JOURNAL OF REAL ESTATE RESEARCH
2021, VOL. 43, NO. 2, 248–270
https://doi.org/10.1080/08965803.2021.1938917

Residential Housing Market and Bank Stability: Focusing on OECD and Emerging Asian Countries

Sangjun Lee[a], Alan Tidwell[b] and Changha Jin[c]

[a]Department of Economics, College of Business and Economics, Hanyang University, Ansan, Republic of Korea; [b]Department of Economics, Finance, and Legal Studies, Culverhouse College of Business, The University of Alabama, Tuscaloosa, AL, USA; [c]Department of Economics, Hanyang University, Ansan, Republic of Korea

ABSTRACT

In this study, we examine whether the fluctuation of residential housing prices affects the stability of financial institutions in 31 Organization for Economic Co-operation and Development (OECD) and emerging Asian countries. Utilizing 272,530 unique observations from 1990 to 2017, we explore effects of residential financing on bank stability mostly channeled by housing prices as a collateral effect, and by a type of moral hazard due to asymmetric information between borrowers and lenders. We first apply pooled mean group (PMG) estimators to isolate housing market price deviations from the market's fundamental equilibrium, and then we conduct analysis using bank stability measures including return on assets (ROA,) and non-performing loan ratios (NPL). Results indicate that price deviation in the housing market from fundamental equilibrium is statistically significant for bank stability measures and persists in OECD countries over longer time horizons compared to emerging Asian countries. The findings also imply that loan growth represents a critical factor determining the level of bank stability while result from individual countries vary according to the relative maturity of their economy, level of interdependency between housing market and banking sector, and regulative environment for residential housing finance.

KEYWORDS

Housing price; housing market; financial stability; non-performing loan ratio

This study investigates deviations from fundamental residential real estate price growth and financial stability in the banking industry among 31 Organization for Economic Co-operation and Development (OECD) and emerging Asian countries. Recent research attempts to identify financial contagions or spillover effects between housing and financial markets emphasize endogenous risks embedded in the banking industry and residential real estate markets. Due to the inherent large levels of risk exposure, real estate price deviations away from fundamentally derived expectations may jeopardize financial stability in the banking sector and can be a leading indicator of an individual bank's financial stability, a critical assessment of financial vulnerability. Although these markets are linked through a financial accelerator mechanism[1] that acts as a financial feedback loop (Bernanke, 1995), there is little effort to provide evidence of the entwined relationship between residential real estate markets and bank stability.

CONTACT Changha Jin cjin@hanyang.ac.kr Department of Economics, Hanyang University, 55 Hanyang Univ. Rd, Ansan 15588, Republic of Korea

To finance market growth, lending institutes tend to expand market share by selling various mortgage products or by geographically extending their lending business to newly formed residential markets. According to financial accelerator theory, lenders require collateral to secure real estate residential loans because of information asymmetry, whereby lenders have little information about the reliability of any given borrowers' ability to repay the loan. Because rising housing prices increase the value of the underlying collateral held by lending institutes, lenders expect to improve financial stability during these periods (Koetter & Poghosyan, 2010). Therefore, an individual bank with extended lending capacity can increase lending output in the real estate market while also improving profitability through cumulative interest income and associated mortgage lending fees (Kiyotaki & Moore, 1997).

Increasing housing prices can also intensify possible moral hazards raised from asymmetric information between lending institutions and individual borrowers (Bernanke, 1995), while lax underwriting standards could result in higher observed transaction prices. As such, increases in lending activity may positively relate to increases in default probability. In that sense, changes in residential housing prices further link to expected losses in a given default situation, even embedded within a real estate boom. Therefore, individual banks increase their capital reserves in expectation of housing market downturns. Individual banks are also likely to issue new debt financing to fund the increased capital reserve amount for possible loss provision, deteriorating its equity-to-asset ratio. However, we consider the moral hazard issue as an unobservable variable, and thus use the deviation of house price from its fundamental value as a proxy (Ben-David, 2011).

This paper provides a comprehensive examination of the relationships between residential house prices and bank profitability and stability. We document, as a collateral effect, the impact housing price deviations (from fundamental price)[2] have on bank stability; whereas most of the associated existing literature focuses on the interrelationships among residential market–related variables, and macro-economic and social-economic variables as determining factors for residential loan growth. Moreover, many previous studies lack bank-level analysis but instead rely on aggregate country-level data; this study uniquely employs data derived from individual banks in 31 OECD and emerging Asian countries, reflecting firm-level characteristics. We apply the pooled mean group (PMG) estimator suggested by Pesaran et al. (1999) and adopted by Koetter and Poghosyan (2010), and the mean group (MG) estimator introduced by Pesaran and Smith (1995)[3] to isolate housing market price deviations from their fundamental equilibrium; then we conduct analysis using bank stability measures including return on assets (ROA), non-performing loan ratio (NPL), and loan growth. Results show house price deviations from fundamental equilibrium prices significantly affects bank stability measures in OECD and emerging Asian countries. Fundamental housing price increases can be viewed as a factor increasing ROA; whereas nonfundamental-based price deviation has a negative impact on ROA, leading to a decrease in bank stability during periods of non-fundamentally linked housing price fluctuations. The findings also imply that loan growth represents a critical factor determining the level of bank stability. This analysis provides the marginal effects of housing market imbalance on bank stability and performance in the context of different housing and banking policy environments.

The remainder of this paper is organized as follows. In the next section, we provide a discussion of monetary policy and the effect it can have on housing markets. We also discuss the impact of housing market price changes on loan growth and how this can affect bank stability. We then describe the data and empirical methods employed and discuss results. The paper concludes with a summary of salient findings and a discussion of policy implications.

