測(United Nation Population Prospectus)的資料，預估未來 25 年人口結構變動對於房價的邊際影響。在八個樣本國家中，預估平均每年將下跌 1.34 個百分點，中國大陸房價下跌幅度最大，香港則沒有明顯的影響。此一推估結果對於目前正享受房市紅利的亞洲經濟體，可謂是一警訊，值得投資人以及不動產相關政策執行者的注意。

關鍵字：人口老化、房地產價格、亞洲新興經濟體。

# Table of Content

# List of Figures

# List of Tables

# 1. Introduction

Population aging is currently happening and expected to persist for a considerable amount of time. According to the working paper written by United Nations Population fund (UNFPA, 2012), declining fertility rates and rising longevity at older ages are two main reasons for population aging. This paper also points out that the world will gradually surrounded by elderly people. Estimates even show that one in nine persons in the world is aged 60 years or over currently, and such ratio is projected to increase to one in five by 2050. Meanwhile, there will be nearly 80 percent of older population in the world living in developing economies by 2050. Hence, population ageing is no longer the privilege of advanced countries; it's a worldwide phenomenon that poses various challenges to the society as a whole.

The negative impact of population aging on asset prices and financial market has been debated for years. The advocate claims that aging will lead to "Asset market meltdown" with excess supply and depressed prices in the asset market, because relative larger retired population will sell off assets to that of smaller working generations. On the contrary, the opponent argues that the efficient financial market is equipped with forward-looking mechanism, which means the market have already taken all future demographic information including the aging process into account. Since real estate is one of the most important investments for households and enterprises, I would like to figure out the association between real estate prices and population aging.

More and more emerging economies have entered aging process in a very fast pace, and these economies have also enjoyed substantial economic growth in the mean time. Figure 1.1 presents the economy growth in emerging economies is far larger than that of

the advanced economies during past 25 years. Using population median age and old age dependency ratio to measure the degree of aging, I could tell from Table 1.1 and 1.2 that the emerging economies are now at lower aging level but projected to converge or even surpass some of developed economies hereafter. In other words, I could regard people in emerging economies now are becoming richer but expected to face the problem of population aging at the same time. On the other hand, aging process and economic growth in advanced countries show much steady pattern compared to emerging economies. Therefore, I consider that the experience from developed regions cannot fully reflect to developing ones.

However, previous studies relating to population aging and house prices are mainly focused on single country study (Mankiw et al. (1989), Engelhardt et al. (1990), Hendershott (1990), Swan (1995), Cheng (2006), and Weng (2012)) or international study for developed countries (Takats (2012), Nguyen (2012)). Until recently, the issue of demographic impact on house prices in developing economies has drawn much attention on press article discussions[1], but there are still very few academic studies to prove the relationship systemically.

Inspired by Takats (2012), I examine the correlation between population aging and real house prices from eight Asian emerging economies during 1988 to 2011. The result assures that population aging affect real house prices significantly and negatively. What is more, I further use the demographic projection data from UN Population Prospectus (2010) to simulate future house price movement. Through 2035, the simulation

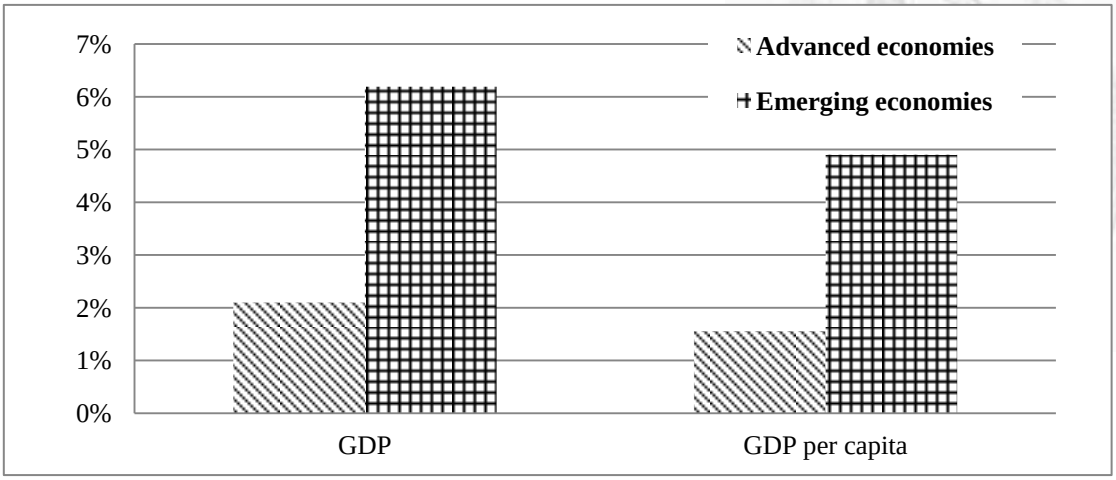
[1] Want China Times (August 1, 2012) cited an economist's opinion that housing prices in China will see a decline in 10 years due to the country's aging population. United Daily News (January 5, 2013) reports that the population dividend in Taiwan will diminish in 2030, and there will be a large drop on housing prices at that time. Bloomberg (March 20, 2013) quote an analyst's view that oversupply and an aging population are two main pressures for housing prices in Korea.

indicates real house prices in emerging economies are expected to drop by 1.34 percent per annum on average according to demographic changes only, confirming there is little possibility of “Asset Market Meltdown.”

There are two contributions in this study. First, this is one of the first papers yielding a valid and negative link between population aging and real house prices in emerging Asian economies’ perspective. Second, this paper incorporates available house price determinants into estimation model to control for specific housing factors, which were often ignored on previous works.

The remainder of this paper is structured as follow: chapter 2 reviews past literatures, chapter 3 describes the research hypothesis, estimation model, econometric approach, and related data, chapter 4 presents empirical results, robustness checks, and housing price projections, lastly, chapter 5 presents conclusions and offers policy implications.

Figure 1.1 Comparison of Economy Growth by Economic Development (1985-2011)




※ Sources: World development Indicators and AREMOS

※ Note: Advanced economies consist of G7 members, and emerging economies include China, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan, and Thailand.

Table 1.1 Estimates and Projections of Population Median Age

| **Panel A: Emerging economies** | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Unit: %* | *1985* | *1995* | *2005* | *2010* | *2015* | *2025* | *2035* |
| China | 23.9 | 27.3 | 32.2 | 34.5 | 36.2 | 40.1 | 44.7 |
| H.K | 28.4 | 33.6 | 39.1 | 41.8 | 43.7 | 46.6 | 48.9 |
| Korea | 24.4 | 29.5 | 35.0 | 37.9 | 40.6 | 45.1 | 48.6 |
| Indonesia | 19.9 | 22.8 | 26.0 | 27.8 | 29.6 | 33.3 | 36.9 |
| Malaysia | 20.4 | 22.5 | 24.6 | 26.0 | 27.5 | 30.2 | 33.2 |
| Singapore | 27.3 | 31.8 | 37.5 | 37.6 | 40.3 | 44.8 | 47.8 |
| Taiwan | 25.1 | 29.8 | 34.7 | 37.4 | 39.9 | 45.5 | 50.4 |
| Thailand | 21.8 | 26.7 | 32.2 | 34.2 | 36.2 | 40.1 | 43.4 |
| **Panel B: Advanced economies** | | | | | | | |
| *Unit: %* | *1985* | *1995* | *2005* | *2010* | *2015* | *2025* | *2035* |
| Canada | 31.0 | 34.8 | 38.6 | 39.9 | 40.8 | 42.4 | 43.9 |
| France | 33.6 | 36.3 | 38.9 | 39.9 | 40.8 | 41.9 | 42.7 |
| Germany | 37.1 | 38.3 | 42.1 | 44.3 | 46.5 | 48.3 | 49.4 |
| Italy | 35.5 | 38.5 | 41.7 | 43.2 | 45.0 | 48.4 | 50.3 |
| Japan | 35.1 | 39.6 | 43.1 | 44.7 | 46.4 | 50.1 | 52.2 |
| U.K | 35.3 | 36.5 | 38.8 | 39.8 | 40.3 | 40.8 | 41.9 |
| U.S | 31.4 | 34.1 | 36.2 | 36.9 | 37.3 | 38.6 | 39.6 |

※ Source: United Nation Population Prospectus (2010)

※ Note: Median Age is the age that divides the population in two parts of equal size.

Table 1.2 Estimates and Projections of Old Age Dependency Ratio

| **Panel A: Emerging economies** | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Unit: %* | *1985* | *1995* | *2005* | *2010* | *2015* | *2025* | *2035* |
| China | 11.0 | 10.9 | 12.4 | 12.7 | 14.4 | 21.7 | 33.3 |
| H.K | 12.5 | 15.0 | 18.2 | 18.4 | 21.5 | 35.4 | 50.8 |
| Korea | 7.9 | 9.5 | 14.3 | 17.1 | 20.0 | 31.9 | 48.7 |
| Indonesia | 7.8 | 8.0 | 9.1 | 9.5 | 10.0 | 13.8 | 20.6 |
| Malaysia | 7.7 | 7.3 | 8.0 | 8.6 | 10.1 | 14.8 | 19.9 |
| Singapore | 8.6 | 9.7 | 13.0 | 13.6 | 17.6 | 31.5 | 50.2 |
| Taiwan | 9.1 | 12.9 | 15.1 | 16.1 | 18.6 | 31.5 | 48.0 |
| Thailand | 8.0 | 10.1 | 13.1 | 14.1 | 15.9 | 23.8 | 33.6 |
| **Panel B: Advanced economies** | | | | | | | |
| *Unit: %* | *1985* | *1995* | *2005* | *2010* | *2015* | *2025* | *2035* |
| Canada | 16.9 | 19.7 | 20.9 | 22.5 | 25.8 | 35.9 | 44.3 |
| France | 22.2 | 25.8 | 28.0 | 28.5 | 32.6 | 39.8 | 45.9 |
| Germany | 23.7 | 24.5 | 31.4 | 33.4 | 35.5 | 43.9 | 60.3 |
| Italy | 22.1 | 26.9 | 32.0 | 33.5 | 36.5 | 42.2 | 54.8 |
| Japan | 16.8 | 23.0 | 32.5 | 38.3 | 46.8 | 54.7 | 61.4 |
| UK | 26.2 | 26.9 | 26.9 | 27.8 | 30.6 | 34.6 | 41.2 |
| US | 20.3 | 21.5 | 20.5 | 21.8 | 24.6 | 32.7 | 38.1 |

※ Source: United Nation Population Prospectus (2010)

※ Note: Old-age dependency ratio is the ratio of the population aged 65 years or over to the population aged 20 to 64.

# 2. Literature Review

There are three streams of literatures that are relevant to the connection between aging and real estate prices. Firstly, I would like to demonstrate the theoretical and empirical background of the relationship between demographics and financial asset markets. Secondly, articles on cross countries house price determinants are introduced. Lastly, I would focus on articles about demographics and housing market.

## 2.1 Theoretical background

"Life Cycle Hypothesis" proposed by Modigliani and Brumberg (1954), and Ando and Modigliani (1963) suggest the interdependence between demography and asset prices. The hypothesis assumes that individuals smooth out their consumption pattern over their entire lifetimes. Thus, each would use his or her positive savings to build up asset portfolio in their early working ages, and sell off their stock of assets during retirement. Once the speed of population aging moves faster, the growing size of old-age population would gradually liquidate their asset holdings, thus lead to excess supply and downward pressure on asset prices in asset market.

## 2.2 Demographics and financial asset markets

Motivated by theoretical reasoning, there are thriving empirical works to examine the relationship between demographics and financial asset markets. However, the findings of past studies are diverse and open to debate owing to different empirical methods, demographic proxies, and covered samples. The following are the related empirical literatures.

