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Are there "Flying Geese Effects" on the Economies and Real Estate Markets between Japan and Taiwan?

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After the Industrial Revolution in Europe in the 18th century, the economic development of Asia was initiated by Japan in the 1900s. As the costs of labor and land escalated, some industries gradually relocated to other Asian countries or regions which Akamatsu (1962) terms the flying geese pattern. To explore the flying geese effect between Japan and Taiwan, this study analyzes data from the gross domestic product and stock and housing markets of both countries from 1975 to 2023. During the pre-bubble and the overall study periods, the Japanese markets significantly influenced the stock and housing markets of Taiwan, thus demonstrating the flying geese effect and reflecting the strong economic performance of Japan. However, in the post-bubble period, the Taiwanese markets diverged from the trajectory of Japan, and developed their independent momentum. These shifts can be attributed to the outward capital and industrial migration of Japan, increasing competition from the emerging markets, and growth of the integrated circuit industry of Taiwan.

Keywords

The flying geese pattern, Bubble, The lost decades, Auto-Regression distributed lag (ARDL), Error correction model (ECM), Granger causality

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1. Introduction

The development of the modern economy began with the Industrial Revolution in 18th century Europe. The mass production model in the Age of Machines rapidly boosted the economy of Europe. The United States (U.S.) continued the economic development relay due to its vast land supply. Japan subsequently gained knowledge of the advanced machine technology after The Meiji Restoration in the 19th century and applied in WWI for weapon manufacturing, which launched its leading role in developing the industry and economy of Asia.

As land and labor costs increased with the economic growth of Japan, some industries began to transfer their manufacturing bases offshore. Hong Kong, Singapore, South Korea, and Taiwan were the first choices for outsourcing or supply chain selection and became known as newly industrialized countries or economies (NICs or NIEs). Akamatsu (1962) terms this growth pattern in the Asian economy as the flying geese pattern. Among the NICs, the relationship between Taiwan and Japan is unique. Japan governed Taiwan for 50 years after 1895 when the Qing Dynasty lost the First Sino-Japanese War. Many infrastructural systems in Taiwan, such as the train and irrigation systems, were built during the governance period of Japan. As a result, the industry, economy, and markets of Japan and Taiwan remain closely related.

In considering this close relationship between Japan and Taiwan, this paper empirically explores their economic growth relationship according to the flying goose theory. By observing the long-term trends of both real estate markets, we find similar growth patterns in the 1980s. The six-fold growth in the real estate market of Japan and the three-fold increase of the market in Taiwan during the same period of time also invited our research interest. Both real estate market booms in Japan and Taiwan followed their respective economic growth before 1990. However, both of their economic and real estate market development diverged after 1991 due to different levels of bubbles and tax systems on real estate ownership and investment. Therefore, we also intend to examine the relationship between the real estate markets in Japan and Taiwan for the entire sample period and the pre- and post-bubble periods.

In order to explore whether there is a flying geese effect between Japan and Taiwan, the objective of this study is to examine the relation between Japan and Taiwan in terms of their economic development from 1975 to 2023. The stock market is used as a proxy of economic development as it usually serves as a window of the economy. As the sample period is a long period of time, and there are obvious structural changes from the bubble burst in Japan in 1991, we also divide the sample period into pre- and post-bubble periods for individual empirical analyses. Furthermore, both the housing markets in Japan and Taiwan appeared to move with the economy, so we extend the object of examination to the housing markets. The hypotheses of this study are:

(1) H1: There existed a flying geese effect between Japan and Taiwan from 1973 to 2023, and the pre-bubble (1973-1991) and post-bubble (1991-2023) periods during economic development, with the use of the stock market as the proxy dependent variable.

(2) H2: There existed a flying geese effect between Japan and Taiwan from 1973 to 2023, and the pre-bubble (1973-1991) and post-period (1991-2023) periods in the housing markets.

The remaining parts of the paper are divided into five sections. The second section reviews the related literature and theories, including the flying geese pattern and the Fisher equation. The third part provides a narrative analysis of the economy and real estate markets of Japan and Taiwan, coupled with a comparative analysis of the U.S. subprime mortgage crisis in 2008. The fourth section presents the research methodology, followed by the empirical results. The last section offers the conclusion.

2. Review of Theory and Literature

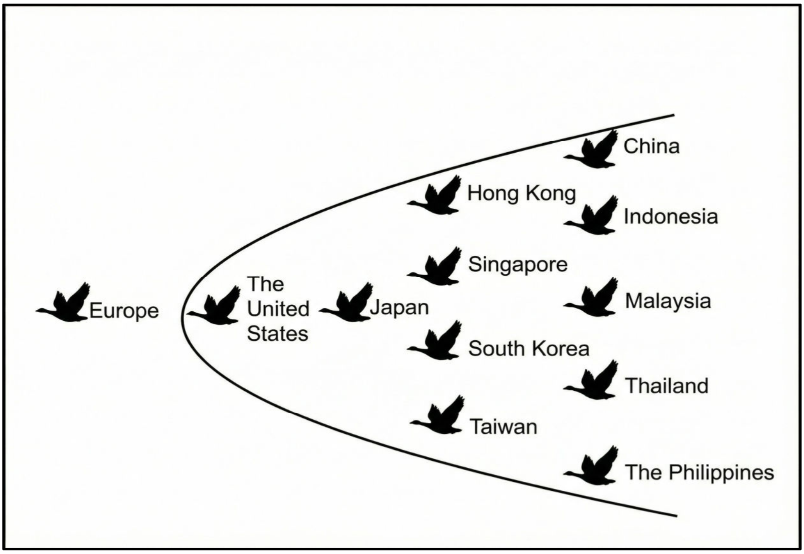
2.1 Flying Goose Theory

Akamatsu (1962) proposes a theory for economic growth patterns in Asian countries. He shows that the economic growth in Asia is brought eastward by Western European capitalists in advanced countries, including the stages that range from importing products, developing production skills, to exporting products. Korhonen (1994) states that the flying geese pattern starts with a labor-intensive industry in a relatively less developed country that is adopted from a more developed country. The former initially provides services or products for the domestic markets. As the production technique matures or advances, the less developed country then starts to export.

The development of the Asian economies from the 1970s to 1990s followed this pattern, with Japan acting as the head goose to lead the Four Dragons or NICs (Taiwan, Singapore, South Korea, and Hong Kong). These were followed by Indonesia, Malaysia, Thailand, and the Philippines before the emergence of China. Figure 1 illustrates the flying geese growth pattern in Asian countries.

Given the close economic ties of Taiwan with Japan, Yau and Nieh (2009) investigate this relationship and find a long-run equilibrium relationship between their currencies (New Taiwan dollar (NTD)/ Japanese Yen (JPY)) and stock prices. They also find a positive causal relationship between Japanese and U.S. exchange rates and the stock prices of Taiwan over the long term.

Figure 1 Flying-Geese Economic Development Pattern from Europe to Asia



Source: Drawn by the authors.

2.2 Quantity Theory of Money - The Fisher Equation

The equation of exchange proposed by Irving Fisher for the quantity theory of money has the following relation:

$$MV = PQ$$

where M is the total money supply (MS), V is the velocity of the circulation of money or transaction, P is the price level or inflation, and Q is the total national output (its rate of change represents economic growth).

According to the Fisher equation, when a country experiences economic growth (increased output), the money supply can be proportionally increased while holding transaction velocity and price level constant. In this scenario, the increased money supply seeks investment vehicles such as stocks and real estate, thus driving up asset prices (Lin et al., 2019). The cases of Japan and Taiwan in the 1980s exemplify how economic growth can lead to asset price appreciation.

However, if the government increases the money supply (MS) first to stimulate the economy (Q) during a recession or financial distress, this additional money supply will still seek investment opportunities. If the economy remains sluggish under these conditions, asset market prices may deviate from their fundamental values, thus creating a bubble phenomenon. During such periods of time, the price level becomes deflated due to reduced transaction velocity or loss of confidence (The Economist, 2013). This pattern was observed during the Great Recession following the subprime mortgage crisis and the implementation of various quantitative easing (QE) policies in the U.S. during the 2010s.

2.3 Related Literature

Grimaldi et al. (2009) compare the banking crises between Sweden and Japan in the early 1990s. They conclude that both countries experience asset price increases and credit expansion, but the land tax system of Sweden favors holding property. Additionally, the general guarantee of the Swedish government to the banking system successfully restored confidence in 1993 and limited the negative effects of the banking crisis compared to Japan. They also indicate that the labor shortage in Japan might be an underlying factor in its productivity problems, overlooked by the long-term macroeconomic policy. While they point out that inadequate and impromptu policies in Japan might have contributed to its prolonged recession, we argue that the economic scale and pressure from capital influx which caused currency appreciation are not comparable between these two countries.

Humpage and Shenk (2008) note that after several ineffective policy actions, the Bank of Japan (BoJ) implemented QE from March 2001 to March 2006. This tool, which replaced the zero-interest rate policy between February 1999 and August 2000, shifted the daily operating target from overnight rates to the level of current-account balances at banks. This action effectively increased the current accounts of the BoJ nine-fold. They suggest based on the experience of Japan that central banks can act more aggressively to provide downside risk premiums to the market as inflation and short-term rates approach zero. In contrast, Eggertsson and Ostry (2005) argue that the BoJ could have resumed targeting short-term interest rates instead of focusing on current accounts or base money. Both articles note that the BoJ failed to communicate and defend its policy intentions credibly. We argue that global deflation began with the 1997 Asian financial crisis and continued until 2002. Meanwhile, the severe acute respiratory syndrome (SARS) outbreak affected Asian countries from 2002 to 2003. Combined with the aging population and industrial exodus of Japan, monetary tools alone are likely insufficient to counter deflation.

Lin and Lin (2011) show that stock markets are integrated with real estate markets in Japan and partially integrated in Taiwan. Kim and Park (2016) find that regional housing price cycles in East Asia co-move with world housing prices. They show that domestic monetary and business-cycle effects are important in housing price cycles in China, Hong Kong, Japan, and Taiwan. In contrast, credit supply (monetary policy) is crucial for Korea. Their research confirms that money supply and economic growth in the Fisher equation are significant factors that affect housing prices.

Nagayasu (2017) discusses the Balassa-Samuelson theorem, which states that effective exchange rates are determined by real interest rate differentials or productivity differentials in traditional sectors. He concludes that the real effective exchange rate movements of most countries are driven by idiosyncratic rather than common factors, particularly in advanced countries after the subprime mortgage crisis. As a major global currency, the JPY became a hedging tool against the U.S. dollar (USD) in 2012 following the series of QE policies of the U.S.