Literature Review

Monetary Policy and the Residential Housing Market

Financial institutions have played a critical role as an intermediary between monetary authorities and the real estate economy in which the monetary authorities have influence; specifically through the credit channel associated with credit costs for residential financing and housing prices (Kiyotaki & Moore, 1997). Monetary authorities adopt various tools for monetary policy initiatives, such as open market operations, setting the benchmark interest rate, and mandating reserve minimums.[4]

Giuliodori (2005) examines the effect of the European Central Bank's monetary policy on mortgages and residential housing markets, providing support that monetary policy effects the housing market through the mortgage banking credit channel. Iacoviello and Minetti (2008) also examine the impact of monetary policy via bank-lending channels, confirming that the housing market is influenced by monetary policy. They point out that the magnitude of impact varies according to firm-level characteristics of lending institutions after controlling for macroeconomic variables such as: gross domestic product (GDP), consumer price index (CPI), T-bill rate, and residential housing prices. Relatedly, Elbourne (2008) examines the response in U.K. housing prices and consumption to changes in monetary policy. Using Structural Vector Autoregressions (VAR), the study provides empirical evidence that federal fund rate changes affects prices in the housing market and also secondarily impacts consumption levels by 12 to 15%, indicating that monetary policy has a direct impact on the housing market and an indirect impact on consumption. McDonald and Stokes (2013) analyze the relationship between the U.S. housing market bubble and the federal funds rate. Applying Granger causality tests and VAR modeling, they find a causal relationship between federal funds rate changes and real estate prices and conclude that changes in the federal funds rate acts as an endogenous shock to the housing market, and further, relatively low federal funds rates during the 2001 to 2004 period had a high correlation with increasing housing prices—resulting in a housing bubble in subsequent years.

Additionally, recent studies attempt to explain the role of capital inflow, financial innovation, speculation, and trading volume of housing as additional causal factors that might explain housing market price deviations. Kim and Yang (2011) find that the amount of capital inflow contributes to asset price appreciation in emerging Asian economies, i.e., positive capital flow shocks increase stock prices immediately but land price appreciation is delayed. Wong et al. (2019) also suggest that foreign inflow is a critical determinant of housing prices along with income, population, and speculation activity. Tillmann (2013) provides a similar argument on capital flow and housing prices in

OECD countries. And Kok et al. (2018) find that house prices and transaction volume respond positively to shocks in monetary liquidity.

Residential Housing Market and Loan Growth

Financial accelerator theory (Bernanke, 1995) states that small changes in the financial sector can produce large changes in the economy, resulting in a type of feedback loop. Pertaining to real estate, lower credit cost achieved through monetary policy can lead to an increase in housing prices that positively affects collateralized asset value, allowing for favorable lending practices and loan growth. In a type of feedback loop, loan growth can contribute to more price expansion in housing markets. Bernanke (1995) and Goodhart and Hofmann (2008) examine the relationship between housing price and bank loan growth, confirming that increases in housing prices have a positive impact on residential loan growth and, additionally, positive credit governance. Gerlach and Peng (2005) explore the long-run relationship between residential markets and loan growth in Hong Kong from 1982 to 2001. Using VAR analysis, they find that increased residential housing prices contribute to increased loan growth, but increased loan growth does not affect residential housing prices. In addition, they provide evidence that the amount of margin on interest paid narrows as the NPL increases. Liang and Cao (2007) examine the interrelationship between loan growth and residential markets in China from the first quarter of 1999 to the second quarter of 2006. Using a vector error correction model (VECM), they find that an increase in loan growth has a direct impact on house prices, but an increase in housing prices does not affect loan growth. Their results imply that control of the benchmark interest, such as the federal funds rate, is a feasible tool for controlling housing market demand by increasing or decreasing the borrowing cost.

Goodhart and Hofmann (2008) examine the relationship between monetary policy and macroeconomic variables including GDP, CPI, nominal interest rate, credit extension, total loan amount, and housing price. Using a panel VAR model of 17 countries from 1970 to 2006, they find monetary policy has a significant impact on housing price, but the effect is observed only in the period of the housing boom. Davis and Zhu (2011) examine the relationship between the commercial real estate market and loan growth. They include 17 countries in their VECM and find that macroeconomic variables impact commercial real estate price and loan growth. However, the directional relationship is such that the commercial real estate market leads loan growth but loan growth does not lead commercial real estate market prices. The result of variance decomposing on commercial market price shows that 47% of the variance is derived from the commercial real estate market itself, whereas 33% of the variance is from loan growth.

Hott (2011) explores lending behavior and real estate prices, examining the relationship between real estate market funding and creditworthiness of borrowers. Results suggest that banks can substantially contribute to real estate cyclical behavior through their lending behavior and expectations (i.e., mood swings, momentum forecasts, and disaster myopia). Mood swings refer to people being more confident when there is a boom and less confident when prices are decreasing; when confidence (or lack thereof) is contagious it can lead to herding behavior. Momentum forecasts refer to price movements of the housing market that are related to past price movements, which is interpreted as

evidence for momentum trading. Disaster myopia represents a tendency over time to underestimate the probability of low-frequency shocks. Thus, the worst scenario may be when the subjective probability declines even when actual probabilities remain constant or even increase.

Bank Loan Growth and Bank Performance

Foos et al. (2010) examine whether banks can grow without harming their stability and how relative loan growth relates to bank profitability. They define abnormal loan growth as the relative difference between loan growth at an individual bank level and the median loan growth of all banks from the same country for that year and find abnormal loan growth affects loan losses of individual banks. Given that borrowers do not immediately default after receiving a bank loan, they conclude that abnormal loan growth leads to an increase in loan loss provisions during the subsequent three years, a decrease in relative interest income, and lower capital ratios—suggesting that loan growth represents an important determinant of bank risk.

Huszar and Yu (2019) examine the lending practices of nontraditional, less-regulated, nonbank lenders. They construct a state mortgage licensing constraint index as proxy of regulation for new nonbank lenders across the states. They find that the lenders with less-regulated home states tend to originate riskier loans and to show higher loan approval rates with higher loan-to-income ratios. They conclude that state regulations play an important role on the soundness of the mortgage industry and that lax underwriting standards resulted in the recent U.S. housing bubble and the subsequent economic recession.