The very first empirical work is presented by Bakshi and Chen (1994). They explore the post-war period data from the U.S. and justify that when the average age increases, the aggregate demand for financial asset will grow and housing demand will thus fall. Meanwhile, they also argue that people's risk aversion will increase as they grow older, so there is a positive connection between equity premium and average age. Followed by the finding of Bakshi et al. (1994), Erb, Harvey, and Viskanta (1997) explore a statistically positive relationship between real equity returns and changes in country-specific "average age" in the sample of several developed and emerging countries during 1970 to 1975. There is also a finding in the United States suggesting the fraction of population ages from 25 to 45 and above 65 has negative effect on real equity prices, and the fraction of population ages from 45 to 60 has a positive impact on real equity prices. However, Ang and Maddaloni (2003) have different point of view, they argue that the link between demographic variables, including changes in average age, and equity excess return in the U.S, is no longer applied to other countries significantly. They offer empirical evidence that changes in the proportion of old age population could negatively affect equity risk premiums in 15 developed markets from 1970 to 2000, and this demographic impact on risk premium would be more influential on economies with well social security system and low market development.

Poterba (1998) considers the connection between population age structure and the return on financial assets in the United States is improbable. At the beginning, Poterba uses data from Survey of Consumer Finances to explore the household age-asset accumulation profile. He discovers households' assets holding reaches to its peak in their early 60's, and then decrease gradually after retirement. This finding casts doubt on the "Asset market meltdown view". Next, he reveals there is weak statistical and economic evidence on historical relationship between demographic structure and real

returns on Treasury bills, long-term government bonds, and corporate stocks in the sample of U.S, Canada, and U.K. Poterba concludes that the lack of cross-country observations, international capital mobility, and forward-looking behavior could mitigate the impact of age structure on financial asset returns. Yet, Poterba (2004) revisited the study of the link between demography and asset returns. The updated information on Survey of Consumer Finance reveals the same result. What is more, historical correlation between population age structure asset prices and asset returns only shows moderate effect. The results could be divergent under different econometric specifications, but in general, it offer stronger support to the relationship between demography and asset prices than that between demography and asset returns. He even argues that one could not applies the estimated coefficients relating to demography and asset prices to forecast future asset price movements, because the outcome would be biased by omitted variables and become too large to believe.

On the other hand, there are some scholars employing specific age cohort to represent for population age structure. Yoo (1994) investigates that population aged from 45 to 54 have the largest impact on household's wealth accumulation. The time series evidence even shows a negative relation between financial asset returns and the size of this age group, but only financial asset with relative low volatility such as Treasury bills would yield significant result. Likewise, Davis, Li (2003) find the fraction of population aged from 40 to 64 significantly raises real share prices and lower real bond yields in seven industrialized economies from 1950 to 1999. Apart from previous studies merely including demographic variables in econometric model, the results remain consistent after controlling for other factors such as GDP growth rate and real share price volatility to prevent from omitted variables bias. Contrary to previous works using only specific age group such as fraction of population age 40 to 64, as the proxy

of historical demographic status, Brooks (2006) tries to find out whether overall age cohorts in the age distribution are associated with financial asset prices and returns for a variety of developed countries from 1920's. The result suggests that population aging would not reduce real asset prices, and some individual country evidences even report that the asset price is likely to grow under the expansion of old age population proportion.

Rather than studies investigating the demographic effect on financial asset prices and returns, some recent studies start to elucidate the influence of population aging on macroeconomic variables as well as the size of financial markets. Park, and Rhee (2005) proposed empirical evidence from 86 countries that population aging does affect savings, investment, asset prices, and the size of asset markets. First, saving rate, investment rate, and current account to GDP ratio are expected to reduce due to population aging. Second, aging is also associated with real interest rate, but is not correlated with real equity returns significantly. Third, the size of bond market would increase as the population grows older. In Davis (2006)'s empirical research, according to historical data from a wide range of countries, population age structure is correlated with the size of financial assets after considering country-specific financial structure variables. In general, population aging would not result in severely shrink in the size of financial markets. Increases in the fraction of population over 65 could incline to greater bond market size; the fraction of population from 40 to 64 would simultaneously enlarge the size of bond and equity markets. Similar to the finding of Park et al. (2005), population aging has a negative impact on private saving and external balance.

Judging from the articles reviewed above, the estimation approaches could be divided into two main groups: (1) Micro-level research using only single country household survey data. (2) Macro-level analysis using either single country or

multinational macroeconomic information to infer a statistical relationship between population age structure and asset prices/returns.

Davis et al. (2003) and Poterba (1998) noted that there are three drawbacks applying cross-sectional asset accumulation profile. First, the average figures could be distorted by the wealthiest 10 percent of households who still hold large amount of assets after retirement. Second, the asset profile doesn't consist of social security wealth and defined benefit pension funds. Third, the cross sectional data could not fully reflect "Time effect", "Age effect", and "Cohort Effect"[2]jointly. These distortions may induce life cycle hypothesis hardly proven, and underestimate the effect of population aging. In addition, Poterba (1998, 2004) comments that compared to single country analysis, international analysis could capture different country-specific demographic patterns and increase the degrees of freedom for the estimation. Therefore, I choose to perform an international macro-analysis in order to fully capture the effect of international demography pattern on housing prices.

### 2.3 House price determinants in different regions

Along with the demographic impact, there are still many critical factors influencing real asset prices and returns. Since my study is targeted on cross-country analysis; in this section, I refer to review related studies of house price determinants in a global or regional perspective.

In general, most of the house price determinants papers construct a long-run equilibrium housing valuation by a set of explanatory variables at the very beginning. Then, house price overvaluation, undervaluation and the pattern of house price cycle are

[2] Time effect means individual's asset accumulation would be varied under different time periods. Age effect means individual chooses to hold different level of assets in different age levels. Cohort effect refers to individuals born in different eras would have distinct wealth accumulation patterns.

determined by further econometric techniques. Since I care much about the house price trends in the long term, I simply refer to the association between long-run fundamental variables and real house prices.

In addition, real house prices are driven by specific variables with robust support from empirical works, such as real GDP, real GDP per capita, and real interest rate. I would mostly emphasize on other factors linking to real house prices in the following literatures.

Because emerging economies have become more influential in global economy, some papers start to discuss the house price determinants in these regions. Egert and Mihalijek (2007) examine the determinants of house price dynamics in Central and Eastern European transition economies. They find that fundamental factors would work well in the regression model. Total population, construction cost and monetary aggregates are significantly and positively correlated with real house prices.

In the study of Glindro, Subhanij, Szeto, and Zhu (2008), they conclude several significant house price determinants as long-run price fundamentals in nine Asia-Pacific economies. They found that real mortgage rate, mortgage credit over GDP ratio, land supply index, real effective exchange rate, real share price and institutional factors are associated with real house prices. The institutional factors mentioned above attempt to account for the impact of market arrangement on equilibrium real house prices.

Moreover, Ciarlone (2012) surveys the driving forces of fundamental housing prices in a set of emerging economies. The result is consistent with that of Glindro et al. (2008); in addition, he finds unemployment rate as a prominent explanatory variable.

Recent study covering the most countries and the longest time span is the paper written by Igan and Loungani (2012). They use global house price data from various advanced and developing countries. The findings are coherent to previous works, and

most importantly, they verify the only demographic variable, growth rate of working-age population, is significantly and positively related to the changes in real house price.

Tillmann (2012) uses panel VAR approach on six emerging Asian markets to draw the link between capital inflow and asset prices appreciation. The study suggests that historical capital inflow could statistically explain the growth of real estate and equity prices.

Hence, to sum up, the empirical evidence shows that real house prices could be determined by three categories of elements. First, demand side factors which include household wealth, interest rate, demographic structure, labor market condition, and the foreign capital. Second, supply side factors consist of land supply and construction cost. Third, alternative investments, such as equity price and exchange rate could also concern real house prices through channels of wealth effect or substitution effect.

### 2.4 Demographics and housing market

The formal empirical association between demographic structure and house prices could be traced back to the work discussed by Mankiw and Weil (1989). They discover that changes in housing demand affect house prices positively, and essentially, changes in housing demand are primarily caused by changes in the number of births over time. This link help to explain the house price boom in 1970's, because the baby boom generation in 1950's had grown up to their working age. They even use the relation to forecast that house price would decline by a total of 47 percent by 2007 as the baby bust generation started to enter house-buying age.

Some scholars challenge the drastic view of Mankiw et al. (1989). Engelhardt and Poterba (1990) report the evidence in Canada using the same methodology suggested by

Mankiw et al. (1989). They verify that the housing demand is no longer significantly related to house prices; and in most cases, the result shows negative association, violating the finding by Mankiw et al. (1989). Thereby, they conclude that the statistical relationship between house demand and house prices is still controversial, and severe fall in house prices is unlikely. Similarly, Hendershott (1990) and Swan (1995) find the methodology of Mankiw et al. (1989) imperfect. They think the empirical model should be modified, and huge decline in house price is implausible.

Besides the single-country research for developed economies, there are some works concentrating on developing regions. Cheng (2006) finds that population age structure has impact on house prices in Taiwan significantly. The outcome suggests the fraction of working-age population and young-age dependency ratio is correlated with house prices positively, and the fraction of old-age population and old-age dependency ratio correlated with house prices negatively. Weng (2012) take 9-year house price data from China, such limited source actually yields a very different consequence compared to other previous studies. He finds positive link between the fraction of old-age population and housing returns.

Since the lack of data availability for cross-border house prices, nearly no international study for demographics and housing market has published until the recent paper by Takats (2010, 2012). He uses house prices data from 22 advanced economies over 40 years, and justifies demographic variables, including old age dependency ratio and total population, are significantly related to real house prices. He further concludes the historical demographic tailwind leads to partial house prices dividends in the past 40 years, and the forecasted demographic headwind would result in real house prices in advanced economies to decline approximately 80 basis points per annum in the next 40 years, holding other conditions constant.

Subsequently, Nguyen (2012) revisits the issue of cross-country demographics and house prices using similar approach of Takats (2010). She includes broader set of samples containing emerging economies, and also controls the financial openness in individual countries. There are three chief findings: First, the insignificant of financial openness indicates that cross-border real estate investment is rare and has little impact on house prices. Second, demographic factors are only jointly significant on the samples of advanced economies. Third, she constructs a high-order polynomial estimation correspondent with Brook (2006). The result is consistent with life cycle hypothesis showing that old age and young age cohorts would affect house prices negatively, while working age cohort would have positive impact on house prices.

In summary, there are not as many discussions on the influence of aging on real estate prices as the impact of demographics on financial asset prices in academic circles. Yet this issue is gradually drawing scholars' attention, the research outcome is still not in consensus. My empirical work in emerging economies is to investigate the relationship thoroughly and to contribute useful views in this field.

# 3. Hypothesis and Methodology

In this chapter, research hypothesis and empirical model will be established at first. Then, I will introduce methodology including unit root test and panel regression with time fixed effect. Finally, I will report preliminary data description.