In summary, previous studies conclude that both stock and real estate markets are interrelated and affected by macroeconomic policies and variables, including economic growth, money supply, and interest and exchange rates. Furthermore, the markets of countries with close trading partnerships tend to have similar cycles. Both conclusions support the rationale of this study for variable selection and market co-movements in Japan and Taiwan.

3. Narrative and Comparative Analyses of Economy and Real Estate Markets in Japan, Taiwan, and the U.S.

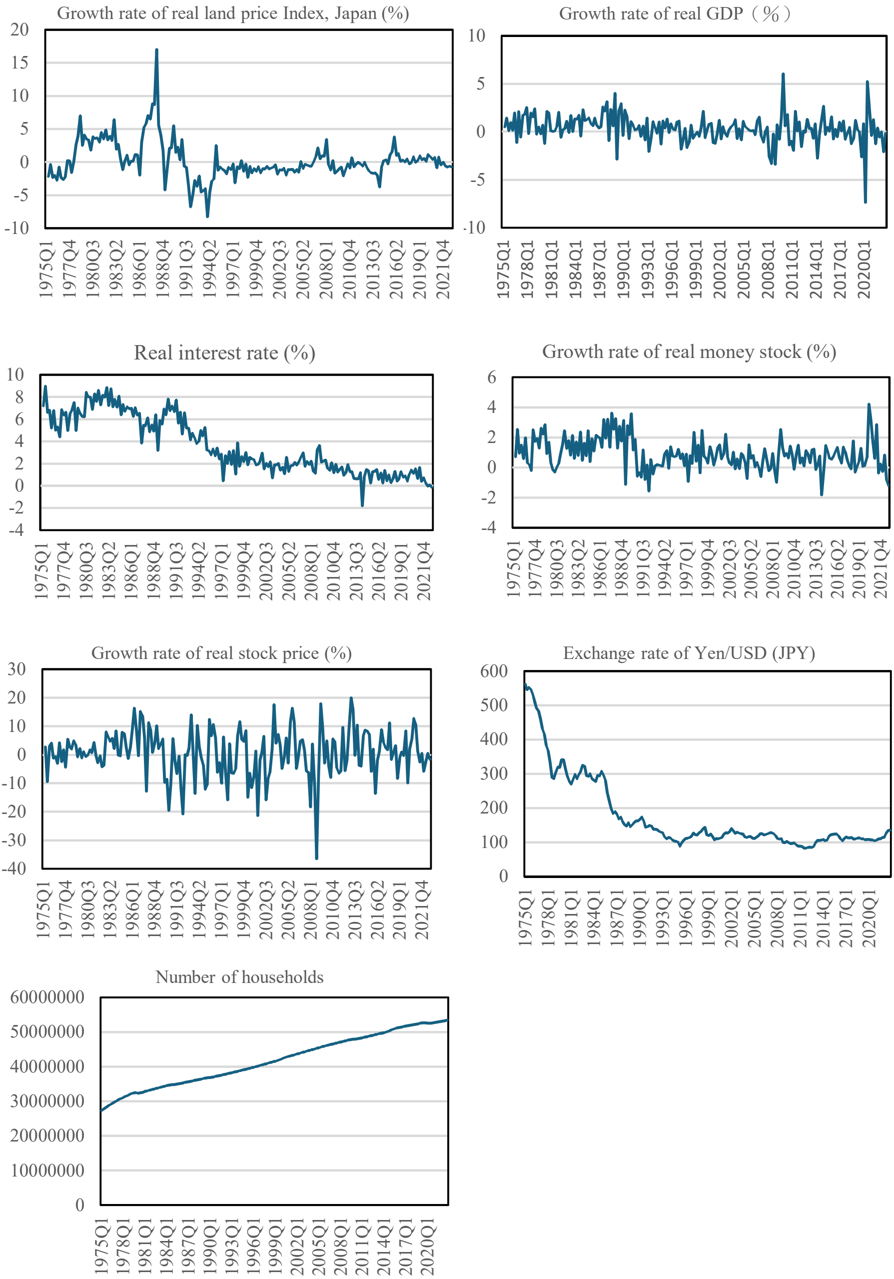
3.1 Economic Growth and Housing Markets: Japan

In the 1980s, Japan initiated a loose monetary policy through interest rate reduction, which lowered rates from 9% in 1980 to a record low of 2.5% in 1986 (as shown in Figure 2). Following The Plaza Accord in 1985, the money supply increased dramatically. This ample money supply and low-cost capital combination encouraged highly leveraged investments in stock and real estate markets. Figure 2 and Table 3 show the trends of variables to be examined in the empirical models in Japan and Taiwan, including the residential land or housing prices, gross domestic product (GDP) growth rates, real interest rates, change in money supply, stock index, exchange rates and the number of households. As shown in Figure 2, the stock market index of Japan rose seven-fold, from 5000 in 1980 to 35,000 in 1989. Similarly, the residential land price index in Tokyo increased 6-7 times during this decade.

Wood (1993) documents the remarkable surge in Japanese house prices. According to the Management and Coordination Agency, the property market value of Japan exceeded 2 quadrillion JPY[1] at the end of 1989, approximately four times the estimated 500 trillion JPY value of U.S. property. By early 1990, the real estate value of metropolitan Tokyo' was estimated to be equivalent to all real estate in the U.S.

[1] 1 USD = 143.7 JPY in December 1989

Figure 2 Trends of Variables in Japan (1975-2022)



To curb inflating housing prices, the BoJ implemented aggressive interest rate increases, and raised rates from 2.5% in 1989 to 6% in 1990, a 3.5 percentage point increase within a year. Simultaneously, the government introduced a consumption tax in 1989. These concurrent tightening measures in monetary and fiscal policies punctured the real estate bubble, which ultimately led to its collapse. The subsequent crash in both the stock and real estate markets triggered a cascade of defaults, which initiated financial deleveraging effects and a vicious cycle. This period marked the beginning of the Lost Decades of Japan and ushered in a prolonged recession in Japan.

3.2 Economic Growth and Housing Markets: Taiwan

As one of the NICs or Four Dragons, Taiwan followed the growth pattern of Japan from the 1970s to 1980s. Figure 3 shows the economy of Taiwan which accelerated in 1978 and maintained an average growth rate of 5%-15%. This rapid growth earned Taiwan the title of Economic Miracle. Similar to the currency appreciation pressure in Japan, Taiwan adopted a slow appreciation strategy to protect its export industry. The announcement of this strategy attracted more capital or hot money inflow. The NTD exchange rate rose from 1 USD/40 NTD in 1988 to 1 USD/26 NTD in 1992, or a 54% appreciation in 4 years. In line with the economic growth, the money supply (M1B) increased by 50% in 1989 to manage capital inflow. During this period of time, interest rates were cut from 13% in 1982 to 4.5% in 1988. The abundant and low-cost capital eventually drove up both the stock and real estate markets.

The stock and real estate markets peaked in 1990, which severely impacted housing affordability. Following the pattern in Japan, the Central Bank of Taiwan abruptly raised interest rates by 3% in 1990, as shown in Figure 3, which caused the stock index to plummet from 12,000 points to 2,000 points. House prices fell by approximately one-third, moderated by market rigidity and underlying economic fundamentals.

Examining the development of both the economies and real estate markets in Japan and Taiwan during the 1980s reveals similar patterns in economic growth, monetary policy, currency appreciation, and real estate price surges. Figure 4 illustrates the relationship between the two economies and housing markets. Based on these parallel developments, we examine the interrelation of the stock and housing markets between these two countries. Suppose the empirical results show cointegration or causality in the economic growth or real estate markets between Japan and Taiwan during specific periods (particularly the 1980s), regardless of later divergence. In that case, we can confirm that there is a flying geese pattern in economic and real estate market developments.

Figure 3 Trends of Variables in Taiwan (1975-2022)