Goodhart and Hofmann (2008) examine the effect of delinquent mortgages on bank financial stability. Loans classified as delinquent 90 days or more that are held for extended periods without any progress are obviously problematic for lenders because the property losses can be larger due to possible crime, social cohesiveness, and community viability. However, Goodhart and Hofmann (2008) point out that the bank shareholder would optimally refuse to undertake liquidity-enhancing actions on these delinquent loans; then the benefits accrue to debtholders rather than equity holders when bank is insolvent. In addition, since the overall bank's capital level is affected by losses on either securitized or non-securitized loans, there may be a possibility for banks to delay loss recognition on delinquent mortgages in residential mortgage-backed securities (RMBS).

Koetter and Poghosyan (2010) find that deviations from fundamentals in the housing sector affect bank stability, and cite three reasons for price deviation persistence: population growth, real income, or wealth. Our paper differs from previous studies in that we focus on the effect of house price deviations (from fundamental price) on bank profitability and stability. We are the first to do this comprehensively across OECD and emerging Asian countries. Most of the associated existing literature focuses on the interrelationships among housing market–related variables, and macroeconomic and socioeconomic variables as determining factors for residential loan growth. This study is most similar to Koetter and Poghosyan (2010), as the authors also isolate housing market price deviations from their fundamental equilibrium in German real estate markets and find housing price deviations contribute to bank instability.

Data and Method

Pooled Mean Group (PMG) Estimate

We apply the Pooled Mean Group (PMG) estimator suggested by Pesaran et al. (1999) and adopted by Koetter and Poghosyan (2010) to analyze house price determinants in OECD and emerging Asian countries. The primary advantage of PMG is that we can examine short-run coefficients (including the intercepts) and adjustment speed to the long-run equilibrium relationship. This model assumes the error variances to be heterogeneous country by country, whereas the long-run slope coefficients are restricted to be homogeneous across countries classified as OECD or emerging Asian. We also allow for the short-run adjustment to be country-specific, since each country varies in the exposures to systematic risk factors. For robustness, we also apply the Mean Group (MG) estimator introduced by Pesaran and Smith (1995). It allows for all coefficients to vary and be heterogeneous in the long- and short-run.[5]

We include three fundamental determinants of housing prices commonly used in previous literature: nominal GDP per worker, population growth, long-term interest rates, and CPI. Considering prior studies, we expect increases in GDP per worker, population growth, and CPI to have a positive effect on housing price, and long-term interest rates will have an inverse relationship with housing price. The long-run relationship between housing prices and their fundamentals is denoted by Equation (1),

$$hp_{it} = \theta_0 + \theta_{1t} gdp_{it} + \theta_{2i} pop_{it} + \theta_{3i} rate_{it} + \theta_{4i} cpi_{it} + \mu_i + \varepsilon_{it} \tag{1}$$

where i and t represent country and time period, respectively. The log of nominal house prices is hp and log of GDP per capita is gdp. The population growth is denoted as pop, 10-year bond rate is $rate$, and consumer price index is cpi. The country-specific fixed effect is μ_i. And ε_{it} is the deviation of house prices determined by fundamentals. The autoregressive distributed lags (ARDL (1.1.1.)) dynamic panel represent the long-run equation as follows.

$$\begin{aligned} hp_{it} = {} & \delta_{10} gdp_{it} + \delta_{11} gdp_{it-1} + \delta_{20} pop_{it} + \delta_{21} pop_{it-1} + \delta_{30} rate_{it} + \delta_{31} rate_{it-1} + \delta_{40} cpi_{it} \\ & + \delta_{41} cpi_{it-1} + \lambda_i hp_{it-1} + \mu_i + \varepsilon_{it} \end{aligned} \tag{2}$$

We impose lag house price determinants. The error-correction equation is denoted as follows:

$$\begin{aligned} \Delta hp_{it} = {} & \phi_i (hp_{it-1} - \theta_{0i} - \theta_{1i} gdp_{it-1} - \theta_{2i} pop_{it-1} - \theta_{3i} rate_{it-1} - \theta_{4i} cpi_{it-1}) + \delta_{10i} \Delta gdp_{it} \\ & + \delta_{20i} \Delta pop_{it} + \delta_{30i} \Delta rate_{it} + \delta_{40i} \Delta cpi_{it} + \varepsilon_{it} \end{aligned} \tag{3}$$

where

$$\phi_i = -(1 - \lambda_i), \quad \theta_{0i} = \frac{\mu_i}{1 - \lambda_i}, \quad \theta_{1i} = \frac{\delta_{10i} + \delta_{11i}}{1 - \lambda_i}, \quad \theta_{2i} = \frac{\delta_{20i} + \delta_{21i}}{1 - \lambda_i},$$
$$\theta_{3i} = \frac{\delta_{30i} + \delta_{31i}}{1 - \lambda_i}, \quad \theta_{4i} = \frac{\delta_{40i} + \delta_{41i}}{1 - \lambda_i}$$

The PMG estimator imposes a homogeneity restriction on the coefficient of long-run house price determinants θ_0, θ_1, θ_2, θ_3, and θ_4 with the error-correction speed adjustment parameter ϕ_i and short-run adjustment coefficients δ_{10i}, δ_{20i}, δ_{30i}, and δ_{40i}. The

deviation from PMG estimations indicates temporary deviations in house prices from its fundamental value at the country level.

$$deviationhp_{it-1} = hp_{it-1} - \hat{\theta}_{0i} - \hat{\theta}_1 gdp_{it-1} - \hat{\theta}_2 pop_{it-1} - \hat{\theta}_3 rate_{it-1} - \hat{\theta}_4 cpi_{it-1} \quad (4)$$

We also note real estate price deviations from fundamental values estimated by $deviationhp_{it-1}$ and simple specification of house price changes by hp_{it-1}. The relationship in Equation (1) reveals that increasing or declining housing prices can represent deviations if fundamental variables are not supportive of these changes. Likewise, variation in housing price changes and deviations from fundamentals differ in estimating bank stability and performance.