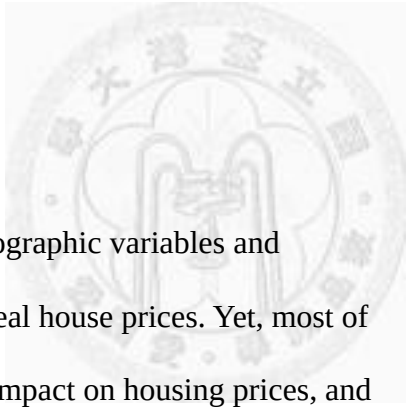
## 3.1 Hypothesis

I anticipate a negative effect of population aging on real house prices in several Asian economies. At first, my expectation is originated from the "Life Cycle Hypothesis", which suggests population aging would result in asset market excess supply and downward pressure on asset prices. Second, based on the reviewed articles, I find the results of demographic impact on both financial asset and real estate prices are supported by most papers. Yet, there are some papers yielding inconsistent outcomes which would cast doubt on past findings. The inconsistency is mainly due to inappropriate statistical approaches, no control variables and lack of effective samples. Therefore, I decide to apply multinational macro-analysis with control variables to overcome these problems. Third, real estate market is dominated by local investors, and the lack of international investment would compensate the negative impact of aging compared with financial assets.

After several improvements in research design, I assert that population aging would negatively affect real house prices in emerging Asian economies. The above inference leads us to the following hypothesis.

H1: *Population Aging will negatively affect the housing prices in emerging Asian*

*economies,* holding other things constant.



### 3.2 The Empirical Model

According to the studies suggested earlier, both demographic variables and macroeconomic variables are crucial factors relating to real house prices. Yet, most of previous studies solely concentrate on the demographic impact on housing prices, and this would cause omitted variable bias, which makes the result of estimated coefficients misleading. Hence, in order to establish a suitable model, I should take all relevant explanatory variables into account. Furthermore, endogeniety and muticollinearity problem should be considered as well.

Model (1) is the baseline specification applied by Takats (2012). He implements a two periods overlapping generation model. In this model, young individuals work and have exogenous work income, but they need to save for consumption at older age. Saving is done through a divisible fiat asset such as real estate. The result suggests that real GDP per capita (*RGDPCAP*) captures the economic effect such as household wealth and is positively correlated with real house prices (*RHPI*). On the other hand, he also includes two demographic factors. The one is old age dependency ratio *(OLD*), measured by the fraction of population aged over 65 divided by working age population aged from 20 to 64. The other one is total population (*POP*), all residents regardless of legal status or citizenship in the official territory. As Takats noted in his theoretical model, these two forces work simultaneously, but in the opposite way. More specifically, old age dependency ratio could capture “composition effect” which is negatively linked to house prices, while total population could capture “size effect” which is positively linked to house prices.

$$RHPI = f\ \{RGDPCAP(+), OLD(-), POP(+)\} \quad (1)$$

Model (2) incorporates additional demand side factors including unemployment rate (*UNEMPLOY*), real interest rate (*RIR*) and the stock value of foreign direct investment inflow (*FDI*). Unemployment rate is the proxy of labor market conditions, and is expected to have a negative sign. Real interest rate is defined as lending rate deflated by inflation rate. It is approximately equal to the opportunity cost of purchasing real estate, and it is also expected to have a negative impact on housing prices. It's worth a note that, since the Asian housing market is highly influenced by the so called "Hot money." This study incorporates the stock value of foreign direct investment inflow over GDP into the estimation to control for capital inflow caused by foreign demand for domestic housing. The sign of FDI is expected to be positive.

$$RHPI =$$
$$f\ \{RGDPCAP(+), OLD(-), POP(+), UNEMPLOY(-), RIR(-), FDI(+)\} \quad (2)$$

Supply side factor is also very prominent in the decision of house prices, so land supply (*LSI*) is included into model (3). To prevent from simultaneous bias in the equation, I choose to use land supply index with one-period lag. According to the law of supply, I consider the expected sign of land supply is negative.

$$RHPI =$$
$$f\ \{RGDPCAP(+), OLD(-), POP(+), UNEMPLOY(-), RIR(-), FDI(+), LSI(-)\} \quad (3)$$

Meanwhile, preceding studies mention that house prices may be affected by the prices of alternative investment assets; at the same time, the population age structure could affect these assets as well. Treating both demographic variables and asset prices as regressors would result in endogeneity concerns. Hence, I would not incorporate the prices of alternative investments into the regression.

## 3.3 Methodology

### 3.3.1 Unit Root Test

In time series analysis, stationarity should be examined at first to prevent from spurious regression. Due to lack of observations in individual time series, running traditional Augmented Dickey-Fuller test is unlikely, so I conduct one classic panel unit root test proposed by Im, Pesaran and Shin (IPS, 2003) to verify whether the variables are stationary in levels or in first-differences.

IPS (2003) develops the technique that relaxes the assumption of a common autoregressive parameter in Levin, Lin and Chu (2002). Moreover, this method could be implemented under unbalanced panel dataset and assumes both the number of panels N and the number of time periods T are fixed. Thanks to the unbalanced panel data set and limited observations in my study, I consider that IPS (2003) method the most appropriate one among several existing panel unit root tests.

In details, IPS (2003) suppose that the stochastic process, $\Delta y_{it}$, is generated by the first-order autoregressive process.

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \varepsilon_{it} \quad i=1,\ldots,N,\ t=1,\ldots,T \tag{4}$$

The null hypothesis is all panels contain unit roots,

$H_0: \beta_i = 0$ for all $i$, (5)

Against the alternative hypothesis indicate some panels are stationary,

$H_1: \beta_i < 0$ for all $i$, (6)

This formation of the alternative hypothesis allows for $\beta_i$ to differ across panels, and it is more general than the homogeneous alternative hypothesis, such as $\beta < 0$.

### 3.3.2 Panel Regression Estimation

I would like to implement a cross-country macro-analysis in order to figure out the link between aging and real house prices, panel data analysis would be a suitable choice for empirical estimation. As Stock and Watson (2007) noted, panel data can be used to learn more about economic relationships from the experiences of the many different entities in the data set and from the evolution over time of the variables for each entity.

I estimate the empirical model using panel regression with time fixed effect only. This method is proposed by Takats (2012), and is extended by adding more regional specific controlling variables into my research. The fundamental reason to implement time fixed effect is to control for unobserved variables that are constant among countries but evolve over time, such as the boom and bust in business cycles.

Most of the readers may wonder why I didn't incorporate country fixed effect that is usually the general approach when dealing with panel data. There are three explanations: First, technically, panel regression with entity fixed effect does not work well with slow changing variables over time. The trend of population aging is

slow-moving and is easily to be assumed as time invariant unobserved variable in the setting of entity fixed effect model. Second, the panel data in my study is time series dominated, so I consider time fixed effect should be used in priority compared to country fixed effect. Third, the selection of samples is limited in a specific area, geographically called "Monsoon Asia." I believe that some unobserved variables such as cultural attitude toward purchasing real estate are similar among this region; thus, the importance of country fixed effect has been eliminated.

Due to the concern of prospective country heterogeneity mentioned in last paragraph, I create a high income per capita dummy variable called ECON to capture country-specific economic development status. "Four Asian Tigers" is used as a classification to separate countries into two groups, because these countries have enjoyed higher per capita income during whole sample period. If countries belong to "Four Asian Tigers", then ECON equals to 1; otherwise, ECON equals to 0. I could treat this indicator variable as an entity fixed effect that varies across regions but not over time. Once I classify these two regional clusters, the characteristic of countries within the cluster could be more homogeneous.

After introducing all the associated variables and specifying the empirical framework, I summarize my regression model as searching for a statistical and economic relationship between real house price and demographic factors, after controlling for several macroeconomic variables. The precise regression is as follow.

$$RHPI_{i,t} =$$

$$\beta_0 + \beta_1 RGDPCAP_{i,t} + \beta_2 OLD_{i,t} + \beta_3 POP_{i,t} + \beta_4 ECON_i + \beta_5 UNEMPLOY_{i,t} +$$

$$\beta_6 FDI_{i,t} + \beta_7 LSI_{i,t} + \beta_8 RIR_{i,t} + \beta_9 \lambda_t + \varepsilon_{i,t} \quad (7)$$

In equation (7), the first subscript, *i*, refers to the country being observed, and the second subscript, *t*, refers to the year at which it is observed. $\beta_0$ denotes regression intercept. $\lambda_t$ denotes only T-1 year dummies that capture time fixed effect. I leave one year dummy omitted to prevent from perfect multicollinearity. On the other hand, $ECON_i$ denotes the high income per capita binary variable. I design this term to capture potential heterogeneity in regions with different economic development status. This binary variable allows for two different intercepts and identical slope for independent variables.

### 3.4 Data Description

I use panel data (also called time series and cross sectional data), which consists of eight entities during the time periods from 1988 to 2011, in this study. The selection of these entities is mostly focused on the emerging economies with available house prices information in the Asian region, so I end up choosing four newly industrialized economies, which are also known as "Four Asian Tigers" in the 1990's – Hong Kong, Korea, Singapore, and Taiwan, and four rapidly developing economies – China, Indonesia, Malaysia and Thailand.

For dependent variable, real house price index (RHPI), I use nominal house price indices compiled by the Bank for International Settlements (BIS) and CEIC Asia database. All of the house prices information is published by public sector or reputable private real estate agency. Then, the house prices are transformed into real term by deflating home country's consumer price index.

The Asian house price data have been applied by numerous studies for different topics (Zhu (2006), Glindro et al. (2008), Ciarlone (2012), and Igan et al. (2012)). However, unlike the above studies using quarterly data, I choose to adopt yearly data

with longer time span into my research by taking averages of the quarterly house prices in a year in order to fully capture the slow-moving trait of demographic changes.

Figure 3.2 and 3.3 report real house prices trends in selected area. In newly industrialized economies, the housing market is quite mature and tends to be market-oriented, so there are more available price observations during the sample period. Moreover, the house price is highly co-moved with Asian business cycle, such as Asian Financial Crisis in 1997 and Global Financial Crisis in 2008. On the other hand, in rapidly developing economies, the real house price is less volatile subject to external business environment and tends to grow over time; however, there is only one exception, Indonesia. The real house price in Indonesia is declining year over year owing to the surging of domestic inflation deflates growth in real estate nominal value.

There are three limitations that we should bear in mind when applying residential house prices. First, the price indices are made up of several methods. For example, some indices are produced by the price of representative property while others may be produced by the hedonic price method. Second, the coverage of region may be different. National data could be referred to the property price in capital city, ten largest cities, or exactly the whole country. Third, the underlying property could be totally in different types. It could be existing houses over newly built houses or single detached house over apartment. These limitations will lead to slight variation in the estimation compared to relatively standard financial assets, such as equity and bond.

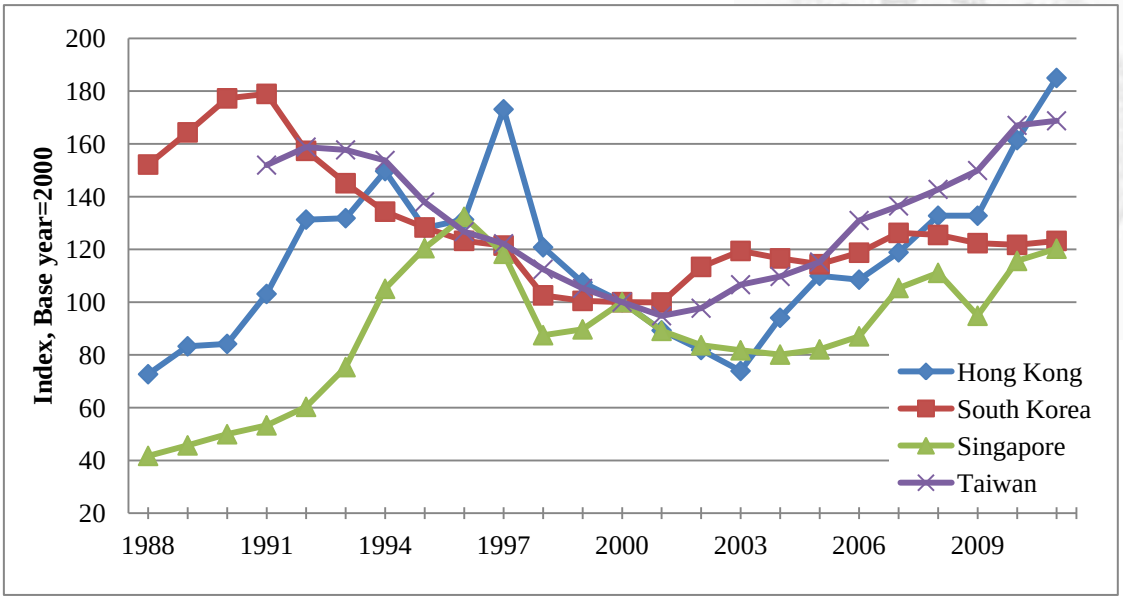
Demographic variables such as old age dependency ratio and total population are collected from United Nation World Population Prospects (2013). Both data series are basically from five-year interval and are interpolated linearly into yearly frequencies. In fact, the interpolation approach for demographic variables is quite common in related research (Ang et al. (2002), Egert et al (2007), and Takats (2012)).