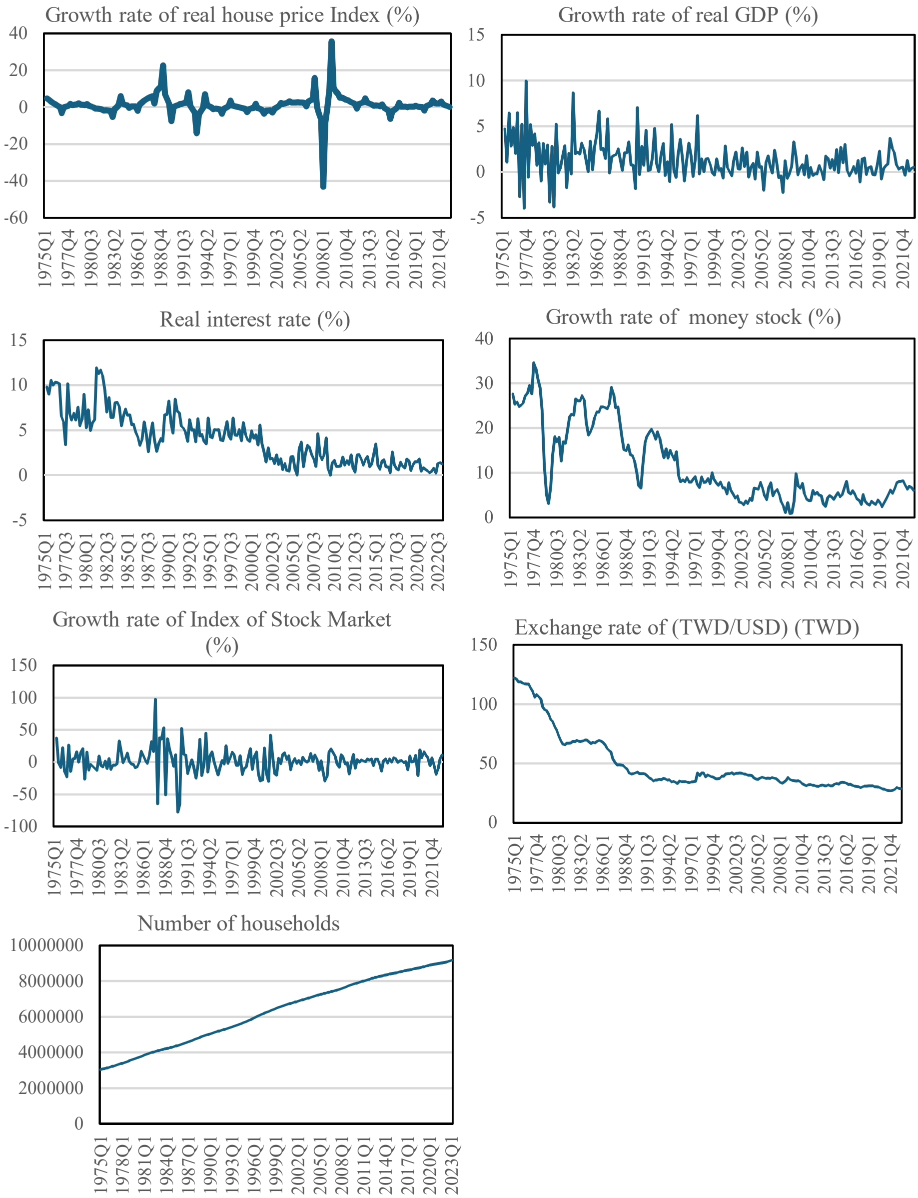
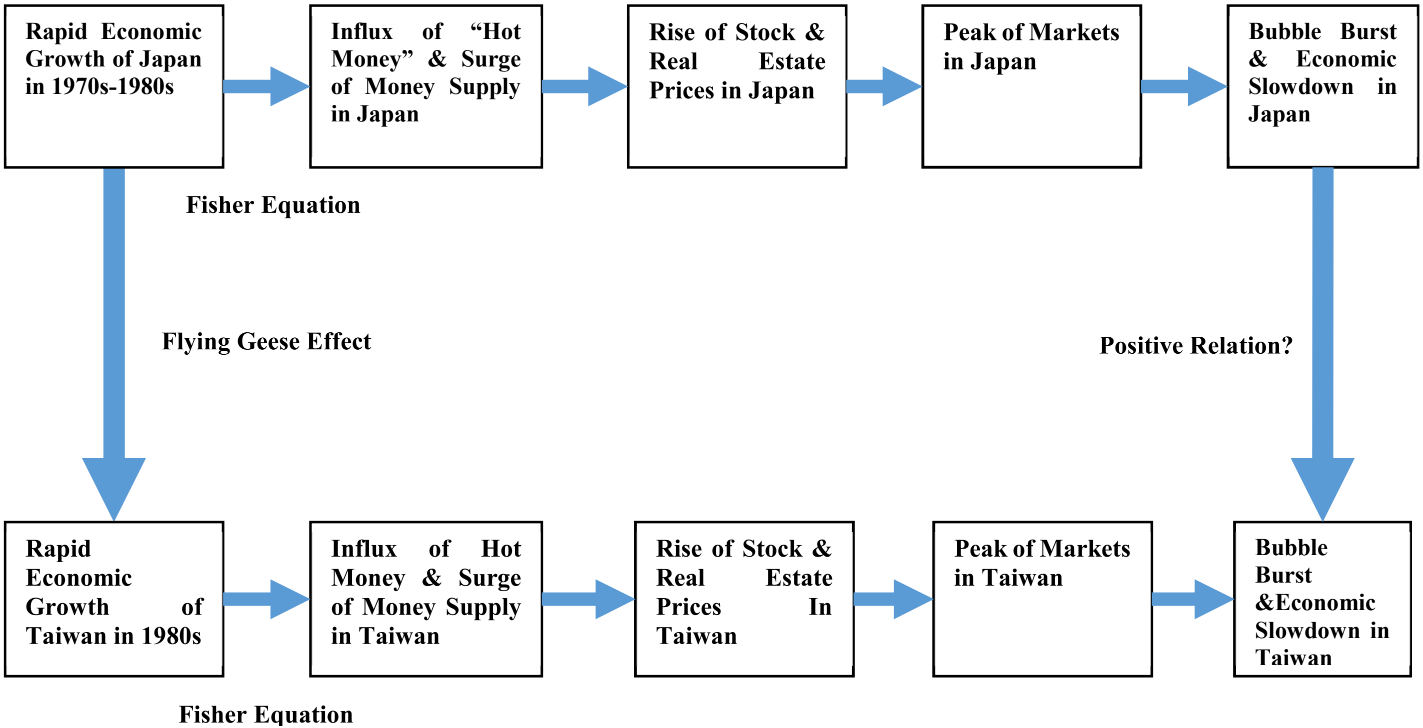


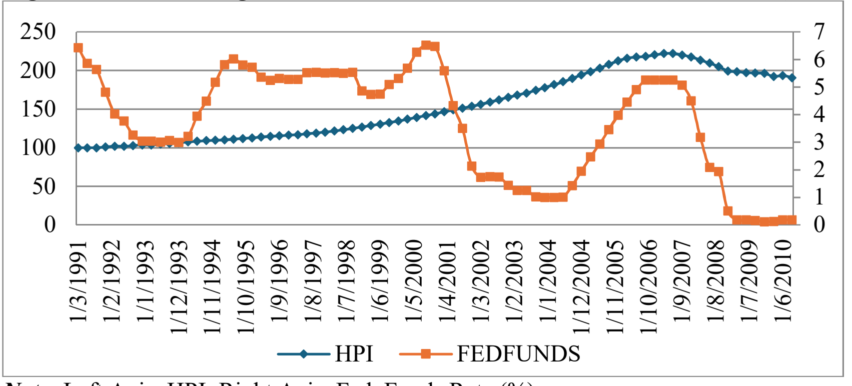
Figure 4 Interrelation of Economy and Real Estate Market between Japan and Taiwan



3.3 Experience of U.S. Subprime Mortgage Crisis as Comparison

The subprime mortgage crisis that erupted in 2008 in the U.S. can also explain for the real estate boom and bust in Japan. Figure 5 shows a sudden dive in interest rates from around 6% in 2001 to 1% in 2004, which led to the continuous growth of housing prices in the following years until 2008.

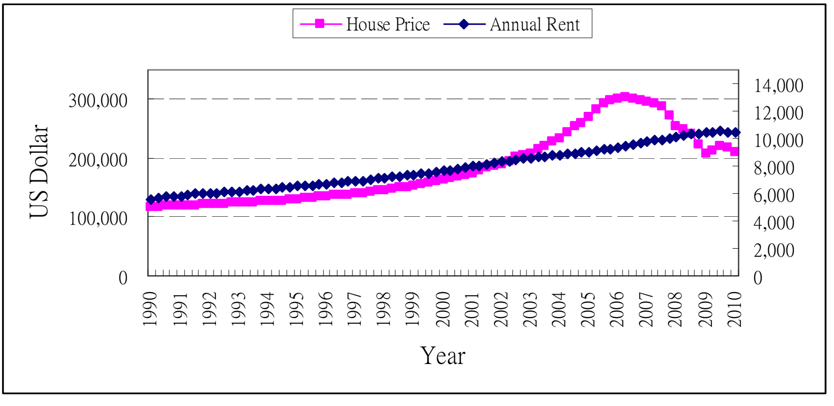
Figure 5 Housing Prices vs. Interest Rates in the U.S. (1990-2010)



Note: Left Axis: HPI; Right Axis: Fed. Funds Rate (%).
***Sources*:** Federal Housing Finance Agency Index[2]; Federal Reserve Bank[3]

Figure 6 indicates a housing price surge versus stable rent in the early 2000s. The deviated path of housing prices from stable annual rent from 2001 to 2006 implies the potential burst of the real estate bubble in the U.S.

Figure 6 Deviation of House Price from Rent in the U.S.



***Sources*:** Lincoln Institute of Land Policy.

[2] https://www.fhfa.gov/data/hpi
[3] https://www.federalreserve.gov

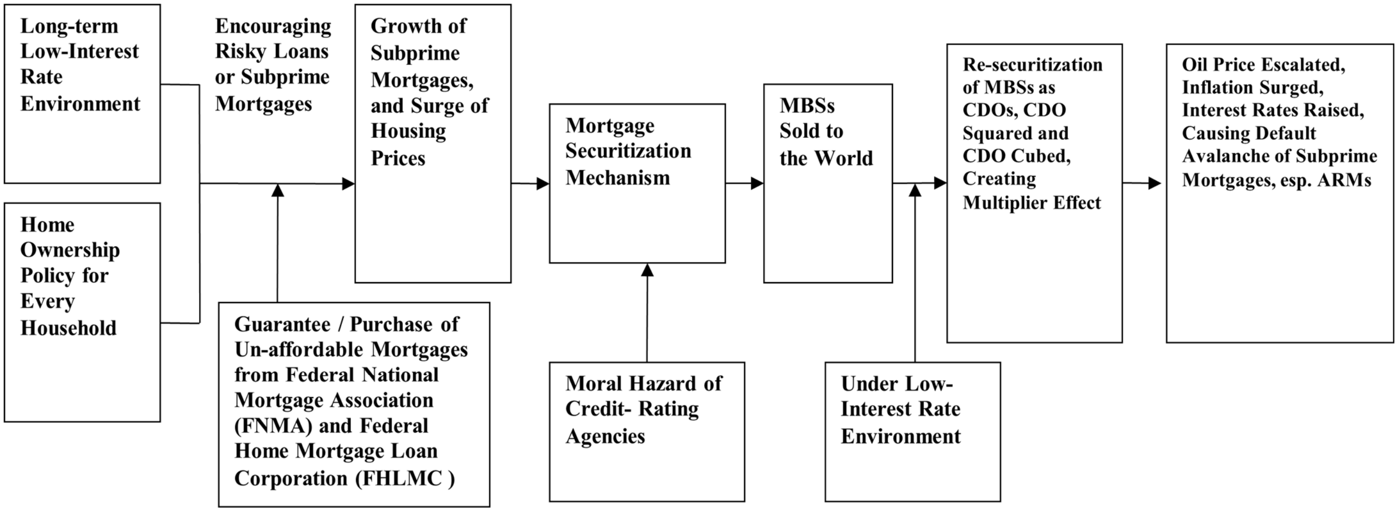
We illustrate in Figure 7 how subprime mortgages developed and low interest rates and home ownership policies in the U.S. drove house prices. Through a mortgage securitization structure that allowed the sale of mortgages with guarantees from government-sponsored entities (GSEs, i.e., Fannie Mae and Freddie Mac), the banking industries gradually loosened lending standards without proper due diligence. In a worldwide low interest rate (or deflation) environment, mortgage-related products were designed to attract global investors with high yields (and associated high risks), supported by reckless and short-sighted credit rating agencies (CRAs). The popularity of high-yield mortgage-related securities (MRSs) created unique roles for mortgage brokers, led to predatory lending practices, and sparked the re-securitization of mortgage-backed securities (MBSs, e.g., collateralized-mortgage obligations (CMOs), collateralized debt obligations (CDOs), CDO squared and cubed) in the U.S. The re-securitization process essentially involved collateralizing MBSs of a fixed-income nature and repeatedly attracting money from naive investors, thus creating a multiplier or leveraging effect. During the low-interest rate period, proceeds from mortgage security sales were reinvested in housing, which led to a rising spiral of housing and MRS prices.