Panel Data Analysis for Bank Stability and Housing Price

We employ panel fixed models to estimate the relationship between housing price and bank stability and performance. The bank stability and profitability model is denoted as follows:

$$y_{it} = \beta_0 + \beta_1 asset_{it} + \beta_2 equity_{it} + \beta_3 income_{it} + \beta_4 cost_{it} + \beta_5 loangrowth_{it} + \beta_6 changehp_{it} + \beta_7 deviationhp_{it} + \mu_i + \varepsilon_{it} \quad (5)$$

where y_{it} is denoted as return of assets (ROA) as a proxy for bank profitability in the ROA model and NPL for bank distress level in the NPL model.[6] The variable *asset* is the natural logarithm of total assets in local currency; and capital to asset ratio is *equity*, the share of interest income to total operating asset is *income,* while the amount of cost to total income is denoted as *cost*, and growth rate of total loans is identified as *loangrowth*. The variable *changehp* represents a change in house price and *deviationhp* is the long-run equilibrium from housing price fundamental values as denoted in Equation (4), while μ_i is the fixed effect, and ε_{it} is the error term. The capital to asset ratio denoted as *equity* is the proxy to measure bank capitalization which we expect to have a positive relation with ROA because the capital to asset ratio is an indicator of the bank's liquidity measure. Likewise, we also expect a positive relation between interest income and operating asset ratio to ROA. Loan growth is also expected to have a positive relationship with ROA because increased loan size will normally generate service fee revenue and interest income. We also expect that housing price will lead to loan growth and thus will positively impact on bank ROA. However, *deviation* is proxy for market fluctuation not supported by long-term fundamental variables which may lead to a potential loss in a bank's ROA and negatively impact financial solvency. We expect cost to be negatively related to ROA, whereas asset size mathematically lowers ROA since it is a denominator; however, asset size can also be a proxy for high performance banks leading to an increase in ROA (Kohlscheen et al., 2018).

Furthermore, we include interaction terms between loan growth and housing market fluctuation variables to test financial accelerator theory, which indicates that loan growth is positively related to rising housing prices, and also increases the value of underlying collateral assets held by banks. We include two interaction terms between loan growth and change of house price (*loangrowth* × *changeHP*) and between loan growth and

Table 1. Descriptive statistics.

	OECD Countries				Emerging Asian Countries			
Variable	Mean	SD.	Min.	Max.	Mean	SD.	Min.	Max.
ROA (%)	1.62	6.45	−528.78	947.83	1.94	4.87	−45.00	223.08
NPL (%)	2.97	5.14	0	100	6.02	11.13	0	100
Z-score(ln)	3.40	1.10	−6.43	9.56	2.71	1.01	−3.00	8.85
Asset (ln)	5.78	2.74	−6.91	20.09	9.42	3.55	−0.69	23.67
Equity (%)	21.62	28.97	0	101.75	20.59	22.30	0.04	100.00
Income (%)	0.81	2.29	0	99.74	1.84	3.45	0	88.62
Cost (%)	66.08	29.06	0	988.89	53.41	35.42	0	873.58
Loangrowth (%)	11.14	64.58	−100	981.26	40.91	150.07	−100	966.67
GDP (U.S.$)	32,562	14,332	10,853	107,525	12,326	14,225	311	57,714
Pop (%)	0.80	0.74	−1.85	6.02	1.39	0.89	−1.47	5.32
Rate (%)	5.27	3.40	−0.36	23.92	5.72	4.89	0.00	27.82
CPI	80.83	16.51	24.60	105.50	71.08	22.90	8.90	119.61

Note. Mean is sample mean. SD is standard deviation. Min and Max are minimum and maximum, respectively. ROA is return of assets, NPL is non-performing loan ratio, and Z-score is natural logarithm of z-score traditional formula, and Asset is the natural logarithm of total assets in local currency. Equity is the capital to asset ratio. Income is a share of interest income to total operating asset. Cost is total income to total cost ratio. Loangrowth is growth rate of total loans. HP is house prices index in 2015 = 100. GDP denotes nominal domestic product per capita in US dollars, Pop is population growth, and Rate is long-term interest rates (10 years) and CPI is consumption price index in 2015 = 100.

deviation in house price (*loangrowth* × *deviationHP*). If loan growth and change of house price simultaneously occurs, we expect the interaction effect to significantly affect our dependent variables, beyond a simple linear relationship.

$$y_{it} = \beta_0 + \beta_1 asset_{it} + \beta_2 equity_{it} + \beta_3 income_{it} + \beta_4 cost_{it} + \beta_5 loangrowth_{it} + \beta_6 interaction\ term_{it} + \mu_i + \varepsilon_{it} \quad (6)$$

Data Description and Summary Statistics

We obtain regional housing prices, macroeconomic variables, and financial information for individual banks from the World Bank, Bank for International Settlement (BIS), and Bankscope database for the period from 1990 to 2017 amounting to 272,530 observations. We then analyze annual income statements and balance sheets for banks from 24 OECD and 8 emerging Asian countries.[7]

Table 1 presents descriptive statistics for variables included in our study. We include individual bank-level data including ROA, NPL, Z-score, total asset, equity, income, cost, and loan growth, excluding outliers and missing variables, for OECD and emerging Asian countries.

Table 2 represents the national composition of our sample and includes 260,014 observations for OECD countries and 12,516 for emerging Asian countries. For the OECD countries, the top five countries (United States, Germany, Italy, Japan, and France) account for 80.87% of the OECD sample, while the top 10 countries account for 92.60% of the sample. Among emerging Asian countries, China, Hong Kong, Indonesia, Philippines, Malaysia, Korea, Thailand, and Singapore account for 21.94%, 16.35%, 14.75%, 12.05%, 11.60%, 9.92%, 7.13% and 6.27%, respectively, in the sample observation.

Although we do not present the correlation metrics for the research variables for OECD and emerging Asian countries, we generally find that ROA is negatively correlated

Table 2. Percentage of individual banks for each country.