Macroeconomic variables such as real GDP per capita, unemployment rate and real interest rate are compiled from World Bank's World Development Indicator Database (WDI). The stock value of foreign direct investment inflow over GDP is collected from United Nations Conference on Trade and Development (UNCTAD). Finally, the land supply indices are from CEIC database. Since the definitions of land supply vary from country to country, I decide to follow the method of Glindro et al. (2008). I use building permits as proxy, and standardize different series by indexation.

In addition, demographic data and macroeconomic data in Taiwan are compiled from AREMOS database. The original source is from national statistic bureau, also known as Directorate-General of Budget, Accounting and Statistics. This source is reliable and is used by many cross-country studies including Taiwan.

Summarized descriptions for the house price indices and explanatory variables are in Appendix A, B, and C.

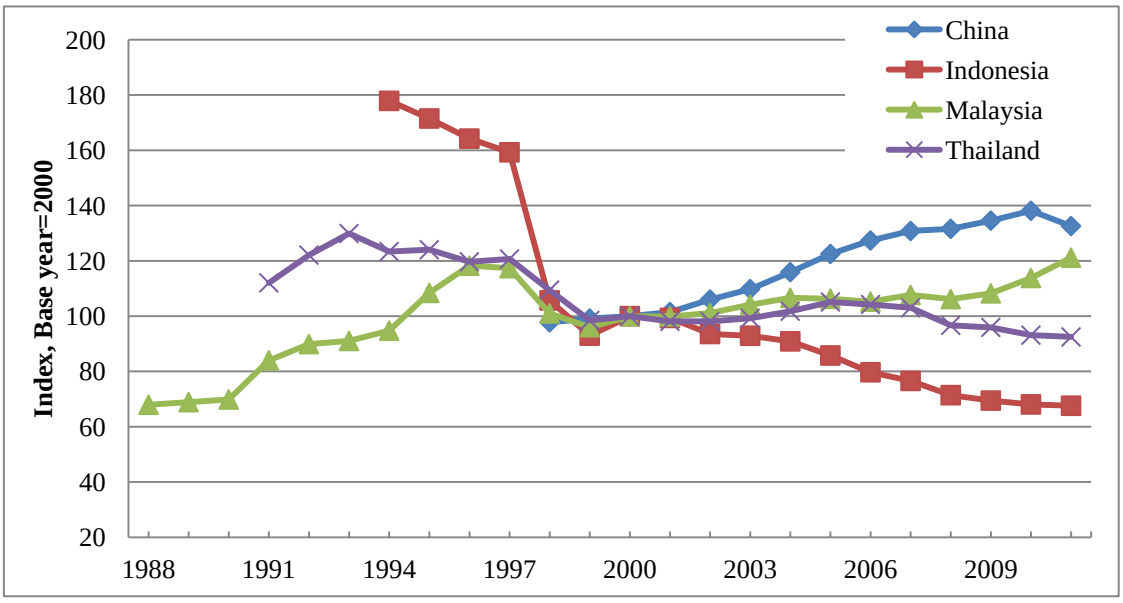
Figure 3.1 Real House Prices in Four Asian Tigers




※ Sources: Bank for International Settlements (BIS) and CEIC.

※ Note: Time Series are deflated by consumer price indices. 2000=100

Figure 3.2 Real House Prices in Rapidly Developing Economies




※ Sources: Bank for International Settlements (BIS) and CEIC.

※ Note: Time Series are deflated by consumer price indices. 2000=100

# 4. Empirical Results

In this chapter, I will show unit root test, descriptive statistics, and correlation analysis at the very beginning. Then, I will report multivariate analysis to infer the relationship between demographic factors and real house prices. Next, robustness checks will be implemented to ensure my estimation would be unaffected under different model settings. Finally, I will employ the population projection data from United Nation Population Prospects (2013) to forecast the expected annual housing returns caused by demographic factors in the next 25 years.

### 4.1 Unit Root Test

Table 4.1 reports the outcome of unit root tests. The alternative hypothesis is that some panels are stationary against all panels contain unit roots. The result shows most of the variables are stationary in first differences, except that unemployment rate and real interest rate are already significantly following an I(0) process under 10% significance level in both tests. Therefore, unemployment rate and real interest rate are treated as log level variable and value level variable respectively. The other variables are regarded as log-difference variables in the following discussion.

Table 4.1 Im-Pesaran-Shin Unit Root Tests

| Variable | IPS in log levels | IPS in log differences |
|---|---|---|
| Real house price index | 0.5412 | -3.6476*** |
| Real GDP per capita | 1.4691 | -5.7415*** |
| Old age dependency ratio | -0.2794 | -2.0752*** |
| Total population | 2.6599 | -3.1022*** |
| Unemployment rate | -1.3568* | -6.7805*** |
| Foreign direct investment | 0.0389 | -6.2464*** |
| Land supply index | 0.5480 | -5.3843*** |
| Real interest rate (Value level) | -4.5247 | -8.4663*** |

※ Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All values are in IPS statistics. The null hypothesis is the process has a unit root. Unemployment rate and real interest rate reject the null hypothesis both in log level and in value level.

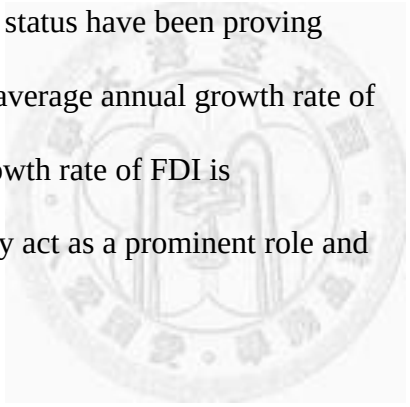
**4.2 Summary Statistics**

Table 4.2 reports descriptive statistics for individual countries and the whole sample respectively. The interpretation of first difference in logs could be regarded as growth rate or return[3], so the format of log-difference variables is showed in percentage.

The intuitive link between old age dependency ratio and real house prices could be found on Table 4.2. For those countries with high old dependency ratio growth, such as Korea, Taiwan and Thailand, the return of real house prices is relatively lower than the other country with modest old dependency ratio growth. Two exceptions are Indonesia and Singapore. Indonesia suffers negative real housing return subject to its young demographic structure, while Singapore enjoys positive real housing gain under its older one. Besides, the descriptive statistics also reveal that countries with relative higher population growth rate are also accompanied by higher real housing returns. I could observe examples from Hong Kong (1.02%), Singapore (2.50%), and Malaysia

[3] $\ln(x + \Delta x) - \ln(x) \cong \frac{\Delta x}{x}$ ; in calculus term, that is, $d\ln(x) = \frac{dx}{x}$

(2.24%). Meanwhile, I also observe that macroeconomic status have been proving substantially during the sample period; for example, the average annual growth rate of GDP per capita is about 4.4% and the average annual growth rate of FDI is approximately 4.8%. These non-demographic factors may act as a prominent role and affecting real house prices at the same time.



### 4.3 Correlation Analysis

Table 4.3 reports the Pearson correlation matrix for the whole sample. The result exhibits that total population is positively and significantly correlated with real house prices, but old age dependency ratio doesn't show significant negative correlation. It's also worth noting that other independent variables such as GDP per capita and unemployment rate report both significant and expected association with real house prices. Nonetheless, some of independent variables such as FDI inflows and land supply show confounding correlations which violate the theoretical relationships. Hence, I should leverage multivariate analysis covered in the next section to find out more detailed information.

Besides, I should also examine the potential correlation within the explanatory variables. All of the correlation coefficients are well below $\pm$ 0.8; that is, the perfect multicollinearity problem is eased. To further investigate the existence of multicollinearity, Table 4.4 reports variance inflation factors (VIF) for independent variables. As Kennedy (2003) notes that if VIFs exceed 10, there might be multicollinearity problem for independent variables in multiple regressions. Since the average VIF is about 4 and all VIFs are below 10, I consider there is no multicollinearity problem for independent variables in my study.

Motivated by Poterba (1998) and Ang et al. (2002), I would also like to figure out

whether adding cross-country analysis increases statistical power or not. The idea is that, if most of sample countries follow different demographic patterns, using cross-country analysis will yield more information about the relationship between demographic factors and dependent variable. Table 4.5 and Table 4.6 exhibit cross-country correlations for old age dependency ratio and total population. Most of the correlation coefficients are below $\pm 0.8$, indicating that sample countries follow more or less different demographic patterns with each other. Thus, I confirm that using cross-country analysis will increase statistical power and yield more affluent information.

Table 4.2 Summary Statistics

| Country | | China | Hong Kong | Indonesia | Korea | Malaysia | Singapore | Taiwan | Thailand | Overall |
|---|---|---|---|---|---|---|---|---|---|---|
| **RHPI** | *Mean* | 2.34% | 4.06% | -5.69% | -0.92% | 2.51% | 4.60% | 0.52% | -0.96% | 0.99% |
| | *Std.* | 2.51% | 15.62% | 9.99% | 6.66% | 6.32% | 13.79% | 6.69% | 4.69% | 9.93% |
| **RGDPCAP** | *Mean* | 8.50% | 2.90% | 3.70% | 4.41% | 3.65% | 3.82% | 4.36% | 3.71% | 4.38% |
| | *Std.* | 2.62% | 3.40% | 4.51% | 3.45% | 3.92% | 4.32% | 7.15% | 4.88% | 4.67% |
| **OLD** | *Mean* | 0.80% | 1.53% | 0.93% | 3.32% | 0.76% | 2.21% | 2.08% | 2.42% | 1.76% |
| | *Std.* | 0.71% | 0.84% | 0.41% | 0.97% | 1.21% | 1.28% | 1.12% | 0.75% | 1.27% |
| **POP** | *Mean* | 0.84% | 1.02% | 1.34% | 0.61% | 2.24% | 2.50% | 0.66% | 1.00% | 1.28% |
| | *Std.* | 0.35% | 0.67% | 0.23% | 0.21% | 0.39% | 0.73% | 0.30% | 0.29% | 0.80% |
| **UNEMPLOY** | *Mean* | 1.18 | 1.21 | 1.74 | 1.16 | 1.27 | 1.09 | 1.06 | 0.54 | 1.16 |
| **(Log-level)** | *Std.* | 0.24 | 0.58 | 0.51 | 0.31 | 0.23 | 0.33 | 0.48 | 0.44 | 0.50 |
| **FDI** | *Mean* | 4.80% | 1.52% | 4.58% | 7.90% | 3.22% | 4.68% | 3.34% | 8.12% | 4.77% |
| | *Std.* | 13.28% | 21.13% | 38.21% | 22.09% | 15.53% | 11.76% | 18.47% | 21.42% | 21.34% |
| **LSI** | *Mean* | 12.17% | -4.29% | 4.39% | 2.30% | 4.53% | 6.28% | 0.08% | -5.00% | 2.55% |
| **(One-period lag)** | *Std.* | 10.30% | 28.08% | 37.53% | 22.77% | 12.44% | 16.37% | 22.25% | 48.17% | 27.47% |
| **RIR** | *Mean* | 1.50 | 4.64 | 5.91 | 3.55 | 3.80 | 4.24 | 5.59 | 5.64 | 4.36 |
| **(Value-level, %)** | *Std.* | 3.77 | 4.71 | 8.39 | 2.52 | 3.78 | 3.75 | 1.64 | 2.93 | 4.50 |

※ Note: All variables are in log-differences, except that unemployment rate is in log level, and real interest rate is in value level. The dependent variable is real house price index (RHPI). RDGPCAP is real GDP per capita. OLD is old age population over 65 divided by working population from 15 to 64. ECONDUMMY equals to 1 if the country is belong to “Four Asian Tigers” and zero otherwise. POP is total population. UNEMPLOY is natural log of unemployment rate. FDI is the stock of foreign direct investment inflow over GDP. LSI is land supply index with one-period lag. RIR is real interest rate.