As oil prices hit a record high of $126 USD per barrel in mid-2006, the Federal Reserve raised interest rates from 2% in 2006 to 6% in 2007 to curb increasing inflation. The surge in interest rates eventually impaired the affordability of mortgagors, especially for subprime adjustable-rate mortgages (ARMs), which led to a record high delinquency rate of 25% for subprime mortgages in 2008 (Rosen, 2009). As Coval et al. (2008) conclude, securities produced by structured finance activities have a far lower chance of surviving severe economic downturns than traditional corporate securities of equal rating. With MRSs sold worldwide, the collapse of the multiplier effect ultimately crashed the global financial markets.

3.4 Comparison of Boom and Bust of Housing Markets in Japan, Taiwan and the U.S.

From our previous discussion, the rise of Japan and Taiwan in the 1980s followed similar patterns: rapid economic growth which led to currency appreciation pressure and speculative influx of international capital. Both governments adopted slow appreciation strategies to protect their export industries while increasing the money supply to manage speculative capital. The combination of increased money supply and capital influx eventually drove up equity and real estate prices.

Figure 7 Causes and Development of Subprime Mortgage Crisis



***Source*:** Drawn by authors.

The surge in U.S. house prices in the early 2000s stemmed from different factors: government homeownership policies that supported subprime buyers through low interest rates, the guarantees of GSEs on subprime mortgages, and the relaxed lending standards of banks. The government incorrectly assumed markets could absorb all of the risks. In the low-interest rate or deflationary environment of the early 2000s, MRSs were readily sold to domestic and international markets due to their high yields. Proceeds from the MRSs were reinvested in real estate and mortgages, which created a multiplier or leveraging effect.

As oil prices escalated in 2006, inflation pressure mounted accordingly. The Federal Reserve Board raised rates sharply from 1% in 2005 to 6.5% in 2007 (Figure 5), thus triggering increased default rates. The average default rate for ARMs exceeded 50%. The surge in subprime mortgage defaults ultimately crashed the markets, which led to a global financial tsunami.

While different factors contributed to the housing booms in Japan/Taiwan versus those of the U.S., rising interest rates commonly triggered their busts. The 1990 bubble burst in Japan led to the Lost Decades. In the U.S., the subprime mortgage crisis erupted after interest rates surged, prompting the Federal Reserve Board to initiate a QE policy in early 2009. In summary, Japan and Taiwan experienced an economy-driven surge, while the U.S. underwent a policy-driven surge. The sharp rise in interest rates was the common factor in deflating these real estate markets. These experiences offer valuable lessons for policymakers.

3.5 Analyses and Objectives

Based on the previous discussion, we examine whether the macroeconomic and demographic factors (economic growth, exchange rates, money supply, interest rates, stock markets), and number of households) affected the residential land or housing prices of Japan and Taiwan. Given the similar patterns of economic and housing market growth in Japan and Taiwan before 1990, we develop the following two objectives:

(i) to determine whether the economy or stock market of Japan led that of Taiwan from 1975 to 2023 or during other specific periods. Specifically, to determine whether the flying geese pattern occurred and when the two economies diverged, and

(ii) to determine whether the housing prices in Japan led that of Taiwan, and when they diverged. In other words, to determine if the flying geese pattern manifested in the real estate markets between Japan and Taiwan during the 1980s before the peak in 1990.

4. Data and Methodology

4.1 Variables

Table 1 presents the variables employed in our model, including GDP, House Price, Exchange Rate, Money Supply, Stock Price, Interest Rate and the Number of Households. According to the Fisher equation, GDP and Money Supply are crucial elements that affect asset prices. As the economies of Japan and Taiwan accelerated in the 1980s, capital flight triggered surges in exchange rates and asset prices. Since the stock market often serves as a window of the economy, it reasonably acts as an economic proxy. Interest rate policy typically complements money supply as a monetary policy tool. For real living demand for housing, the number of households has been increasing during the sample period, which is based on the population census conducted every five years in Japan. These variables in Japan and Taiwan are quadratically imputed to the yearly time series and then imputed again to the quarterly time series. Monetary variables are all deflated by the consumer price index to make them real terms.

4.2 Models

4.2.1 Conditional Error Correction Models

To explain the dynamics of the economy or markets in Japan and Taiwan, we estimate the models of their stock and housing prices to examine their relationships.

First, we estimate the autoregressive distributed lag (ARDL) models to test the stock markets. The ARDL model describes the dynamic relationship between housing prices and the explanatory variables as follows:

$$y_t = \alpha + \sum_{i=1}^{k}\sum_{j=0}^{p_k} x'_{i,t-j}\beta_{ij} + \sum_{j=1}^{p} \gamma_j y_{t-j} + \Phi_t\delta + \epsilon_t \tag{1}$$

where y_t is the housing price and x'_{t-j} is the jth lagged vector of the explanatory variables, and y_{t-j} is the jth lagged dependent variables, Φ_t includes the deterministic factors such as seasonal dummies, and ϵ_t is a stochastic error term. α is a constant term, β_{ij} is the coefficient of the jth lagged term of the ith explanatory variable, and γ_j is the coefficient of the jth lagged dependent variable. We estimate the models and choose the number of lags based on the Akaike information criterion (AIC).

Second, from the ARDL model, the cointegrating relationship of the variables under the assumption of the stationary state of the variables $y_t = y_{t-1} = \cdots = y_{t-p} = y^*$ and $x'_t = x'_{t-1} = \cdots = x'_{t-p} = x'^*$.

$$y^* = \theta_0 + \theta_1 x'^* \tag{2}$$

where $\theta_0 = \alpha/\phi$ and $\theta_{1i} = \left(\sum_{j=0}^{p_i}\beta_{ij}\right)/\phi$, $\phi = 1 - \sum_{j=1}^{p}\gamma_j$ are the cointegration parameters.

Table 1 Source of Data of Variables for Japan and Taiwan

Variable	Code	Unit and Explanation	Source	Country
Δy_{jp}	Real GDP	Growth rate of real GDP (2020 prices), %	Cabinet Office, Japan	Japan
Δy_{tw}	Real GDP	Growth rate, %	Directorate General of Budget, Accounting and Statistics, Executive Yuan, Taiwan	Taiwan
Δp_{jp}	Land price index, Japan	Growth rate of real national land price index of 2020 prices (2020=1) , %	Ministry of Land, Infrastructure, Transport and Tourism, Japan	Japan
Δp_{tw}	House Price Index, Taipei	House Price Index	Sinyi Housing Price Index[1], Journal of Housing Studies[2]	Taiwan
E_{jp}	Ex. Rate	Exchange rate of JPY/USD (2020)	Bank of Japan	Japan
E_{tw}	Ex. Rate	Exchange rate of NTD/USD	Central Bank, Taiwan	Taiwan
Δm_{jp}	M2	Growth rate of average ending balance of real money stock (M2+CD until March 2008, M2 after April 2008, 100 million in 2020 prices) , %	Bank of Japan, Times Series Data Search	Japan
Δm_{tw}	M2	Growth rate of real money stock, %	Directorate General of Budget, Accounting and Statistics, Executive Yuan, Taiwan	Taiwan
Δs_{jp}	Stock	Growth rate of Index of Stock Market 2020 prices (2020=1) , %	Nikkei 225 Indexes	Japan
Δs_{tw}	Stock Price	Taiwan Weighted Stock Index	Goodinfo![3]	Taiwan

(*Continued…*)

(Table 1 Continued)

Variable	Code	Unit and Explanation	Source	Country
ri_{jp}	Real interest rate	Prime rate – CPI growth rate, %,	Bank of Japan, Times Series Data Search	Japan
ri_{tw}	Real interest Rate	Rediscount Rate, %	Central Bank, Taiwan	Taiwan
H_{jp}	Number of households	Number of households	Population Census, Japan	Japan
H_{tw}	Number of households	Number of households		Taiwan

***Notes*:** Uppercase letters of variables indicate level of the variables and lowercase letters indicate level of logarithm of the variables 1. https://www.sinyinews.com.tw/quarterly (in Chinese), 2. Chang et al. (2008). *Journal of Housing Studies,* 17(2): 13-34. 3. Taiwan Stock Market Info. Network, https://goodinfo.tw/tw/index.asp (in Chinese).

Finally, by using those parameters and noting that $\triangle y_t = y_t - y_{t-1}$, and $\Delta x_t = x_t - x_{t-1}$, we can derive the conditional error correction model (CECM) from the ARDL model.

$$\Delta y_t = \phi\theta_0 - \phi y_{t-1} - \phi\theta_1 x'_{t-1} + \sum_{j=1}^{p_k} \Delta x'_{t-j}\beta_{t-j} + \epsilon_t \tag{3}$$

$$\Delta y_t = -\phi[y_{t-1} - \theta_0 - \theta_1 x'_{t-1}] + \sum_{j=1}^{p_k} \Delta x'_{t-j}\beta_{t-j} + \epsilon_t \tag{4}$$

where $\phi = \left(1 - \sum_{j=1}^{p} \gamma_j\right)$ is the error correction parameter and the terms in the brackets are the cointegration relationship $y^* = \theta_0 + \theta_1 x'^*$. We test the hypothesis of cointegration via a bounds test (Pesaran et al. 2001), which is available under the situation where it is not certain whether the explanatory variables are I(0) or I(1).

4.2.2 Vector Autoregression Models

To test the relation between the housing markets in Japan and Taiwan, we estimate the bivariate vector autoregression (VAR) models of stock prices, GDP, and housing prices of Japan and Taiwan.

$$y_{1t} = \sum_{j=1}^{p1} \alpha_{1j} y_{1,t-j} + \sum_{k=1}^{p2} \alpha_{1k} y_{2,t-k} + v_{1t} \tag{5}$$

$$y_{2t} = \sum_{j=1}^{q1} \alpha_{2j} y_{2,t-j} + \sum_{k=1}^{q2} \alpha_{2k} y_{2,t-k} + v_{2t} \tag{6}$$

where y_{1t} is the Japanese data and y_{2t} is the Taiwanese data. When we test the hypothesis of Granger causality from Taiwanese data on Japanese data, we test the hypothesis of $H_0\!: \alpha_{1k} = 0\ (k = 1, \cdots, p_2)$. When we test the Granger causality from Japanese to Taiwan, we test the hypothesis of $H_0\!: \alpha_{2j} = 0\ (j = 1, \cdots, q_1)$. Impulse response functions are also calculated.