Countries	No. of Obs.	Proportion of Obs.	Countries	No. of Obs.	Proportion of Obs.
OECD Countries (Total 260,014 Obs.)					
United States	140,331	53.97%	Denmark	2,087	0.80%
Germany	34,443	13.25%	Sweden	2,026	0.78%
Italy	12,978	4.99%	Belgium	2,013	0.77%
Japan	12,937	4.98%	Netherlands	1,817	0.70%
France	9,318	3.58%	Australia	1,677	0.64%
United Kingdom	8,733	3.36%	Portugal	1,301	0.50%
Switzerland	7,744	2.98%	Ireland	1,033	0.40%
Austria	7,596	2.92%	Finland	801	0.31%
Spain	4,139	1.59%	New Zealand	501	0.19%
Norway	2,554	0.98%	Greece	470	0.18%
Canada	2,450	0.94%	Iceland	330	0.13%
Luxembourg	2,424	0.93%	Israel	311	0.12%
Emerging Asian Countries (Total 12,516 Obs.)					
China	2,746	21.94%	Malaysia	1,452	11.60%
Hong Kong	2,046	16.35%	Korea	1,241	9.92%
Indonesia	1,846	14.75%	Thailand	892	7.13%
Philippines	1,508	12.05%	Singapore	785	6.27%

to NPL, and that bank Z-score and loan growth are positively related to ROA in both OECD and emerging countries. We also conduct the correlation analysis using a panel of macroeconomic variables for OECD and emerging Asian countries. In both groups, we find a positive correlation for *hp* to GDP and CPI, and a negative correlation for *hp* to interest rate. In this sense, we can infer that the credit channel via monetary policy has a greater impact on housing markets in both groups.

Figure 1 displays house prices for selective OECD countries. We find a persistent increasing trend from the 1990s that reaches its peak around 2005 to 2008 for countries such as: France, United Kingdom, Spain, Italy, and United States. However, Japan, Switzerland, and Germany show relatively stable housing markets during the same period. Figure 2 depicts house prices for the emerging Asian countries. Most of the emerging countries except Singapore show a relatively moderate increasing pattern subsequent to 1990. While housing prices in several OECD countries reach their peak around 2005 to 2008, most Asian countries continue in a moderately increasing housing market pattern.

Analysis

Deviation of Housing Price from Market Fundamentals

Table 3 displays the long- and short-run relationships between housing price and market fundamentals providing the PMG and MG specification results for the full sample as denoted by Equations (2) and (3).[8] Before we conduct the PMG specification, we perform the residual based Kao panel cointegration test, suggested by Kao (1999). The augmented Dickey–Fuller (ADF) test is adopted and the group *t* statistics reject the null hypothesis of no cointegration for the panel data set in our study.[9] In Table 3, the PMG and MG estimations for house price (HP) includes population growth (*Pop*), GDP per worker (*GDP*), interest rate (*Rate*), and CPI (*CPI*). Results from the PMG model indicate a significant positive long-run relationship between house price (*hp*) and GDP per worker, population growth (*Pop*), and CPI (CPI). The *GDP* (1.072) and *Pop* (1.058) coefficients are

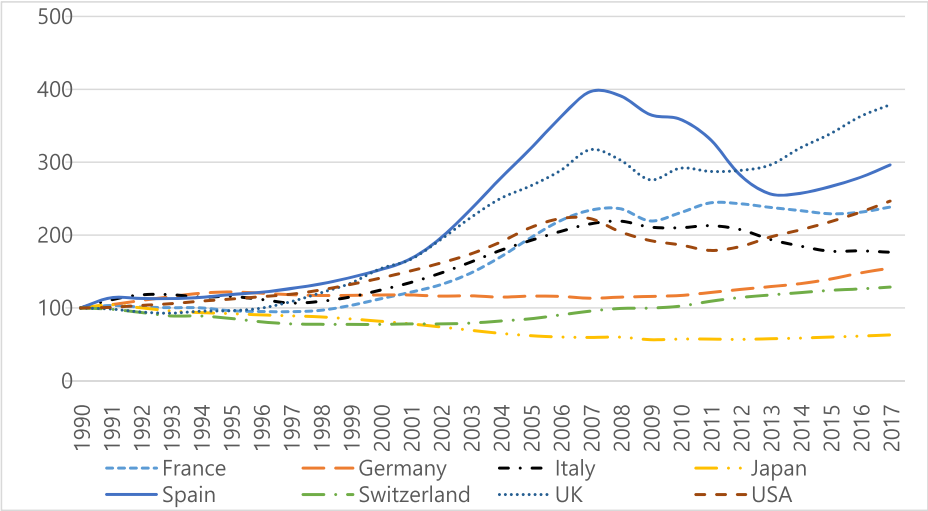

Figure 1. House price in selected OECD countries (1990 = 100). *Source:* BIS residential property price database.

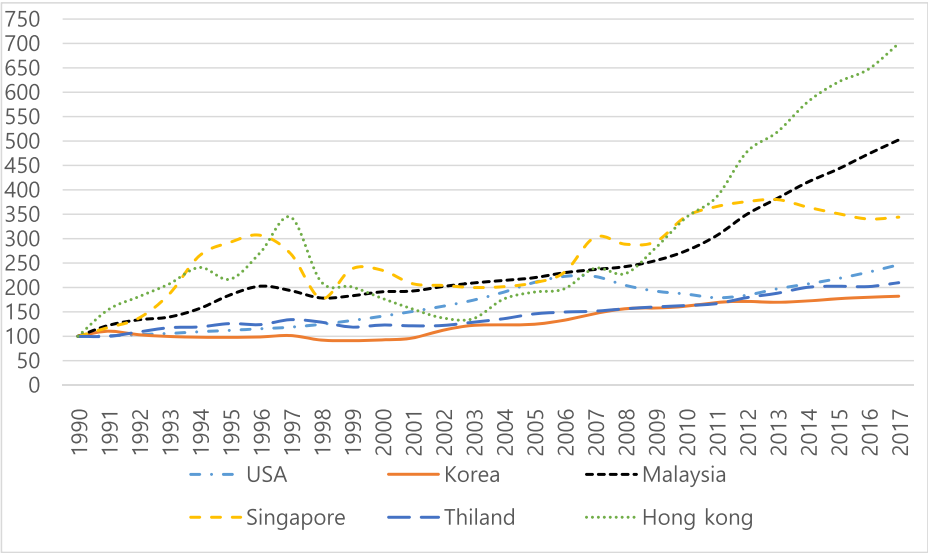

Figure 2. House price in selected emerging Asian countries (1990 = 100). *Source:* BIS residential property price database.

statistically significant at the 5% level, and *CPI* (0.53) is marginally significant at the 10% level. The impact of interest rate (*Rate*) is negative and significant at the 10% level in the long-run model. These results suggest that growth of income, population, and CPI increases housing prices in the long-run model, similar to previous literature (see, for example: Capozza et al., 2002; Adams & Fuss, 2010; Koetter & Poghosyan, 2010; Glindro et al., 2018; Pan & Wang, 2013). We also find a negative and significant speed

Table 3. House price model using PMG and MG estimation.