Table 4.3 Correlation Matrix

| | RHPI | RGDPCAP | OLD | POP | ECON DUMMY | UNEMPLOY | FDI | LSI | RIR |
|---|---|---|---|---|---|---|---|---|---|
| **RHPI** | 1 | | | | | | | | |
| **RGDPCAP** | 0.491*** (0.000) | 1 | | | | | | | |
| **OLD** | -0.096 (0.224) | -0.112 (0.129) | 1 | | | | | | |
| **POP** | 0.133* (0.092) | -0.094 (0.204) | -0.267*** (0.000) | 1 | | | | | |
| **ECON DUMMY** | 0.126 (0.111) | -0.109 (0.139) | 0.419*** (0.000) | -0.101 (0.174) | 1 | | | | |
| **UNEMPLOY** **(Log-level)** | -0.197** (0.012) | -0.110 (0.136) | -0.254*** (0.000) | -0.082 (0.267) | -0.049 (0.500) | 1 | | | |
| **FDI** | -0.242*** (0.002) | -0.314*** (0.000) | -0.007 (0.922) | 0.018 (0.813) | -0.019 (0.795) | 0.140* (0.058) | 1 | | |
| **LSI** **(One-period lag)** | 0.136 (0.093) | 0.211** (0.006) | 0.072 (0.358) | 0.061 0.436 | -0.058 0.458 | -0.051 0.510 | -0.051 0.513 | 1 | |
| **RIR** **(Value-level)** | -0.080 (0.311) | -0.028 (0.706) | 0.071 (0.336) | 0.030 (0.687) | 0.032 (0.656) | 0.081 (0.264) | -0.045 (0.544) | -.079 .313 | 1 |

※ Note: *p*- values are in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01. All variables are in log-differences, except that unemployment rate is in log level, and real interest rate is in value level. The dependent variable is real house price index (RHPI). RDGPCAP is real GDP per capita. OLD is old age population over 65 divided by working population from 15 to 64. ECONDUMMY equals to 1 if the country is belong to "Four Asian Tigers" and zero otherwise. POP is total population. UNEMPLOY is natural log of unemployment rate. FDI is the stock of foreign direct investment inflow over GDP. LSI is land supply index with one-period lag. RIR is real interest rate.

Table 4.4 Variance Inflation Factors, VIF

| Variable | VIF |
|---|---|
| RGDPCAP | 3.15 |
| OLD | 1.72 |
| POP | 1.26 |
| ECONDUMMY | 1.30 |
| UNEMPLOY | 1.77 |
| FDI | 1.46 |
| LSI | 1.60 |
| RIR | 1.36 |
| YEAR DUMMIES | 4.85 |
| Mean VIF | 3.98 |

Table 4.5 Correlation Matrix for *OLD*

| | China | Hong Kong | Indonesia | Korea | Malaysia | Singapore | Taiwan | Thailand |
|---|---|---|---|---|---|---|---|---|
| China | 1 | - | - | - | - | - | - | - |
| Hong Kong | 0.506 | 1 | - | - | - | - | - | - |
| Indonesia | 0.720 | -0.014 | 1 | - | - | - | - | - |
| Korea | 0.679 | -0.078 | 0.871 | 1 | - | - | - | - |
| Malaysia | 0.423 | -0.285 | 0.504 | 0.586 | 1 | - | - | - |
| Singapore | 0.868 | 0.676 | 0.637 | 0.432 | 0.314 | 1 | - | - |
| Taiwan | -0.615 | 0.072 | -0.502 | -0.720 | -0.587 | -0.242 | 1 | - |
| Thailand | 0.237 | 0.310 | 0.478 | 0.068 | -0.034 | 0.625 | 0.390 | 1 |

Table 4.6 Correlation Matrix for *POP*

| | China | Hong Kong | Indonesia | Korea | Malaysia | Singapore | Taiwan | Thailand |
|---|---|---|---|---|---|---|---|---|
| China | 1 | - | - | - | - | - | - | - |
| Hong Kong | 0.507 | 1 | - | - | - | - | - | - |
| Indonesia | 0.974 | 0.384 | 1 | - | - | - | - | - |
| Korea | 0.964 | 0.407 | 0.913 | 1 | - | - | - | - |
| Malaysia | 0.886 | 0.480 | 0.944 | 0.753 | 1 | - | - | - |
| Singapore | -0.028 | 0.141 | -0.128 | 0.036 | -0.233 | 1 | - | - |
| Taiwan | 0.918 | 0.658 | 0.906 | 0.821 | 0.918 | -0.021 | 1 | - |
| Thailand | 0.651 | 0.241 | 0.695 | 0.654 | 0.704 | -0.435 | 0.613 | 1 |

### 4.4 Estimation Results

Table 5.1 reports the estimation results of demographic impacts on real house prices. All variables are expressed in log-differences, except that unemployment rate is expressed in log level and real interest rate is expressed in value level. Due to the special characteristic of log-difference variables, coefficients could be interpreted as elasticity; accordingly, one percent increase in independent variable lead to $\beta_i$ percent growth in dependent variable.

Model (1) is a revised version of Takats (2012) and Neugyen (2012), and the core difference is that I add a high income per capita dummy variable to separate countries apart into two clusters. The outcome is quite consistent to previous works, and all of the variables have correct signs. Real GDP per capita and total population positively and significantly correlated with dependent variable at a 5 percent significance level. While old age dependency ratio has an insignificant opposite effect.

On the other hand, the high income per capita dummy variable exhibits positive and significant correlation. I consider that there are some unobserved variables in this region, such as cultural attitude toward real estate, housing market openness and market transaction transparency that may have a directly or indirectly supportive impact on housing market. My point of view is partially supported by Glindro et al. (2008) and Ciarlone (2012). They quantify unobserved institutional factors by using "Rankings of Economic Freedom" published by Heritage Foundation, and prove that it could positively affect housing prices. Figure 4.1 presents historical trend of overall economic freedom in selected area, and I find out "Four Asian Tigers" are characterized as leading group in the performance of economic freedom[4]; nevertheless,

[4] Hong Kong and Singapore are ranked as free economies. Taiwan and Korea are ranked as mostly free

the other four rapidly developing economies have poor performance on economic freedom[5]. Thus, the classification of high income per capita dummy variable could reveal some useful information on institutional factors in regions.

Also note that, the intercept in model (1) is large and significant in 10 percent level, which means that there are still some unexplained factors in the regression. Therefore, I could not firmly conclude the potential impact of old age dependency ratio, and need to adjust the model setting by including more explanatory variables. Then, I consecutively incorporate additional explanatory variables into the regression model as model (2) to (6) show.

Unemployment rate yields a strong negative linkage to real house price, confirming the empirical findings in Egert et al. (2007) and Ciarlone (2012), and most importantly, the inclusion of unemployment rate raises model's explanatory power by 2 percent, making old age dependency ratio become significant in the subsequent models.

Foreign direct investment inflow positively influences real house prices without strong statistical significance. The sign of FDI inflow is under expectation and is coherent to the finding of Tillmann (2012). What's more, land supply index with one-period lag is negatively associated with housing prices, indicating that the supply of land is counter-cyclical to housing market cycle in the short run. This finding is coherent to the traditional economic reasoning, but different from the empirical result of Glindro et al. (2008) and Ciarlone (2012). The insignificancy of these two factors is because both land supply and FDI inflow varies from times, I then argue that transforming these two variables into year over year frequencies could dilute their

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economies.

[5] Malaysia and Thailand are ranked as moderately free economies. Indonesia and China are ranked as mostly unfree economies.

impact to real house prices.

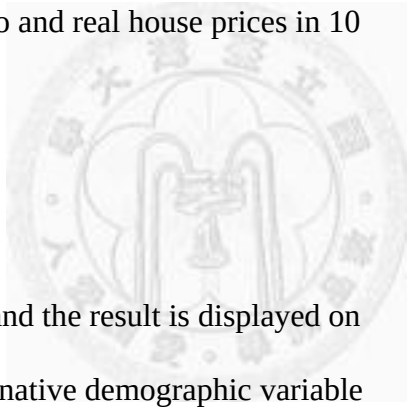
Unexpectedly, real interest rate, the rule of thumb of plenty asset price valuations, has barely impact on housing prices, and this result is similar to Nguyen (2012). I consider the key reason that causes the coefficient's insignificancy is endogeneity concern. Regard to empirical findings by Davis, Li (2003) and Poterba (2004), aging would depress financial asset prices in the long run; hence, when I explain real house prices by demographic factors and real interest rate at the same time could result to invalid consequence. Just like Takats (2010) mentioned, the regression would measure the impact of aging directly through the demographic factors and also indirectly through real interest rate. Therefore, I drop the real interest rate from the list of independent variables.

For model diagnosis, I consider that dependent variable could be well explained by independent variables chosen through the model settings, because there are adjusted R-squares with adequate size and strongly significant F-statistics. Furthermore, the Durbin-Watson statistics report no conclusive evidence of autocorrelation for error terms.

Overall, it seems like model (4) explains the pattern of house prices the best. The estimated demographic coefficients have expected signs and significantly reasonable values. For instance, one percent growth in old age dependency ratio leads to 1.12 percent of real house price fall. The elasticity of total population is nearly two times of old age dependency ratio; that is, 2.41. The other independent variables could be regarded as control variables of macroeconomic factors, supply side factors and other unobserved regional factors respectively. Hence, in the following robustness checks and house price projections, model (4) would be used as a benchmark specification.

In sum, the alternative hypothesis is supported by a significant and negative

statistical correlation between old age dependency ratio and real house prices in 10 percent significant level.



### 4.5 Robustness Checks

Afterwards, I conduct several robustness checks and the result is displayed on Table 4.8 and 4.9. Different proxies for aging and alternative demographic variable are used as substitutes in the benchmark model.

Firstly, previously, there are abundant articles employing the fraction of old age population (over 65) over total population to discover its correlation with asset prices. I name the fraction of old age population as a new variable called OLD 2, and replace the original one. The result shows consistency with model (4) by size and sign.