5. Results of Analysis

5.1 Descriptive Statistics

Table 2 shows the descriptive statistics of the variables in Japan and Taiwan. Some interesting features of the factors regarding the housing markets are worth noting. The maximum and minimum real GDP growth during the sample period in Japan are 6.05% and -7.36%, respectively. This wide variance could imply its change in real land price index of a maximum of 17% and minimum of -8.26%. In Taiwan, the fluctuation of the housing market is more volatile than that of Japan, especially during the 2008 U.S. subprime mortgage markets. The maximum and minimum changes in the Taiwanese housing market are 38.66% and -42%, respectively. This drastic fluctuation was caused by the impact of 2008 U.S. subprime mortgage crisis and the global financial tsunami, and then the implementation of the increased money supply, i.e., the QE monetary policy (see Figure 3).

Table 2 Descriptive Statistics of Variables in Japan and Taiwan (1975-2022)

Variable	Mean	Std. Dev.	Maximum	Minimum
(a) Japan				
Real Land Price Index (national growth rate %)	0.205	2.817	17.037	-8.264
Real GDP (growth %)	0.370	1.448	6.051	-7.364
Real Interest Rate (%)	3.586	2.609	8.958	-1.795
Real M2 (growth %)	0.899	1.036	4.210	-1.824
Real Stock Price (growth %)	0.663	8.133	19.985	-36.513
Real Exchange Rate (JPY/USD)	172.4	105.4	552.0	83.1
Number of Households	42,042,443	7,349,301	53,646,582	27,729,976
(b) Taiwan				
Real House Price Index (national growth rate %)	0.467	5.675	38.667	-42.028
Real GDP (growth %)	1.290	2.036	9.943	-3.951
Real Interest Rate (%)	3.947	2.830	11.931	-0.006
Real M2 (growth %)	11.506	8.417	34.600	0.890
Real Stock Price (growth %)	1.556	18.940	97.617	-77.614
Real Exchange Rate (TWD/USD)	47.8	23.4	120.9	26.9
Number of Households	6,323,544	1,869,283	9,215,479	3,064,685

5.2 Analysis of Stationarity—The Unit Roots Tests

The results of the unit root tests with the method in Elliott et al. (1992) of the variables in this study are summarized in Tables A1 and A2. Table A1 shows the results of the Taiwan data. Table A2 is for the Japanese data based on the entire sample. We also conduct the same tests for the pre-bubble and post-bubble periods of Japan, respectively and find that the results do not change so they are omitted here.

5.3 Empirical Results of Japan

5.3.1 CECM Model—Factors on the Residential Land Price in Japan

The empirical result of the CECM for the entire sample period (1975-2023) of factors on the residential land price in Japan is shown in Table 3. Two estimated models are tabulated after the estimation of several models to choose the appropriate lag length. Model 1 is the full lag model that sets the lag length $p_k = 2$. Model 2 is the parsimonious lag model, which is selected through the AIC from 62,500 models. However, the error term of this model contains heteroskedasticity from the Breusch-Pagan-Godfrey (BPG) statistics (Breusch and Pagan, 1980) and higher order autocorrelations from the statistics in Ljung and Box (1980). Therefore, the standard errors of the model are calculated from the heteroskedasticity and autocorrelation consistent estimators (Bartlett, kernel and Newey-West fixed bandwidth=5.0). Model 2 does not show the specification error from the specification error test (RESET(2)) in Ramsey (1969), so we select the parsimonious lag model to discuss hereafter. After a preliminary estimation of the models, we find that there are parameter changes from 1988Q2 to 1989Q2. Therefore, we include the dummy variable called Bubble taking 1 between these periods.

The empirical results of the model are explained as follows, and the results of the robustness tests are provided in the Appendix and shown in Figures A and B.

a. Land price (LP) versus its previous term LP (-1): The results show that the land price is negatively related to the price of the previous term, thus indicating that the adjustment speed -3.2% of the error of the previous quarter can be corrected.

b. $\Delta\, p_{jp,t-1}, \Delta\, p_{jp,t-2}, \Delta\, p_{jp,t-3}$: The results are all positive and significant, which indicate that the change in LP is positively correlated with the previous 3-quarters of land price change. This result is consistent with the long-term trend of decline and sluggishness in the land market, especially after the period with the burst of the bubble.

c. Real interest rate change rate - the coefficient of the current term $\Delta\, ri_{jp,t}$ of 0.0063 and the term lagged one quarter of 0.0056: The results are both positive and significant, thus reflecting the deflation trend and liquidity trap situation. The reduction of the current and previous terms of the prime rate led to the decline of land prices due to the lack of investment confidence or profitable opportunity.

d. The second difference of the money supply $\Delta^2\, m_{jp,t}$ and $\Delta^2\, m_{jp,t-1}$: The results show that the current growth of M2 has a positive but insignificant effect on the land price, but its previous term has a significantly negative (-0.4765) influence on the land price. This result shows that the growth of

M2 has a positive but insignificant effect on the land price due to the lack of purchasing power or confidence in investment. Furthermore, the lack of confidence or purchasing power, or the pessimism, exceeds the effect of the M2 growth in the previous term, which caused the land prices to dive lower.

e. D(Bubble): The bubble burst has a negative (-0.048) and significant effect on the land price, which is consistent with the market trend in Japan.

Table 3 Results of Factors on Residential Land Price in Japan (CECM Model, 1975Q4-2023Q2, 191 obs., Lag 4 by AIC)

	Model 1		Model 2	
Variable	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
$p_{jp,t-1}$	-0.0271*	0.014	-0.0324***	0.011
$y_{jp,t-1}$	-0.0096	0.051	0.0231	0.040
$ri_{jp,t-1}$	0.0002	0.002	0.0017	0.002
$\Delta\, m_{jp,t-1}$	0.5145*	0.263	0.6379***	0.209
$s_{jp,t-1}$	0.0180***	0.005	0.0167***	0.004
$e_{jp,t-1}$	-0.0265**	0.012	-0.0237***	0.009
$h_{jp,t-1}$	-0.0638*	0.035	-0.0720**	0.028
Constant	1.3847**	0.583	1.0810**	0.479
$\Delta p_{jp,t-1}$	0.4043***	0.076	0.4110***	0.072
$\Delta p_{jp,t-2}$	0.2910***	0.083	0.2830***	0.078
$\Delta p_{jp,t-3}$	0.1390*	0.079	0.1372*	0.073
$\Delta y_{jp,t}$	0.0193	0.095		
$\Delta y_{jp,t-1}$	0.0590	0.103		
$\Delta y_{jp,t-2}$	0.1106	0.098		
$\Delta y_{jp,t-3}$	0.1603*	0.096		
$\Delta ri_{jp,t}$	0.0053*	0.003	0.0063***	0.002
$\Delta ri_{jp,t-1}$	0.0067**	0.003	0.0056**	0.003
$\Delta ri_{jp,t-2}$	0.0020	0.003	0.0017	0.003
$\Delta ri_{jp,t-3}$	-0.0050*	0.003	-0.0037**	0.002
$\Delta^2 m_{jp,t}$	0.4015*	0.204	0.2809	0.181
$\Delta^2 m_{jp,t-1}$	-0.3107	0.254	-0.4765**	0.206
$\Delta^2 m_{jp,t-2}$	-0.1157	0.224	-0.3043	0.187
$\Delta^2 m_{jp,t-3}$	0.1684	0.212		

(*Continued...*)

(Table 3 Continued)

Variable	Coefficient	Std. Error	Coefficient	Std. Error
$\Delta s_{jp,t}$	0.0067	0.015		
$\Delta s_{jp,t-1}$	0.0057	0.016		
$\Delta s_{jp,t-2}$	-0.0128	0.016		
$\Delta s_{jp,t-3}$	-0.0143	0.016		
$\Delta e_{jp,t}$	-0.0427	0.028		
$\Delta e_{jp,t-1}$	0.0149	0.029		
$\Delta e_{jp,t-2}$	-0.0308	0.027		
$\Delta e_{jp,t-3}$	0.0226	0.029		
$\Delta h_{jp,t}$	-0.7657	1.191		
$\Delta h_{jp,t-1}$	0.1846	1.340		
$\Delta h_{jp,t-2}$	0.0676	1.346		
$\Delta h_{jp,t-3}$	-0.1362	1.188		
Q1	-0.0029	0.005	-0.0036	0.005
Q2	0.0008	0.004	0.0011	0.004
Q3	0.0030	0.005	0.0024	0.005
Bubble	-0.0523***	0.010	-0.0481***	0.009
N	187		187	
Adj. R2	0.7470		0.7601	
SE	0.0143		0.0139	
AIC	-5.4722		-5.5984	
DW	1.8610		1.9116	
Bound	2.7778		4.9880	
BPG	77.0474	0.000	68.7735	0.000
Ljung-Box Q(1)	0.8918	0.345	0.3543	0.552
Ljung-Box Q(2)	1.4687	0.480	1.2847	0.526
Ljung-Box Q(3)	1.5412	0.673	1.3824	0.710
Ljung-Box Q(4)	19.4137	0.001	22.0200	0.000
RESET(2)	4.2010	0.017	2.0394	0.133

Notes: (1) $\Delta = 1 - L$, where L is the lag operator. ***, **, and * represent 1%, 5%, and 10% significance. The observation period is 1975Q4 to 2023Q2, N=192. Seasonal dummies are included. This model is selected through the AIC from 62,500 models. (2) Standard errors in the parentheses are heteroskedasticity and autocorrelation consistent estimators are shown (Bartlett, kernel and Newey-West fixed bandwidth = 5.0). Numbers in the brackets are p-values. (3) Bound test statistic is 4.988023, significant at the 1% level. This indicates that a cointegration relationship exists between variables.