House Price (HP) Model		PMG estimation	MG estimation
Long-run coefficients			
GDP	θ_{1i}	1.072**	0.501
		(0.5512)	(0.555)
Pop	θ_{2i}	1.058**	−0.115
		(0.577)	(0.212)
Rate	θ_{3i}	−1.343*	−0.011
		(0.761)	(0.102)
CPI	θ_{4i}	0.535*	0.021
		(0.301)	(0.03)
Constant	θ_{0i}	−0.446	−1.545
		(0.106)***	(1.054)
Short-run coefficients			
Speed of adjustment	ϕ_i	−0.01***	−0.307***
		(0.002)	(0.068)
Change in GDP	δ_{1i}	0.505***	0.639***
		(0.126)	(0141)
Change in Pop	δ_{2i}	−0.129	−0.101
		(0.079)	(0.078)
Change in Rate	δ_{3i}	−0.01	−0.01**
		(0.003)**	(0.004)
Change in CPI	δ_{4i}	0.001	0.003
		(0.004)	(0.004)
Hausman test (p-value)		0.5839	–
Observations		766	766

Note. Pool mean PMG is pool mean group estimation and MG is mean group estimation. Dependent variable is the natural logarithm of nominal house price index. GDP denotes nominal domestic product per capita. Pop is population growth and Rate is long-term interest rates (10 years) CPI is consumption price index. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

adjustment, implying there exists an equilibrium relationship between short- and long-run estimations. The speed adjustment is –0.01, which indicates an approximate 10% disequilibrium over a one-year interval. The MG model also produced similar short-run results, including a significant speed adjustment coefficient; however, long-run results were not significant.[10]

Housing Price and Bank Stability

Table 4 presents results of the bank stability model from Equation (5) for OECD and emerging Asian countries. In panel data analysis with fixed effect, we test whether loan growth and housing market fluctuation are associated with ROA, controlling for firm-specific factors such as bank size (*Size*), equity-to-asset ratio (*Equity*), interest income to total asset ratio (*Income*), and total cost to income ratio (*Cost*).[11] As denoted in Equation (5), we obtain the deviation of house price from its macro-economic fundamentals. We include data from 1990 to 2017 parceled into two time periods: pre-global financial crisis from 1990 to 2007 (pre-GFC) and post-global financial crisis from 2008 to 2017 (post-GFC).[12] Table 4 shows the results of bank stability using the ROA models in the pre-GFC time period. To evaluate the sensitivity of fluctuation of house price to bank stability measured by ROA, we adopt both the change of house price and deviation from fundamental values (of house price) as two proxies for fluctuation in house prices. We find a positive and significant coefficient for equity-to-asset ratio (*Equity*), income to total asset ratio (*Income*), and loan growth (*loangrowth*) with regard to the ROA model. During pre-

Table 4. Results of panel data analysis with fixed effect for ROA model (Pre-GFC 1990 - 2017).

	OECD Countries		Emerging Asian Countries	
Dependent Variable: ROA	(1)	(2)	(3)	(4)
Asset	−0.168***	−0.172***	0.0630	−0.170
	(0.0127)	(0.0128)	(0.134)	(0.124)
Equity	0.0573***	0.0539***	0.0554***	0.0436***
	(0.00127)	(0.00123)	(0.00790)	(0.00754)
Income	0.0140***	0.0137***	0.00619	0.00539
	(0.00113)	(0.00114)	(0.00440)	(0.00441)
Cost	−0.0198***	−0.0197***	−0.0176***	−0.0215***
	(0.000367)	(0.000358)	(0.00264)	(0.00251)
Loangrowth	0.0363***	0.0386***	0.0886***	0.0822***
	(0.00354)	(0.00348)	(0.0320)	(0.0315)
ChangeHP	0.430***		0.230	
	(0.124)		(0.384)	
DeviationHP		0.0338		−0.140
		(0.0250)		(0.145)
Constant	2.460***	2.641***	1.269	2.847**
	(0.0963)	(0.150)	(1.216)	(1.241)
Observations	50,557	51,473	1,835	1,936
Number of banks	9,167	9,271	597	615
R^2-adjusted	0.135	0.132	0.113	0.117
F-test	292.24	291.77	7.07	7.86
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. ROA is return of assets, NPL is non-performing loan ratio, and Asset is the natural logarithm of total assets in local currency. Equity is the capital to asset ratio. Income is the share of interest income to total operating asset. Cost is total cost to total income ratio. Loangrowth is growth rate of total loans. ChangeHP denotes growth rate of log of house prices. DeviationHP is house prices deviation from their fundamental value by estimating PMG approach.

All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

GFC, most of OECD countries experienced increasing housing prices motivating banks to expand residential lending, this resulted in significant ROA growth. We see this reflected in the positive and significant house price (*ChangeHP*) coefficient for OECD countries. This run-up in housing prices was not especially pronounced in emerging Asian countries and, although positive, we do not find a significant relationship between house price changes and ROA in emerging Asian countries during this time period. OECD countries have more mature finance systems in the primary and secondary markets with various mortgage products compared to emerging Asian countries. Thus the integration of residential market price changes is likely or more directly affect the banking industry through residential mortgage products in OECD countries. Consistent with Warnock and Warnock (2008), we find that bank loan growth positively impacts ROA in both OECD and emerging Asian countries. Interest income also has a significant and positive impact on ROA, implying income from active loans and loan growth are contemporaneously correlated with ROA in both OECD and emerging Asian countries during the pre-GFC period. The equity-to-asset ratio is also positively correlated with ROA, suggesting banks with higher equity-to-asset ratios signal higher earnings management and will have a higher ROA ratio. Changes in housing price positively affect banks' ROA, especially in OECD countries; however, housing market deviations from fundamentals did not significantly impact ROA in both OECD and emerging Asian countries, pre-GFC.