In addition, original old age dependency ratio in the benchmark model is displaced by different versions. For example, the aging proxy in model (7) is OLD 3, the standard definition of old age dependency ratio by United Nation. It's the fraction of old age population over 65 divided by working age population aged from 15 to 64. The aging proxy in model (8) is OLD 4, the fraction of old age population over 70 divided by working age population aged from 20 to 69. The aging proxy in model (9) is OLD 5, the fraction of old age population over 70 divided by working age population aged from 25 to 69. In spite of changes in aging proxies, all of the explanatory variables are still coherent to model (4). An extra discovery is that, the coefficient of old age dependency ratio becomes larger as the definition of old age generation narrows down. This outcome is reasonable because increment in the degree of population aging is the highest in OLD 5 under identical changes in OLD 3 to OLD 5 respectively. Then, a higher degree in population aging will cause higher incremental effect on housing prices.

Since there is only one population age structure variable, I want to further examine whether adding alternative demographic variable would change the result materially or not. Drawing from the result of Davis et al. (2003), high saving age cohort, the fraction of population aged from 40 to 64 would positively affect real asset prices. The result of Model (6) indicates that when I use high saving age cohort as an only age structure variable, it will have positive but insignificant effect on housing prices which still make sense in the economic reasoning. After consolidating old age dependency ratio and high saving cohort together, Model (7) shows that the coefficient of high saving age cohort remain unchanged, and the significant and negative correlation between population aging and housing prices would be unaffected.

After so many robustness checks, I find that the relationship between population aging and real housing prices still remain solid. Therefore, the statistical result from past demographic experiences could be leveraged to forecast future real housing price movements.

### 4.6 Real house prices projection based on demographic impact

After confirming that demographic variables are significantly linked to real housing prices, I could utilize the information in future demographic changes in order to forecast real housing prices in the next 25 years. At first, the projection of old age dependency ratio and population growth is compiled from United Nation Population Prospectus (2010) with medium-variant estimate. Then, I assume to hold other control factors constant. For example, the real GDP per capita remain the same level and the economy is under constant natural unemployment. Finally, I can use the compounded annual changes of demographic variables and coefficients on model (4) to compute the demographic effect on future price movements. The fundamental idea is as follow.

$$\Delta RHPI_{i,t} =$$

$$-1.1234 \times (\Delta OLD_{it}) + 2.4134 \times (\Delta POP_{it}) + 3.9200 \times (ECONDUMMY_i) \quad (8)$$

Figure 4.1 presents the historical and predicted old age dependency ratio (OLD) trend through 2035. The historical movement of OLD is mild, and it turns to grow dramatically after 2010. Among all sample countries, high income per capita countries are expected to have the highest level of old age dependency ratio, Thailand and China are next, and Indonesia and Malaysia are regarded as following much slower aging process.

Table 4.10 and 4.11 report predicted annual changes of old age dependency ratio and total population. I observe that most of countries still enjoy positive but diminishing population growth, but there are some countries such as China, Korea, and Taiwan that will suffer from population loss during the prediction period. Since total population is a positive demographic factor in the benchmark model, the decrease in population will lead to house prices headwind. On the other hand, overall old age dependency ratio increases are positive, indicating a negative effect on house prices.

Table 4.12 shows the forecasted annual real house prices changes in different periods. Generally, due to the slowdown of population growth and rapid population aging, the house price is expected to fall on average about 1.34 percent annually, approximately twice larger than that of Takats's (2012) estimation[6]. This is because there is larger coefficient of old age dependency ratio in the model and faster expected

[6] Takats (2012) forecasts the demographic headwinds will decrease average house price growth by around 0.8 percent per annum through 2050.

aging process in the sample countries. In addition, the positive coefficient on ECONDUMMY make countries with higher income per capita offset some negative demographic impact on housing. To summarize, the estimated partial negative demographic effect is the severest in China, about -4.14 percent per annum; meanwhile, positive changes in real house prices in Hong Kong suggest that the housing price is somehow immune to demographic headwind in the near future.

When interpreting the above result, one should notice for two cautions. First, I arbitrarily assume other control variables in model (4) remain unchanged, that is to say, the simulation result reports marginal changes of house prices owing to solely demographic variation. Hence, I should interpret the result very carefully that demographic variation might be accompanied by personal income growth and unemployment rate fluctuation over time, and these two factors are generally difficult to predict in real practice. If macroeconomic factors outweigh demographic ones, there are still some chances for real house prices growth, especially for growing economies. Second, I assume the demographic pattern is homogeneous within the country in nature; in fact, population structure is different and dynamic in a country. For example, the negative influence of aging will be mitigated in an emerging region like a newly planned community, because population there is younger relative to national level.

All in all, the simulation results confirm that demographic headwind will become a prominent negative factor on housing prices in the future. But this is merely a marginal factor, and I consider thoroughly “housing market meltdown” is unlikely.

Table 4.7 Regression Table I

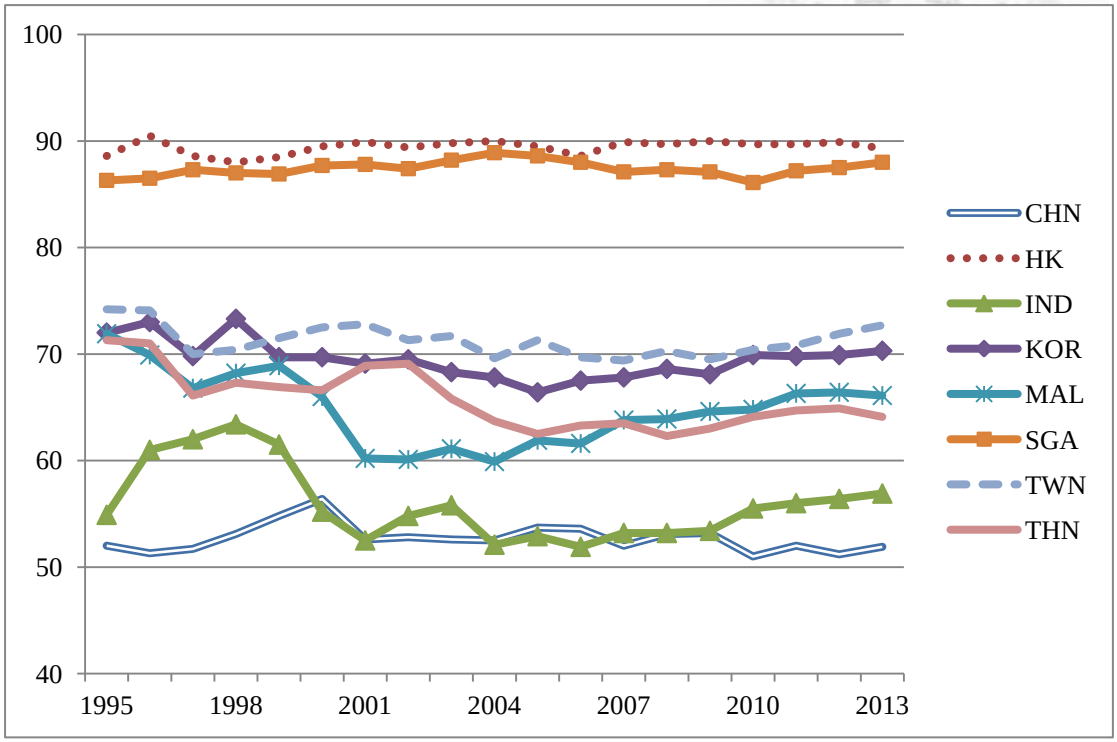
The effect of demographic variables and other control variables on the real house prices

| Variable | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| **RGDPCAP** | 0.4839** | 0.5364** | 0.5614*** | 0.6442*** | 0.6448*** |
| | (2.22) | (2.48) | (2.66) | (2.92) | (2.88) |
| **OLD** | -0.5004 | -1.1520* | -1.2107** | -1.1234* | -1.1251* |
| **(65+/20-64)** | (-0.87) | (-1.90) | (-2.02) | (-1.89) | (-1.87) |
| **POP** | 2.1208** | 2.1123** | 2.1241** | 2.4134** | 2.4150** |
| | (1.97) | (1.98) | (2.00) | (2.22) | (2.21) |
| **ECON** | 0.0328** | 0.0396*** | 0.0400*** | 0.0392** | 0.0400*** |
| **DUMMY** | (2.26) | (2.71) | (2.77) | (2.58) | (2.68) |
| **UNEMPLOY** | - | -0.0373*** | -0.0397*** | -0.0376*** | -0.0377*** |
| **(Log-level)** | | (-3.27) | (-3.43) | (-3.18) | (-3.12) |
| **FDI** | - | - | 0.0259 | 0.0295 | 0.0298 |
| | | | (0.72) | (0.80) | (0.80) |
| **LSI** | - | - | - | -0.0141 | -0.0142 |
| **(One-period lag)** | | | | (-0.63) | (-0.63) |
| **RIR** | - | - | - | - | 0.0002 |
| **(Value-level)** | | | | | (0.09) |
| **Intercept** | -0.0449* | 0.0063 | 0.0079 | -0.0029 | -0.0035 |
| | (-1.66) | (0.21) | (0.26) | (-0.09) | (-0.11) |
| ***Obs.*** | 162 | 162 | 162 | 153 | 153 |
| ***Adjusted R-square*** | 0.33 | 0.35 | 0.35 | 0.34 | 0.33 |
| ***F-statistic*** | 4.06 | 4.24 | 4.09 | 3.75 | 3.59 |
| ***Durbin-Watson Statistic*** | 1.55 | 1.60 | 1.58 | 1.56 | 1.56 |

※ *t* statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are White heteroskedasticity-consistent standard errors & covariance. All variables are in log-differences, except that unemployment rate is in log level, and real interest rate is in value level.

※ The dependent variable is real house price index (RHPI). RDGPCAP is real GDP per capita. OLD is old age population over 65 divided by working population from 15 to 64. ECONDUMMY equals to 1 if the country is belong to "Four Asian Tigers" and zero otherwise. POP is total population. UNEMPLOY is natural log of unemployment rate. FDI is the stock of foreign direct investment inflow over GDP. LSI is land supply index with one-period lag. RIR is real interest rate.

Figure 4.1 Index of Economic Freedom in Emerging Economies




※ Source: Heritage Foundation (2013)

Table 4.8 Regression Table II

The effect of alternative demographic variables and control variables on real house prices

| Variable | (6) | (7) | (8) | (9) |
|---|---|---|---|---|
| **RGDPCAP** | 0.6389*** (2.88) | 0.6425*** (2.44) | 0.5821** (2.56) | 0.6028*** (2.75) |
| **OLD 2 (65+/All)** | -1.3906** (-2.08) | - | - | - |
| **OLD 3 (65+/15-64)** | - | -0.9975* (-1.80) | - | - |
| **OLD 4 (70+/20-69)** | - | - | -1.9182*** (-3.07) | - |
| **OLD 5 (70+/25-69)** | - | - | - | -2.3413*** (-3.71) |
| **POP** | 2.1047* (1.89) | 2.3607** (1.98) | 1.4922 (1.29) | 1.3549 (1.25) |
| **ECON DUMMY** | 0.0373** (2.59) | 0.0372** (2.51) | 0.0519*** (3.52) | 0.0568*** (3.86) |
| **UNEMPLOY (Log-level)** | -0.0377*** (-3.16) | -0.0361*** (-3.13) | -0.0444*** (-3.80) | -0.076*** (-3.97) |
| **FDI** | 0.0304 (0.81) | 0.0293 (0.79) | 0.0278 (0.75) | 0.0260 (0.70) |
| **LSI (One period-lag)** | -0.0165 (-0.73) | -0.0153 (-0.68) | -0.0135 (-0.62) | -0.0156 (-0.73) |
| **Intercept** | 0.0155 (0.45) | -0.0032 (-0.10) | 0.0354 (1.04) | 0.0410 (1.32) |
| ***Obs.*** | 153 | 153 | 153 | 153 |
| ***Adjusted R-square*** | 0.34 | 0.33 | 0.36 | 0.37 |
| ***F-statistic*** | 3.80 | 3.73 | 4.03 | 4.24 |
| ***Durbin-Watson Statistic*** | 1.57 | 1.55 | 1.61 | 1.66 |

※ *t* statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are White heteroskedasticity-consistent standard errors & covariance. All variables are in log-differences, except that unemployment rate is in log level, and real interest rate is in value level.