5.3.2 Cointegration Relationship Analysis

The cointegration relationship illustrates the long-term relationship between variables. The result of the analysis is shown in Table 4 and explained as follows.

a. GDP (0.713, insignificant): The GDP positively affects the land price level in the long run with a weak effect. This result is plausible as the affordability of the investment and confidence were reduced after the bubble burst.
b. Prime rate (-1) (0.051, insignificant): The interest rate in Japan was close to zero for an extended period of time after the bubble burst, which lost its policy effect and fell into a liquidity trap situation.
c. D M2(-1) (19.662, significant): The long-term land price was positively affected by the growth of M2, which is consistent with the principle of demand, holding other factors constant. This result also shows that even though the interest rate lost its effect, the magnitude of the effect of the monetary supply is still a valid policy tool in the real estate market.
d. Stock (0.513, significant): The stock and real estate markets usually moved in the same direction for that period of time, which was a longer period, due to the effect of having the same macro economy and monetary environments. Both these asset markets in Japan moved in the same direction before and after the bubble burst, as shown in Figure 2.
e. Exchange rate (-0.729, significant): The long-term land price was affected by the capital flow. This result shows that the capital outflow led the JPY to depreciate (i.e., the USD to rise), and thus land price to depreciate.
f. Household (-2.220, significant): The land price continued to decline due to the effect of the burst bubble, despite increasing household numbers. The declining trend turned the demand of household for buying to renting and resulted in a decline in confidence and demand for house purchases.

Table 4 Results of Cointegration Relationship from ECM for Japan

Variable	Coefficient	Std. Error	t-Statistic
$y_{jp,t}$	0.7129	(1.072)	0.665
$ri_{jp,t-1}$	0.0514	(0.044)	1.160
$m_{jp,t-1}$	19.6627**	(8.994)	2.186
$s_{jp,t}$	0.5134***	(0.173)	2.960
$e_{jp,t}$	-0.7290**	(0.354)	-2.060
$h_{jp,t}$	-2.2202***	(0.698)	-3.180
Constant	33.3191*	(20.139)	1.654

***Notes*:** Bound test result is 4.988023, which is significant at the 1% level. This indicates that a cointegration relationship exists between variables.

5.4 Empirical Results of Taiwan

5.4.1 CECM model—Factors on the Housing Prices in Taiwan

The empirical result of the CECM for the entire sample period (1975-2023) of factors on the residential land price in Taiwan is shown in Table 5. Two estimation models are tabulated like the Japan model. Model 1 is the full lag model that sets the lag length $p_k = 4$. Model 2 is the parsimonious lag model selected through the AIC from 62,500 models. However, the error term of these models contains heteroskedasticity from the BPG statistics and autocorrelations from the statistics of Ljung and Box (1980). Therefore, in the Taiwan model, the standard errors of those models are calculated from the heteroskedasticity and autocorrelation consistent estimators (Bartlett, kernel and Newey-West fixed bandwidth = 5.0). Model 2 shows a smaller specification error from the specification error test (RESET(2)) of Ramsey (1969) compared to the full lag model; we selected the parsimonious lag model as the model to discuss later. The empirical results are explained as follows. After a preliminary estimation of the models, we find that there are parameter changes from 2008Q1 to 2008Q4, which is the period of the global financial crisis. Therefore, we include a dummy variable called D2008 taking 1 between these periods.

a. House price (HP) versus its previous term HP (-1): The results show that house price is negatively related to the price of the previous term, thus indicating that the adjustment speed (11-12)% of the error of the previous quarter can be corrected.
b. $\Delta\, p_{tw,t-1}, \Delta\, p_{tw,t-2}, \Delta\, p_{tw\,,t-3}$: The results are all positive and significant, thus indicating that house price change is positively correlated with the previous 3-quarters of house price change in Taiwan. This result implies that the change in the house prices of Taiwan provides a good reference for the next period, which shows a herd behavior trend in the housing market.
c. Real interest rate change rate - the coefficient of the current term $\Delta\, ri_{tw,t}$ of -0.008 and the term lagged one quarter of 0.008): The results show that the change in interest rates in Taiwan took into account the boom or bust of the housing markets. Therefore, the magnitude of the change in interest rates is uncertain. This result also indicates that the interest rate policy is still a valid tool to adjust the real estate market prices.
d. The second difference of the money supply $\Delta^2\, m_{tw,t}$: The results show that the current growth of M2 has a positive (0.6549) and significant effect on the house prices. This result shows that the monetary supply still plays an important role in driving real estate prices in Taiwan. This result is consistent with the interest rate in Taiwan, but different from that of Japan.
e. D(2008): 2008 had a negative (-0.163) and significant effect on the house prices in Taiwan. There are two reasons. First, the presidential election in early 2008 provided high expectations towards the economy and optimism to the investors. Second, the market euphoria was destroyed by the subsequent global financial crisis, which caused the housing market to turn sluggish after 2008.

Table 5 Results of CECM Analysis of Taiwan

	Model 1		Model 2	
Variable	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
$p_{tw,t-1}$	-0.1250***	0.020	-0.1141***	0.017
$y_{tw,t-1}$	-0.6039***	0.115	-0.5869***	0.100
$ri_{tw,t-1}$	-0.0149***	0.005	-0.0158***	0.004
$\Delta m_{tw,t-1}$	0.2850**	0.135	0.1465	0.096
$s_{tw,t-1}$	0.1031***	0.020	0.0979***	0.017
$e_{tw,t-1}$	-0.0106	0.038	-0.0244	0.034
$h_{tw,t-1}$	1.2268***	0.222	1.1142***	0.202
Constant	-10.3074***	2.084	-8.7145***	1.862
$\Delta p_{tw,t-1}$	0.2863***	0.075	0.2879***	0.071
$\Delta p_{tw,t-2}$	0.0399	0.079	0.0276	0.075
$\Delta p_{tw,t-3}$	-0.2404***	0.075	-0.2395***	0.070
$\Delta y_{tw,t}$	0.2897	0.235	0.2600	0.223
$\Delta y_{tw,t-1}$	0.6880***	0.262	0.6713***	0.249
$\Delta y_{tw,t-2}$	0.7091***	0.263	0.7435***	0.238
$\Delta y_{tw,t-3}$	0.5309**	0.259	0.3695*	0.199
$\Delta ri_{tw,t}$	-0.0086**	0.004	-0.0080**	0.004
$\Delta ri_{tw,t-1}$	0.0067	0.005	0.0080**	0.003
$\Delta ri_{tw,t-2}$	0.0017	0.004		
$\Delta ri_{tw,t-3}$	0.0008	0.003		
$\Delta^2 m_{tw,t}$	0.7021***	0.237	0.6549***	0.188
$\Delta^2 m_{tw,t-1}$	-0.1249	0.254		
$\Delta^2 m_{tw,t-2}$	0.0131	0.258		
$\Delta^2 m_{tw,t-3}$	-0.2289	0.233		
$\Delta s_{tw,t}$	0.0051	0.021	0.0138	0.020
$\Delta s_{tw,t-1}$	-0.0824***	0.025	-0.0655***	0.022
$\Delta s_{tw,t-2}$	-0.0493**	0.023	-0.0347*	0.020
$\Delta s_{tw,t-3}$	-0.0336	0.021		
$\Delta e_{tw,t}$	0.2598**	0.131	0.2504**	0.126
$\Delta e_{tw,t-1}$	-0.0738	0.136		
$\Delta e_{tw,t-2}$	-0.1930	0.139		
$\Delta e_{tw,t-3}$	-0.0314	0.135		
$\Delta h_{tw,t}$	0.2226	8.080	7.9271**	3.915
$\Delta h_{tw,t-1}$	10.6326	9.647		
$\Delta h_{tw,t-2}$	0.7471	10.254		
$\Delta h_{tw,t-3}$	-1.5061	8.335		
Q1	-0.0001	0.011	0.0052	0.009
Q2	-0.0043	0.011	-0.0006	0.010
Q3	-0.0036	0.011	0.0018	0.010
D2008	-0.1747***	0.033	-0.1630***	0.031
N	188		189	

(*Continued...*)

(Table 5 Continued)

Variable	Coefficient	Std. Error	Coefficient	Std. Error
Adj. R2	0.440471		0.457965	
SE	0.04293		0.042145	
AIC	-3.276089		-3.363841	
DW	1.721096		1.777599	
Bound	7.020101		7.678066	
BPG	76.13964	0.0001	74.18996	0.000
Ljung-Box Q(1)	3.6674	0.055	2.3637	0.124
Ljung-Box Q(2)	8.5466	0.014	7.9691	0.019
Ljung-Box Q(3)	18.593	0.000	17.106	0.001
Ljung-Box Q(4)	44.322	0.000	45.378	0.000
RESET(2)	4.060	0.019	2.562	0.080

***Notes*:** (1) $\Delta = 1 - L$, where L is the lag operator. ***, **, and * represent 1%, 5%, and 10% significance. The observation period of Model 1 is 1976Q1 to 2023Q2, N=191. Seasonal dummies are included. This model is selected through the AIC from 62,500 models. (2) Standard errors in the parentheses are heteroskedasticity and autocorrelation consistent estimators are shown (Bartlett, kernel and Newey-West fixed bandwidth = 5.0). Numbers in brackets are p-values. (3) Bound test statistic is 7.6781 which is significant at the 1% level. This indicates that a cointegration relationship exists between the variables.

5.4.2 Cointegration Relationship Analysis

The cointegration relationship analysis results are provided in Table 6 and elaborated as follows:

a. GDP (-5.142, significant): The house prices are negatively related to the GDP growth. This result shows that house prices continue to appreciate in the long run while GDP growth is flattened. This result explains that the house prices are more driven by investment demand than the economic fundamentals. The consistency of the long-term trend of the housing and stock markets can also explain for this relation.
b. Prime rate (1)(-0.138, 1% significance): The interest rates in Taiwan are negatively related to the long-term house prices. This result shows that the loose monetary policy and low capital cost contribute to the increase in house prices, consistent with the result in Lin et al. (2019).
c. Stock (0.858, significant): The stock and housing markets also move in the same direction over a long period of time in Taiwan due to the effect of the same macroeconomic environment and investment demand. The wealth effect from the stock market to the housing market can also explain for this positive relation. Both asset markets in Taiwan move in the same direction before and after the bubble burst, as shown in Figure 3.
d. Exchange rate (-0.21, insignificant): Similar to Japan, the long-term house prices are affected by the capital flow, but the effect is insignificant. This result also explains the relation between the capital amount and asset prices.

e. Household (9.76, significant): The long-term house prices are positively related to the household number, thus indicating the real demand for home ownership in Taiwan.