Table 5 presents results of the panel data analysis with fixed effect for bank stability from Equation (5) for the 2008 to 2017 period, representing the post-GFC time period. In OECD countries, we find a positive and significant coefficient in bank size (*Asset*), equity-

Table 5. Results of panel data analysis with fixed effect for ROA model (Post-GFC 2008 - 2017).

	OECD Countries		Emerging Asian Countries	
Dependent Variable: ROA	(1)	(2)	(3)	(4)
Asset	0.0653***	0.0885***	0.00921	0.00924
	(0.00920)	(0.00871)	(0.0107)	(0.0152)
Equity	0.0713***	0.0737***	0.0586***	0.0477***
	(0.00175)	(0.00170)	(0.00363)	(0.00483)
Income	0.0481***	0.0506***	0.0702***	0.0615***
	(0.00313)	(0.00310)	(0.00724)	(0.00933)
Cost	−0.0256***	−0.0241***	−0.0252***	−0.0436***
	(0.000299)	(0.000279)	(0.00129)	(0.00173)
Loangrowth	0.0236***	0.0231***	0.0485***	0.0693***
	(0.00318)	(0.00311)	(0.0152)	(0.0205)
ChangeHP	0.0350		0.597	
	(0.141)		(0.428)	
DeviationHP		−0.242***		−0.279*
		(0.0332)		(0.146)
Constant	0.998***	−0.518***	1.373***	1.586***
	(0.0661)	(0.187)	(0.165)	(0.506)
Observations	76,358	81,520	3,604	3,224
Number of banks	19,100	19,762	810	784
R^2-adjusted	0.144	0.140	0.255	0.272
F-test	642.52	671.76	63.57	60.47
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

to-asset ratio (*Equity*), income to total asset ratio (*Income*), loan growth (*loangrowth*), and change of house price (*ChangeHP*). Conversely, cost to total income ratio negatively and significantly impacts ROA.

Similar to results from pre-GFC, we find loan growth significantly contributes to ROA in both OECD and emerging Asian countries, *Income* also impacts ROA, implying the income from active loans are a significant revenue source for banks boosting ROA in both OECD and emerging Asian countries. The equity-to-asset ratio is positively correlated with ROA, while *Cost* again negatively impact ROA. A notable difference in the post-GFC and pre-GFC periods, is the significant impact housing market deviations from fundamental values has on ROA during the post-GFC sample period in both OECD and Emerging Asian Countries. Housing market deviations are negative and significantly related to ROA indicating that housing market price fluctuations unexplained by market fundamentals is inversely related to bank stability. Importantly from a policy perspective, fundamental housing price growth can be viewed as a contributory factor increasing ROA; however, non-fundamental based price deviation has a negative impact on ROA. Suggesting, bank stability decreases during periods of non-fundamentally linked housing price fluctuations, but stability increases when price growth is an artifact of fundamental economic improvements.

Tables 6 and 7 show results of the NPL model from Equation (5) for OECD and emerging Asian countries. A non-performing loan (NPL) is defined as a loan close to default or already in the default process. In general, we define a loan as non-performing when interest and principal payments are past due by 90 days or more; at least 90 days of interest payments have been capitalized, refinanced, or delayed by agreement; or payments are less than 90 days overdue but there are other good reasons to doubt that

Table 6. Results of panel data analysis with fixed effect for NPL model (Pre-GFC 1990 - 2007).

	OECD Countries		Emerging Asian Countries	
Dependent Variable: NPL	(1)	(2)	(3)	(4)
Asset	−0.238***	−0.198***	−0.829	1.265
	(0.0532)	(0.0551)	(0.908)	(0.912)
Equity	0.0808***	0.0788***	0.259***	0.344***
	(0.00722)	(0.00741)	(0.0678)	(0.0721)
Income	0.0283***	0.0307***	−0.0827	−0.577***
	(0.00535)	(0.00558)	(0.166)	(0.171)
Cost	−0.00655***	−0.00251	0.102***	0.160***
	(0.00206)	(0.00207)	(0.0213)	(0.0219)
Loangrowth	−0.113***	−0.136***	−0.260	−0.468***
	(0.0156)	(0.0158)	(0.160)	(0.174)
ChangeHP	−10.59***		−0.994	
	(0.604)		(2.815)	
DeviationHP		0.710***		−0.238
		(0.110)		(0.902)
Constant	5.754***	7.394***	7.133	−9.248
	(0.437)	(0.687)	(9.732)	(10.25)
Observations	21,917	21,917	868	914
Number of banks	4,378	4,378	343	353
R^2-adjusted	0.067	0.050	0.293	0.314
F-test	57.04	43.11	11.65	13.81
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

Table 7. Results of panel data analysis with fixed effect for NPL model (Post-GFC 2008 - 2017).