※ The dependent variable is real house price index (RHPI). RDGPCAP is real GDP per capita. OLD (65+/20-64) is the fraction of old age population over 65 divided by working age population (20 to 64). OLD (70+/20-69) is the fraction of old age population over 70 divided by working age population (20 to 69). OLD (70+/25-69) is the fraction of old age population over 70 divided by working age population (25 to 69). ECON equals to 1 if the country is belong to "Four Asian Tigers" and zero otherwise. POP is total population. UNEMPLOY is natural log of unemployment rate. FDI is the stock of foreign direct investment inflow over GDP. LSI is land supply index with one-period lag.

Table 4.9 Regression Table III

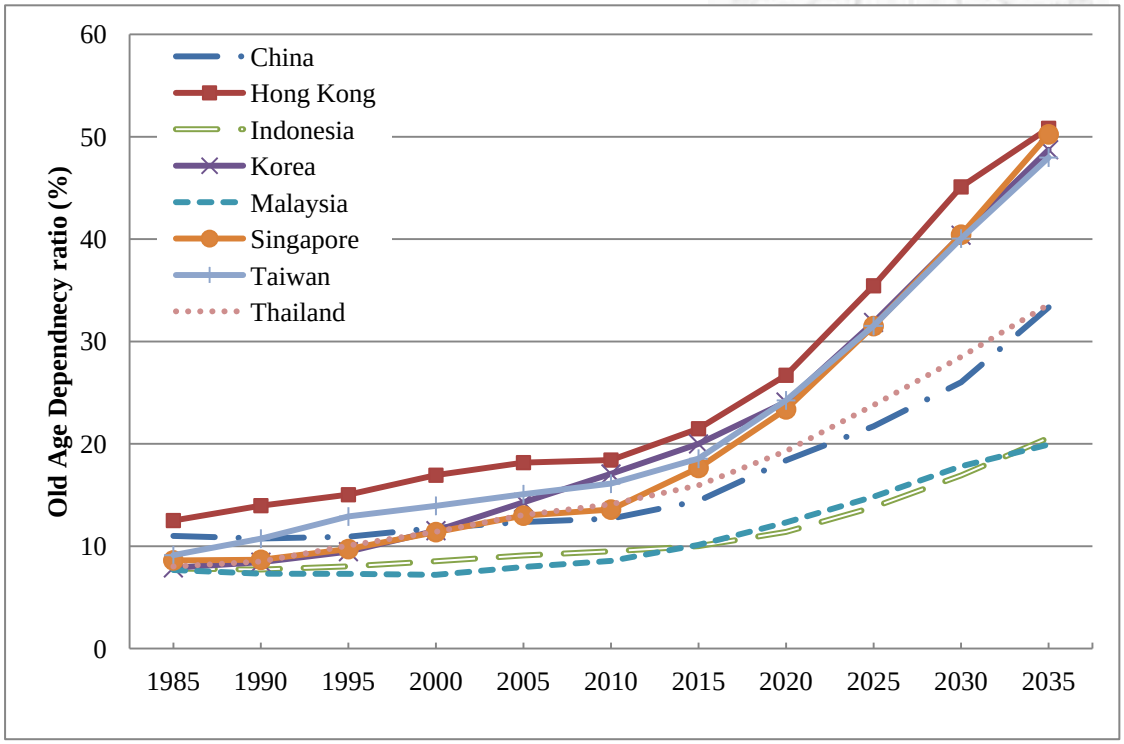
The effect of alternative demographic variables and control variables on the real house prices

| Variable | (10) | (11) |
|---|---|---|
| **RGDPCAP** | 0.6546*** | 0.6282*** |
| | (3.13) | (2.93) |
| **WORK** **(40-64/All)** | 0.3472 | 0.3538 |
| | (0.24) | (0.24) |
| **OLD** **(65+/20-64)** | - | -1.1241* |
| | | (-1.87) |
| **POP** | 2.8088** | 2.4924** |
| | (2.41) | (2.05) |
| **ECON DUMMY** | 0.0289** | 0.0383** |
| | (2.10) | (2.53) |
| **UNEMPLOY** **(Log-level)** | -0.0268** | -0.0375*** |
| | (-2.39) | (-3.14) |
| **FDI** | 0.0224 | 0.0292 |
| | (0.59) | (0.79) |
| **LSI** **(One-period lag)** | -0.0190 | -0.0138 |
| | (-0.82) | (-0.61) |
| **Intercept** | -0.0441 | -0.0106 |
| | (-1.06) | (-0.22) |
| ***Obs.*** | 153 | 153 |
| ***Adjusted R-square*** | 0.32 | 0.33 |
| ***F-statistic*** | 3.60 | 3.60 |
| ***Durbin-Watson Statistic*** | 1.53 | 1.55 |

※ *t* statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are White heteroskedasticity-consistent standard errors & covariance. All variables are in log-differences, except that unemployment rate is in log level, and real interest rate is in value level.

※ The dependent variable is real house price index (RHPI). RDGPCAP is real GDP per capita. WORK (40-64/All) is the fraction of working age population (40 to 60) divided by total population. OLD (65+/20-64) is the fraction of old age population over 65 divided by working age population (20 to 64). ECON equals to 1 if the country is belong to "Four Asian Tigers" and zero otherwise. POP is total population. UNEMPLOY is unemployment rate. FDI is the stock of foreign direct investment inflow over GDP. LSI is land supply index with one-period lag.

Figure 4.2 Estimate and Projected Trend of OLD




※ Sources: United Nations (2010); Council for economic planning and development (2012).

※ Note: OLD is old age dependency ratio. Estimates for OLD are from 1985 to 2010. Projections for OLD are from 2010 to 2035, and the variant is based on medium-fertility.

Table 4.10 Projected Annual POP Growth Rate ($\Delta POP_{i,t}$)

| *Unit: %* | *2011~2015* | *2015~2020* | *2020~2025* | *2025~2030* | *2030~2035* | *Mean* |
|---|---|---|---|---|---|---|
| China | 0.42 | 0.26 | 0.11 | -0.03 | -0.17 | 0.12 |
| Hong Kong | 1.04 | 0.98 | 0.9 | 0.78 | 0.6 | 0.86 |
| Indonesia | 0.98 | 0.83 | 0.7 | 0.57 | 0.44 | 0.70 |
| Korea | 0.39 | 0.28 | 0.17 | 0.04 | -0.11 | 0.15 |
| Malaysia | 1.57 | 1.43 | 1.29 | 1.15 | 0.99 | 1.29 |
| Singapore | 1.11 | 0.81 | 0.72 | 0.6 | 0.4 | 0.73 |
| Taiwan | 0.26 | 0.12 | 0.04 | -0.07 | -0.26 | 0.02 |
| Thailand | 0.5 | 0.34 | 0.22 | 0.12 | 0.02 | 0.24 |
| *Mean* | 0.78 | 0.63 | 0.52 | 0.40 | 0.24 | ***0.51*** |

※ Sources: United Nations (2010); Council for economic planning and development (2012).

※ Note: POP refers to total population. Variant is based on medium-fertility.

Table 4.11 Projected Annual OLD Growth Rate ($\Delta OLD_{i,t}$)

| *Unit: %* | *2011~2015* | *2015~2020* | *2020~2025* | *2025~2030* | *2030~2035* | *Mean* |
|---|---|---|---|---|---|---|
| China | 2.58 | 4.97 | 3.38 | 3.69 | 5.08 | 3.94 |
| Hong Kong | 3.12 | 4.45 | 5.83 | 4.94 | 2.42 | 4.15 |
| Indonesia | 1.02 | 2.65 | 3.92 | 4.13 | 4.02 | 3.15 |
| Korea | 3.22 | 3.79 | 5.76 | 4.85 | 3.83 | 4.29 |
| Malaysia | 3.39 | 4.00 | 3.80 | 3.71 | 2.29 | 3.44 |
| Singapore | 5.39 | 5.78 | 6.16 | 5.12 | 4.44 | 5.37 |
| Taiwan | 3.35 | 5.36 | 5.25 | 4.79 | 3.60 | 4.47 |
| Thailand | 2.47 | 3.89 | 4.27 | 3.69 | 3.35 | 3.54 |
| *Mean* | 3.07 | 4.36 | 4.80 | 4.37 | 3.63 | ***4.04*** |

※ Sources: United Nations (2010); Council for economic planning and development (2012)

※ Note: OLD refers to old age dependency ratio. Variant is based on medium-fertility.

Table 4.12 Projected Real House Prices Change Based on Demographic Impact

| *Unit: %* | *2011~2015* | *2015~2020* | *2020~2025* | *2025~2030* | *2030~2035* | *Mean* |
|---|---|---|---|---|---|---|
| China | -1.89 | -4.95 | -3.54 | -4.22 | -6.12 | -4.14 |
| Hong Kong | 2.92 | 1.29 | -0.45 | 0.25 | 2.65 | 1.33 |
| Indonesia | 1.22 | -0.98 | -2.71 | -3.27 | -3.45 | -1.84 |
| Korea | 1.24 | 0.34 | -2.14 | -1.43 | -0.65 | -0.53 |
| Malaysia | -0.02 | -1.04 | -1.16 | -1.39 | -0.18 | -0.76 |
| Singapore | 0.55 | -0.61 | -1.26 | -0.38 | -0.10 | -0.36 |
| Taiwan | 0.79 | -1.80 | -1.89 | -1.64 | -0.75 | -1.06 |
| Thailand | -1.57 | -3.55 | -4.27 | -3.86 | -3.72 | -3.39 |
| *Mean* | 0.40 | -1.41 | -2.18 | -1.99 | -1.54 | ***-1.34*** |

※ Sources: United Nations (2010); Council for economic planning and development (2012)

# 5. Conclusion & Recommendations

## 5.1 General Conclusion

The negative impact of population aging and asset prices in advanced economies has been investigated empirically by many preceding works and the result has drawn much public attention. However, when it comes to the housing market in emerging economies, many people, including investors, developers, and households are focused on the growth potential in its local economy alone. Demographic factor, especially population aging is rarely discussed on the contrary. In fact, aging will gradually become a prominent issue in emerging economies, since these economies are currently aging faster than some other developed countries like United States.

According to theoretical and empirical reasoning, I bring up an alternative hypothesis that population aging does affect real house prices in eight selected emerging economies. This paper investigates the impact of aging on real house prices in eight Asian economies during 1988-2011. I find that population aging will significantly and negatively affect house prices after controlling the macroeconomic factors such as GDP per capita, unemployment rate, foreign direct investment and land supply index.

Moreover, given demographic variables are persistent and slow moving, I use data from UN population prospectus to simulate the potential decline in house prices in next 25 years. I discover that a thorough “Asset Market Meltdown” is unlikely. On average, real house prices will fall approximately 1.34 percent based on demographic variation alone. Among the eight sample countries, the estimated negative aging effect on house prices is moderate in countries with economic freedom and better institutional environment.