Table 6 Results of cointegration relationship derived from ECM for Taiwan

Variable	Coefficient	Std. Error	t-Statistic
$y_{tw,t}$	-5.1419***	(0.646)	-7.963
$ri_{tw,t-1}$	-0.1383***	(0.035)	-3.969
$m_{tw,t-1}$	1.2836	(0.826)	1.555
$s_{tw,t}$	0.8580***	(0.112)	7.682
$e_{tw,t}$	-0.2135	(0.299)	-0.713
$h_{tw,t}$	9.7628***	(1.236)	7.900
Constant	-76.3558***	(12.157)	-6.281

***Notes*:** The bound test statistic is 3.574548, which is significant at the 5% level. This indicates the existence of a cointegration relationship between the variables.

5.5 Granger Causality Analysis — Performance of Stock Markets between Japan and Taiwan

To examine the lead-lag relationship between the economies of Japan and Taiwan, we use stock market performance as a proxy for economic activity and Granger causality tests. Table 7 shows the results for three periods: (1) the entire sample period (1975-2023), (2) the pre-bubble period (1975-1990), and (3) the post-bubble period (1991-2023). The results indicate that the stock market in Japan led that of Taiwan (p-value = 0.0043) but not vice versa (p-value = 0.1787) for the entire sample period. This finding confirms the flying geese pattern, thus demonstrating the economic leadership of Japan over Taiwan from 1975 to 2023. This result also explains for the close relationship between Japan and Taiwan, as Taiwan has long been a large trade-deficit country to Japan. In addition, when new products in Japan are being tested for acceptance level in international markets, Taiwan is usually the first market for the testing.

As discussed, the economy of Japan fell into the Lost Decades after its bubble economy peaked in 1990. We therefore examine the relationship between Japan and Taiwan before and after the bubble. In the second and third parts of the Granger causality tests, we divide the entire sample period into the pre-bubble and post-bubble periods. The results from the pre-bubble period show a similar pattern as that of the entire period, i.e., the stock market performance of Japan led that of Taiwan, but not vice versa. This result indicates the strong performance of Japan before 1990. Interestingly, an analysis of the post-bubble period shows an inverted result. During 1991-2023, the stock performance of Japan no longer led that of Taiwan (p-value = 0.1679). Instead, the stock market performance of Taiwan significantly led that of Japan (p-value = 0.0282). If stock market performance serves as a proxy, or the window of the economy, we conclude that the economy of Taiwan diverged from that of Japan after 1991 or at least did not follow the path of the Lost Decades. In other words, the leading role of Japan in the flying geese pattern diminished after its bubble burst in 1990. The strong performance of the integrated circuit industry in Taiwan, or the investments of Taiwan in the semiconductor industry in Japan, provide evidence for this empirical result.

Table 7 Results of Granger Causality of (Ln) Stock Markets between Japan and Taiwan

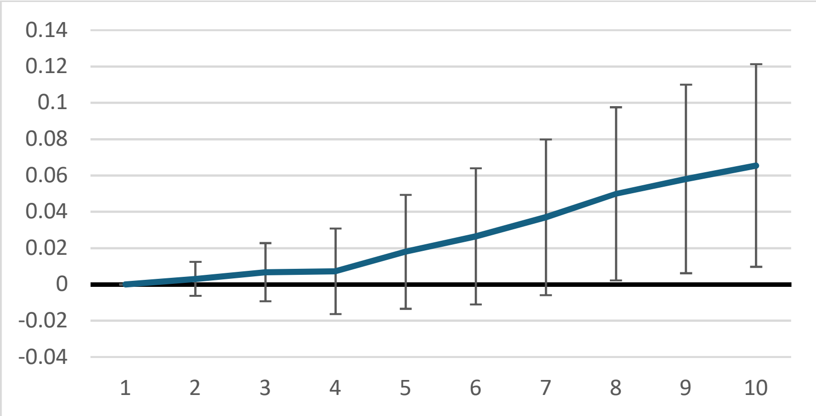
(1) 1975Q1-2023Q2 (Entire Period)	**Chi-square**	**P value**
Stock of Japan Granger causes stock of Taiwan	17.11	0.0043***
Stock of Taiwan Granger causes stock of Japan	7.62	0.1787
(2) 1975Q1-1990Q4 (Pre-Bubble)	**Chi-square**	**P value**
Stock of Japan Granger causes stock of Taiwan	33.20	< 0.01***
Stock of Taiwan Granger causes stock of Japan	8.22	0.1447
(3) 1991Q1-2023Q2 (Post-Bubble)	**Chi-square**	**P value**
Stock of Japan Granger causes stock of Taiwan	7.80	0,1679
Stock of Taiwan Granger causes stock of Japan	12.53	0.0282**

5.6 Impulse Response Function — Relation of Housing Markets between Japan and Taiwan

To examine the relationship between housing markets, we use the impulse response function and split the sample into pre-bubble and post-bubble periods for analysis. The results are shown in Figures 8 and 9. Figure 8(a) shows that the Japanese housing market significantly leads the Taiwanese housing market at the 95% significance level. This result confirms that the flying geese effect existed between their stock markets before the bubble period, and in the housing market. This is a new finding and contributes to the flying goose theory. Figure 8(b), however, shows no significant lead-lag relationship from Taiwan to Japan before the bubble.

Figure 8 Relation of Housing Markets between Japan and Taiwan

(a) pre-bubble period, Japan leading Taiwan, and



(b) pre-bubble period, Taiwan leading Japan

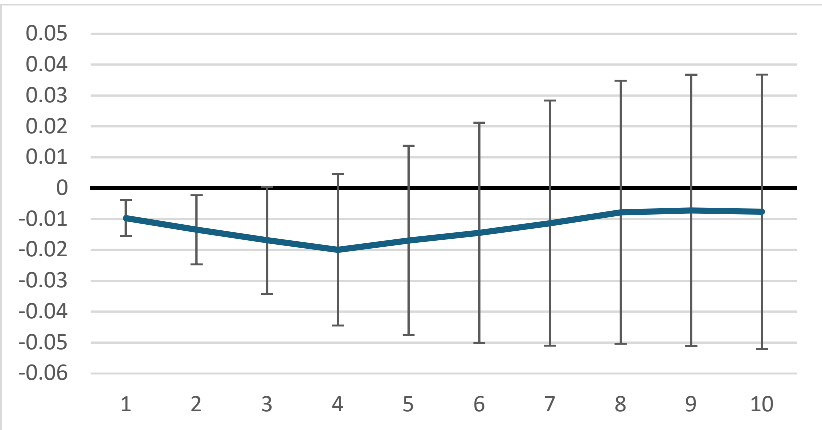
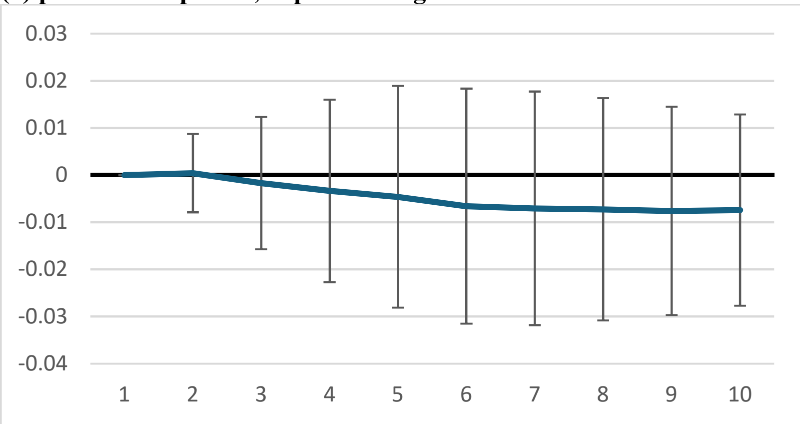


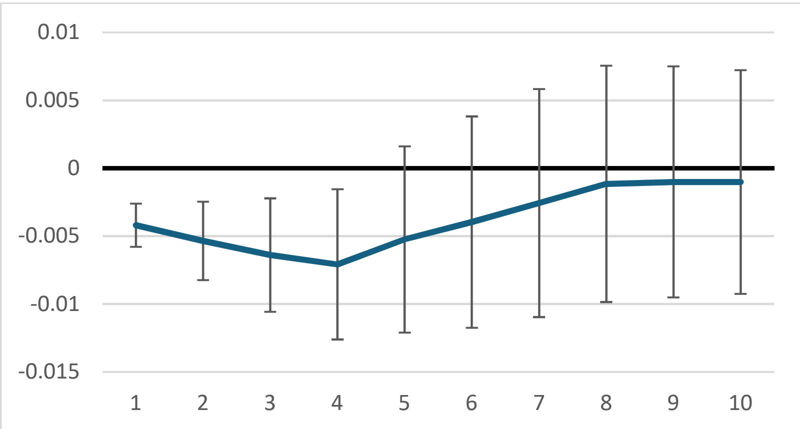
Figure 9 further shows the flying geese effect in the housing markets between Japan and Taiwan after the bubble. Both Figures 9(a) and 9(b) show no significant effect on the housing market between Japan and Taiwan. This result indicates that the Taiwanese housing market, like the stock market, had diverted from the Japanese housing market after 1991 and proceeded to embark on its own path.

Figure 9 Relation of Housing Markets between Japan and Taiwan

(a) post-bubble period, Japan leading Taiwan



(b) post-bubble period, Taiwan leading Japan



6. Conclusion

As Japan led the economic growth in Asia in the early 1900s, it is academically worthwhile to explore the relationship between Japan and the NICs. This study examines the flying geese pattern proposed by Akamatsu (1962) between Japan and Taiwan. We use stock market performance as the proxy variable for the economy and add housing markets as the second dependent variable to examine whether there was a flying geese effect in the real estate sector. We also divide the long sample period of almost half a century into pre-bubble and post-bubble periods to observe the different effects of two distinct economic conditions in Japan. Several new findings are discussed as follows.

The empirical results show that the stock market of Japan led that of Taiwan for the entire sample period (1975-2022) and the pre-bubble period (1975-1990). This finding confirms the flying geese pattern in the stock markets between Japan and Taiwan for these two periods of time. However, Japan no longer had a leading role in the post-bubble period. Instead, the stock market of Taiwan had a significant leading effect on that of Japan. This result indicates that the stock market of Taiwan, or economy, not only diverged from Japan but also developed its own path and led the growth of the stock market. For example, the investment of the Taiwanese giant chip maker Taiwan Semiconductor Corporation Manufacturing Company Limited (TSMC) in Kumamoto, Japan is evidence of the strong performance of this industry and stock market of Taiwan (Yang, 2024). The investment amount was 1 trillion JPY[4], which is equivalent to 1/6 of the annual GDP of Kumamoto. In 2025, the TSMC announced its investment in the U.S. for 165 billion USD. The other example is that Taiwan has surpassed Japan and become the 5th largest trade-surplus country to the U.S. in 2024. Both of these show the independent development of the specific industries and economy of Taiwan.