## 5.2 Policy Implications

Three policy implications could be derived from my work. First, the purchasing power of emerging economies is not definitely the panacea for the asset prices in developed countries, because fast aging emerging economies are also facing downward pressure on asset prices, including housing. Second, turning back to fundamental issue, some population and immigrant policies should be reconsidered in order to increase fertility rate and maintain moderate population growth. For instance, policy makers should think to abolish some restricted population policy like the one-child policy in China, or attract worldwide immigrants to maintain required labor forces. Third, global integration and cross border investment may be a prescription for population aging and asset prices. In my study, countries with high income per capita enjoy more housing premium, and it's partially attributed to better institutional factors that facilitate investments and transactions. I suggest authorities to enhance economic and financial freedom in local market. Once the business environment is friendly and official regulations are flexible, countries could attract investment worldwide, including real estate purchases. Thus, I could infer that a better institutional environment will help weakening the downward pressure of aging to local house prices.

## 5.3 Restrictions & Suggestions

Data availability is an important restriction in my study. Since the house price information in most of the emerging Asian economies is published until very recently, my dataset only covers 24 years and is slightly unbalanced. Sample period with a quarter of a century is acceptable for empirical research, but it's actually not long enough for capturing the holistic effect of demographic transition on house prices.

Besides, most of empirical panel datasets regarding aging and asset prices are time series dominated; using traditional panel regression is not enough. I would like to suggest future studies to incorporate some advanced statistical techniques in order to tackle sophisticated time series problem, such as the adjustments of potential autocorrelation of error terms.

# References

**English References:**


[1] Ando, Albert and Modigliani, Franco (1963), "The Life Cycle hypothesis of saving: aggregate implications and tests." The American Economic Review 53 (1), 55–84.

[2] Ang, Andrew and Maddaloni, Angela (2005), "Do demographic changes affect risk premiums? Evidence from International Data." Journal of business 78, 341–380.

[3] Bakshi, Gurdip S. and Chen, Zhiwu (1994), "Baby boom, population ageing, and capital markets." Journal of Business 67 (2), 165-202.

[4] Bank for International Settlements (2013), "Property Price Statistics Database." <http://www.bis.org/statistics/pp.htm>.

[5] Brooks, Robin (2006), "Demographic change and asset prices." Paper presented at the Reserve Bank of Australia G20 conference on "Demographics and Financial Markets", Sydney, July 2006.

[6] Ciarlone, Allesio (2012), "House price cycles in emerging economies." Bank of Italy Working Paper No.863.

[7] Davis, E. Philip and Li, Christine (2003), "Demographics And Financial Asset Prices In The Major Industrial Economies." in Economics and Finance Discussion Papers 03-07, Economics and Finance Section, School of Social Sciences, Brunel University.

[8] Davis, E. Philip (2006), "How will ageing affect the structure of financial markets." paper prepared for the Reserve Bank of Australia-G20 Seminar on Demography and Financial Markets, July 2006.

[9] Egert, Balázs and Mihaljek, Dubravko (2007), “Determinants of house prices in Central and Eastern Europe.” BIS Working Paper No.236.

[10] Engelhardt, Gary V. and Poterba, James M. (1991), “Demographics and house prices: The Canadian Evidence,” Regional Science and Urban Economics 21, 539-546.

[11] Erb, Claud B., Harvey, Campbell R. and Viskanta, Tadas E. (1997), “Demographics and International Investments,” Financial Analysts Journal (July/August), 14-28.

[12] Glindro, Eloisa T., Subhanij, Tientip S., Szeto, Jessica, Zhu, Haibin (2011), “Determinants of house prices in nine Asia-Pacific economies.” International Journal of Central Banking 7, pp. 163-204.

[13] Hendershott, Patric H., 1991. Are real house prices likely to decline by 47 percent? Regional Science and Urban Economics 21 (December), 553–565.

[14] Igan, Deniz and Loungani, Prakash (2012),” Global Housing Cycles.” IMF Working paper.

[15] Im, Kyung S., Pesaran, M. Hashem, and Shin, Yongcheol (2003), “Testing for unit roots in heterogeneous panels.” Journal of Econometrics 115, pp. 53-74.

[16] Kennedy, Peter (2003), “A guide to econometrics.” Fifth edition, MIT Press, Cambridge.

[17] Mankiw, N. Gregory and Weil, David N. (1989), “The baby boom, the baby bust, and the housing market.” Regional Science and Urban Economics, Vol. 19, issue 2, pp. 235-258.

[18] Modigliani, Franco and Brumberg, Richard (1954), “Utility Analysis and the Consumption Function: An Interpretation of Cross-Section Data”, in K. Kurihara, ed.: Post-Keynesian Economics. Rutgers University Press.

[19] Nguyen, Huong D. (2012), "Population aging and the effects on real estate and financial asset returns." Working Paper, School of International Business, Brandeis University.

[20] Park, Daekeun and Rhee, Changyong (2005), "Meet the Challenge of Aging Economies (Korea)." 20th Meeting of APEC Finance Ministers' Technical Working Group.

[21] Poterba, James M. (1998). "Population Age Structure and Asset Returns: An Empirical Investigation." NBER Working Paper 6774.

[22] Poterba, James M. (2004), "The Impact of Population Aging on Financial Markets." NBER Working Paper No 10851.

[23] Stock, James H. and Watson, Mark W. (2007), "Introduction to econometrics." Second edition, Pearson Addison-Wesley, Boston.

[24] Swan, Craig (1995), "Demography and the Demand for Housing – a Reinterpretation of the Mankiw-Weil Demand Variable." Regional Science and Urban Economics, 25, 41-58.

[25] Takats, Elod (2010), "Ageing and asset prices." BIS Working paper No.318.

[26] Takats, Elod (2012), "Aging and house prices." Journal of Housing Economics, vol 21, no 2, June, pp 131–41.

[27] Tillmann, Peter (2012), "Capital inflows and asset prices: Evidence from emerging Asia." HKIMR Working Paper No.18

[28] United Nations (2012) "Aging in the Twenty-First Century: A celebration and A Challenge."

[29] United Nations (2013) "World Population Prospectus, the 2010 Reversion." <http://esa.un.org/wpp/>.

[30] Yoo, Peter S. (1994), "Age Distributions and Returns of Financial Assets,"

Federal Reserve Bank of St. Louis Working Paper No 94-002B.

[31] Zhu, Haibin (2006), "The structure of housing finance markets and house prices in Asia." BIS Quarterly Review, December, pp. 55-69.

**Chinese References:**

[1] Lin, Chun-Hung, Wang, Kuang-Cheng, Hsu, Ching-Po (2010), "Population Aging, Forecast of Labor Supply, and Effect on Asset Demand: The Empirical Analyses of Taiwan." Chang Gung Journal of Humanities and Social Sciences, 3:1(2010), 171-219.

[2] Wu, Ching-Wen (2008), "The impact of demographic structure changing on macroeconomic variables and financial markets." Unpublished master thesis, Department of International Business, Soochow University, Taiwan.

[3] Weng, Sheng-Yang (2012), "The Impact of Demographic Structure on Real Estate Price : The Empirical Evidence in China." Unpublished master thesis, Department of Insurance, Tamkang University, Taiwan.

[4] Cheng, Hui-Ju (2006), "人口結構變遷對房地產價格影響之研究" Unpublished master thesis, Department of International Business, Soochow University, Taiwan.

# Appendices

A. Data Sources and Definitions:

| Abbreviation | Variable Name | Unit | Definition | Sources |
|---|---|---|---|---|
| **RHPI** | Real house price indices | Indices, 2000=100 | Nominal house price index deflated by domestic consumer price index. For more information about nominal house price, please see Appendix B. | BIS, CEIC |
| **RGDPCAP** | Real GDP per capita | USD, constant on 2000 price | Nominal GDP per capita deflated by GDP deflator. | World Bank. AREMOS |
| **OLD** | Old age dependency ratio | % | The old-age dependency ratio is the ratio of the population aged 65 years or over to the population aged 20 to 64. | World Bank, AREMOS |
| **POP** | Total population | Number | De facto population in a country, area or region as of 1 July of the year indicated. | World Bank, AREMOS |
| **ECON-DUMMY** | Economic Status | Indicator variable | If country belongs to Four Asian Tigers, then economic status equals to 1. Otherwise, the economic status equals to 0. | Author's calculation |
| **UNEMPLOY** | Unemployment rate | % | Unemployment refers to the share of the labor force that is without work but available for and seeking employment. | World Bank, CEIC, AREMOS |
| **FDI** | Inward foreign direct investment stock | % | Inward FDI stock is the value of the share of their capital and reserves (including retained profits) attributable to the parent enterprise, plus the net indebtedness of affiliates to the parent enterprise. This value is deflated by GDP. | UNCTAD |
| **LSI** | Land supply index | Indices, 2000=100 | One-period lag variable. Mostly comprise of building permits. For more information, please see Appendix C. | CEIC |
| **RIR** | Real interest rate | % | Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. | World Bank, AREMOS |

B. Definition of Nominal House Prices:

| Country | Series Definition | Period | Sources | Remarks |
|---|---|---|---|---|
| **China** | 70 cities Property Price Index: All buildings | 1998~2011 | National Bureau of Statistics / CEIC | - **Covered Area**: 70 medium-large sized cities<br>- **Property Type**: All types of dwellings |
| **Hong Kong** | Residential Property Prices, all dwellings | 1988~2011 | Census and Statistics Department / BIS | - **Covered Area**: Whole Country<br>- **Property Type**: All types of dwellings |
| **Indonesia** | Residential Property Prices, new houses (Big cities) | 1994~2011 | Bank of Indonesia / BIS | - **Covered Area**: 14 Big Cities<br>- **Property Type**: Newly constructed dwellings |
| **South Korea** | Residential Property Prices, all dwellings | 1988~2011 | Kookmin Bank / BIS | - **Covered Area**: Whole Country<br>- **Property Type**: All types of dwellings |
| **Malaysia** | Residential House Prices, all dwellings | 1988~2011 | Valuation and Property Services Department / CEIC | - **Covered Area**: Whole Country<br>- **Property Type**: All types of dwellings |
| **Singapore** | Property Price Index: Private Residential: All | 1988~2011 | Urban Redevelopment Authority / CEIC | - **Covered Area**: Whole Country<br>- **Property Type**: All types of dwellings |
| **Taiwan** | Sinyi Residential Property Prices | 1991~2011 | Sinyi Realty Incorporation / CEIC | - **Covered Area**: Whole Country<br>- **Property Type**: Existing dwellings |
| **Thailand** | Residential House Prices, all detached houses | 1991~2011 | Bank of Thailand / CEIC | - **Covered Area**: Capital city and suburbs<br>- **Property Type**: All types of Single-family houses, including land |

※ Note 1: The nominal house price in 2011 is the average of the data in four municipalities (Beijing, Shanghai, Chongqing, and Tianjin).

※ Note 2: The nominal house price in 2011 is estimated by the relevant growth rate in monthly data.

C. Definition of Land Supply Index

| Country | Series Definition | Unit | Sources |
|---|---|---|---|
| **China** | Building Construction: Total Area Completed | Square meters, Thousands | National Bureau of Statistics / CEIC |
| **Hong Kong** | Private Domestic Units: Completions | Units | Rating and Valuation Department / CEIC |
| **Indonesia** | Real Gross Construction Output: Work Completed | IDR, Billions | National Bureau of Statistics / CEIC |
| **South Korea** | Buildings Authorized for Construction: Total Amount | Units | Ministry of Land, Transport and Maritime Affairs / CEIC |
| **Malaysia** | No of Property Sales: Residential | Units | Valuation and Property Services Department / CEIC |
| **Singapore** | Private Residential Units: Under Construction | Units | Urban Redevelopment Authority / CEIC |
| **Taiwan** | Building Permit Granted: Total Construction Floor Area | Square meters | Construction and Planning Agency / CEIC |
| **Thailand** | Land Development License Issued: Bangkok and Vicinity | Units | Bank of Thailand / CEIC |