Regarding the housing markets, the results from the impulse response analysis show that Japan led Taiwan in the housing market before the bubble period. This result explains that the strong performance of Japan in the economy, or the stock market, not only led the stock market of Taiwan but also had a spillover effect in leading the Taiwanese housing market before the bubble period. This finding adds to the flying geese effect in the housing market before 1990. As for the post-bubble period, the results from the impulse response analysis show no relationship in the housing markets between Japan and Taiwan. This is also evident when observing the different trends of the housing indices in Japan and Taiwan in Figures 2 and 3. The divergence of these two housing markets may be attributed to two reasons. First, the Japanese economy fell into the trap of slow growth after the burst of the bubble, or so-called lost decades. The real estate market, therefore, followed the stagnation of the economy.

In contrast, the Taiwanese economy showed vitality after the recession in the 1990s, partly due to the industry strategy plan for the IC industry and its world-class competitiveness. The second reason for the continuing growth of the housing market in Taiwan is its low tax environment. The average property tax in Taiwan was around 0.3% of the property assessed value before 2023, lower than most countries in the world. The low holding tax incentive, coupled with its abundant money supply after following the U.S. QE policy, attracted vast amounts of capital to hoard houses in Taiwan. Nobel laureate Robert Shiller comments that the coexistence of a high homeownership rate (80%), high vacancy rate (18% on average nationwide), and high house prices in Taiwan is a warning signal of irrational exuberance (ETtoday, 2017). After COVID-19, the Central Bank of Taiwan adopted a lax monetary policy following the U.S.,

[4] 1 USD = 143.7 JPY in December 1989.

that is, unlimited QE, which further pushed the housing market values upwards. The government eventually decided to launch the House Hoarding Tax policy nationwide in 2024 to curb the trend of rising prices. Since the definition of hoarding tax applies to 4 or more houses, the effect of this tax policy is worthy of future observation.

There are two variables that show different effects on the housing markets of Japan and Taiwan, which are worth discussing. The first is the interest rate. The interest rate is the cost of capital. A lower interest rate usually stimulates investment motivation and drives up asset prices. The results of Taiwan show this negative relation. In Japan, however, the interest rate shows a positive relation with the house prices. This positive relation indicates the liquidity trap effect as the interest rate was close to zero after the burst of the bubble in Japan and lost its policy effectiveness. The second variable is the household number. According to Figures 2 and 3, the household numbers in Japan and Taiwan increased in the long run. The results of Taiwan show a positive relation with house prices, which is consistent with the real demand for housing. On the contrary, the household numbers in Japan were negatively related to land prices. The reason for this special result can be attributed to the magnitude of depreciation and the trend of the land market after the bubble burst in Japan, which diminished confidence in home purchases in Japan. In addition, the sluggish economy also deteriorated the purchasing power for housing. Both low confidence and purchasing power countered the growth of household numbers. Households turned to renting instead of buying, which led to the oddly negative relationship between household numbers and land prices.

In conclusion, this paper explores the lead-lag relationship in the stock and housing markets between Japan and Taiwan and examines the flying geese effect proposed by Akamatsu (1962). The results show that both the stock and housing markets in Japan have a flying geese effect on Taiwan before 1990 due to the strong economic development of Japan and the similar growth pattern of the money supply in these two countries. However, after the bubble burst in 1991, both the stock and housing markets in Taiwan deviated from Japan due to the bubble effect in Japan, and the development of the IC industry in Taiwan as well as the low property tax environment in the housing market. This study provides empirical evidence for the flying geese pattern before 1990 and suggests to governments the importance of sustainable growth of the economy and the risk of real estate bubbles. Both public and private sectors can learn from the experiences of the economy, stock, and housing markets in these two countries for policy and investment decision making.

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Appendix

For additional robustness checks, we conduct several specification tests as follows.

For both the Japanese and Taiwanese models, we estimate the 62,500 models (models contain 8 variables with 4 maximum lags for each variable) by using the AIC and select the two models: full lag model is called Model 1 and parsimonious lag model is Model 2. We further check those two models by using specification tests such as Ljung-Box Q tests for autocorrelation and BPG test for heteroskedasticity and RESET for specification and parameter constancy through recursive Chow tests. From the recursive Chow tests, we find parameter changes during the bubble periods from 1988Q2 to 1989Q2 in Japan (Figure A). We include a bubble dummy taking one for these periods. Note that F tests are calculated from estimating ARDL models from 1975Q4 by adding the period of 1981Q1 to 2023Q2. The F tests are divided by critical values at the 1% significance level and the statistics are shown in Figure A. We find parameter changes from 2008Q1 to 2008Q4 for the Taiwan model (Figure B). We include the dummy variable taking one for this period. Note that F tests are calculated from estimating ARDL models starting from 1976Q2 by adding one period from 1987Q1 to 2023Q2. The F tests are divided by critical values at the 1% significance level and the statistics are shown in Figure B. Finally, we select the parsimonious lag models for both Japan and Taiwan. However, these models still contain heteroskedasticity and autocorrelation. Therefore, standard errors are estimated from the heteroskedasticity and autocorrelation consistent estimators. These results are summarized in Table 3 for Japan and Table 5 for Taiwan.

Figure A Recursive Chow Tests Results for Japan

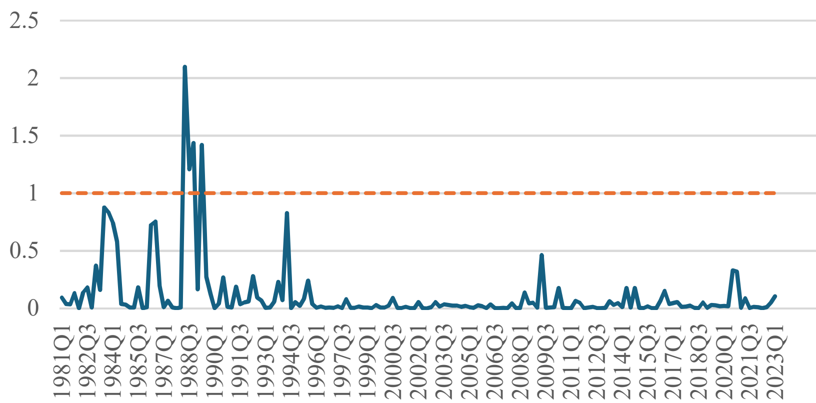

Figure B Recursive Chow Tests Results for Taiwan

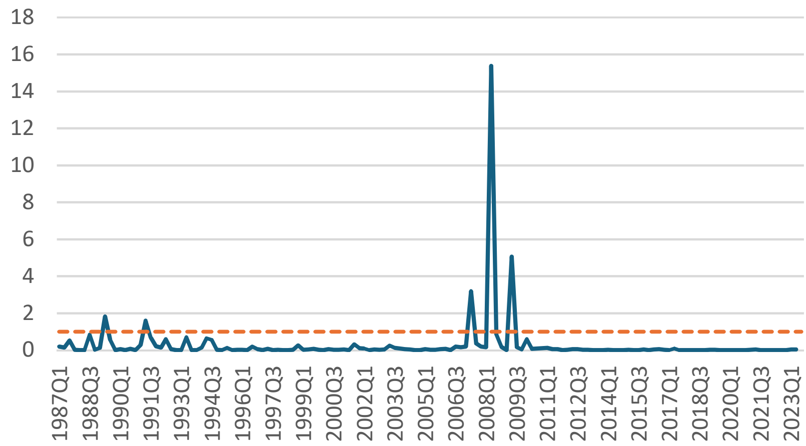

Table A1 The Unit Roots Results for Taiwan: Entire Sample

Variable	Model	DF-GLS	lags	Result
Ln Real National Land Price Index (2020=1)	drift, trend	-2.7985	9	I(1)
D Ln Real National Land Price Index (2020=1)	drift	-2.2945**	8	I(0)
Ln Real GDP (2020=1)	drift, trend	-0.4287	8	I(1)
D Ln Real GDP (2020=1)	drift	-0.2910	7	I(1)
Real Interest Rate	drift, trend	-3.1700**	3	I(0)
D Real Interest Rate	drift	-1.1880	9	I(1)
D Ln Real M2	drift	-0.9925	1	I(1)
D2 Ln Real M2	drift	-2.0699**	7	I(0)
Ln Real Stock Price Index (2020=1)	drift, trend	-2.2131	0	I(1)
D Ln Real Stock Price Index (2020=1)	drift	-1.6575*	3	I(0)
Ln Real Exchange Rate	drift, trend	-0.4652	0	I(1)
D Ln Real Exchange Rate	drift	-11.7267***	0	I(0)
Ln number of households	drift, trend	-1.819993	2	I(1)
D Ln number of households	drift	-0.67337	0	I(1)

***Notes*:** DF-GLS means Elliott-Rothenberg-Stock DF-GLS test statistic.

Table A2 Unit Roots Results for Japan: Entire sample

Variable	Model	DF-GLS	lags	Result
Ln Real National Land Price Index (2020=1)	drift, trend	-1.5286	2	I(1)
D Ln Real National Land Price Index (2020=1)	drift	-2.9231***	1	I(0)
Ln Real GDP (2020=1)	drift, trend	-0.1544	0	I(1)
D Ln Real GDP (2020=1)	drift	-14.7624***	0	I(0)
Real Prime rate (%)	drift, trend	-2.5207	4	I(1)
Real Prime rate (%)	drift	0.2315	4	I(1)
D Real Prime rate (%)	drift	-0.3261	9	I(1)
Ln Real M2	drift, trend	-0.7375	5	I(1)
D Ln Real M2	drift	-4.1656***	4	I(0)
Ln real stock price index (2020=1)	drift, trend	-1.7268	1	I(1)
D Ln real stock price	drift	-9.8430***	0	I(0)
Ln real exchange rate	drift, trend	-0.6404	1	I(1)
D Ln real exchange rate	drift	-5.5005***	2	I(0)
Ln number of households	drift, trend	-1.3333	9	I(1)
D Ln number of households	drift	0.379246	8	I(1)

Notes: (1) DF-GLS means Elliott-Rothenberg-Stock DF-GLS test statistic. (2) Sample (adjusted): 1991Q1 to 2023Q2