	OECD Countries		Emerging Asian Countries	
Dependent Variable: NPL	(1)	(2)	(3)	(4)
Asset	0.0822***	0.0526**	0.0648	0.176***
	(0.0246)	(0.0226)	(0.0504)	(0.0607)
Equity	0.000276	0.000882	0.0631***	0.0436*
	(0.00587)	(0.00552)	(0.0235)	(0.0252)
Income	0.0586***	0.00926	−0.124***	−0.135***
	(0.0115)	(0.0112)	(0.0376)	(0.0408)
Cost	−0.00125	−0.000592	0.0118*	0.0385***
	(0.000914)	(0.000874)	(0.00650)	(0.00707)
Loangrowth	−0.0953***	−0.104***	−0.293***	−0.342***
	(0.00843)	(0.00802)	(0.0708)	(0.0800)
ChangeHP	−3.905***		−5.325***	
	(0.409)		(1.939)	
DeviationHP		1.133***		2.826***
		(0.0925)		(0.598)
Constant	1.264***	7.600***	3.233***	10.94***
	(0.200)	(0.530)	(0.784)	(2.057)
Observations	43,749	47,469	2,714	2,410
Number of banks	11,367	11,807	638	613
R^2-adjusted	0.059	0.063	0.039	0.060
F-test	134.29	161.12	5.60	7.62
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

payments will be made in full.[13] Using fixed-effect panel data analysis, we examine the effect of loan growth and housing market fluctuation on bank NPL ratios, controlling for bank-specific factors such as bank size (*Size*), equity-to-asset ratio (*Equity*), interest

income to total asset ratio (*Income*), and total cost to income ratio (*Cost*). We also adopt house price changes and deviation of house price as two covariates potentially influencing NPL. Importantly, again, deviation in house prices away from fundamental expectations increases the NPL ratio, implying that housing price fluctuations not supported by economic fundamentals are contemporaneously and positively correlated with banks' NPL ratios in both OECD and emerging Asian countries in the pre-GFC period. OECD and Asian countries exhibit a negative NPL response to increases in equity-to-asset ratio (*Equity*); while an increase in *Income* lowers NPL ratios in Asian banks only.[14] Increases in the cost to total income ratio (*Cost*) is positively related to NPL for both country sets. Increases in loan growth (*Loangrowth*), and change in house prices (*ChangeHP*) lowers NPL.

Table 7 presents the results of NPL models, from Equation (5), for the post-GFC period. We generally find more conformity between OECD and Asian countries post-GFC. Increases in equity-to-asset ratio (*Equity*), income to total asset ratio (*Income*), loan growth (*loangrowth*), and change of house price (*ChangeHP*) lowers NPL ratios. And, again, deviation in house price tends to increases a banks' NPL ratio. In both NPL and NPL models we find that housing price overreaction can deteriorate bank stability and increase bank riskiness.

Bank Financial Stability and Z-Score

Based on previous studies (Lepetit & Strobel, 2013; Boyd & Graham, 1986; Hannan & Hanweck, 1988; and Boyd et al., 1993), we construct a Z-score to proxy for individual bank stability. We expect Z-scores to play a critical role when measuring bank risk as well as overall financial stability. We follow the following specification by Lepetit and Strobel (2013):

$$Z - score_{i,t} = \frac{ROA_{i,t} + CAR_{i,t}\left(\frac{capital}{asset}\right)}{SD(ROA_{c,t})} \tag{7}$$

The nominator of Z-score is the sum of the return on assets ($ROA_{i,t}$) and capital-asset ratio ($CAR_{i,t}$) for bank *i* in current period *t* and the denominator of Z-score measure is the standard deviation of the return on assets within each individual country *c* in current period *t* denoted as SD(ROA). The Z-score provide an important measure of bank's financial soundness. If the Z-score is higher values, it implies a higher degree of financial stability, and thus we interpret it a direct measure of bank stability in any country *c*. In our analysis, we take a natural logarithm of the Z-score which in the form of normal distribution.

Table 8 includes results of fixed effects panel data with Z-score as the dependent variable from 1990 to 2007, we find that the bank Z-score has a positive relationship with equity and income while loan growth has a negative relationship with bank Z-score. Consistently, the deviation of house prices has a negative relationship with bank Z-scores confirming that the deviation from fundamental macroeconomic variables negatively impacts a bank's financial stability. In Table 9, examining the period of 2008 to 2017, we find *asset*, *cost*, and *income* have a negative relationship with Z-score along with change in housing price and deviation in house price. We attribute this finding to asset size as

Table 8. Results of panel data analysis with fixed effect for Z-score model (Pre-GFC 1990 - 2007).

	OECD Countries		Emerging Asian Countries	
Dependent Variable: Z-score	(1)	(2)	(3)	(4)
Asset	−0.0861***	−0.0862***	−0.128***	−0.117***
	(0.00212)	(0.00214)	(0.0163)	(0.0167)
Equity	0.0478***	0.0475***	0.0334***	0.0350***
	(0.000211)	(0.000208)	(0.000962)	(0.00102)
Income	0.000832***	0.00100***	−0.000228	−0.0000520
	(0.000187)	(0.000191)	(0.000536)	(0.000593)
Cost	−0.000422***	−0.000438***	−0.00166***	−0.00172***
	(0.000061)	(0.0000604)	(0.000322)	(0.000338)
Loangrowth	−0.00219***	−0.00186***	−0.00411	−0.000945
	(0.000588)	(0.000587)	(0.00390)	(0.00424)
ChangeHP	0.0123		−0.0385	
	(0.0207)		(0.0467)	
DeviationHP		−0.0203***		−0.0263
		(0.00420)		(0.0195)
Constant	3.351***	3.254***	2.973***	2.712***
	(0.0160)	(0.0252)	(0.148)	(0.167)
Observations	50,449	51,363	1,834	1,935
Number of banks	9,108	9,212	596	614
R^2-adjusted	0.624	0.626	0.680	0.642
F-test	3,112.45	3,202.42	117.58	105.67
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

Table 9. Results of panel data analysis with fixed effect for Z-score model (Post-GFC 2008 - 2017).

	OECD Countries		Emerging Asian Countries	
Dependent Variable. Z-score	(1)	(2)	(3)	(4)
Asset	−0.0144***	−0.0141***	−0.00317*	−0.00229
	(0.000917)	(0.000870)	(0.00166)	(0.00173)
Equity	0.0525***	0.0533***	0.0386***	0.0376***
	(0.000178)	(0.000173)	(0.000564)	(0.000547)
Income	−0.00123***	−0.00104***	−0.00144	−0.00149
	(0.000312)	(0.000309)	(0.00113)	(0.00106)
Cost	−0.0000837***	−0.0000897	0.0000692	−0.000215
	(0.0000304)	(0.0000285)	(0.000200)	(0.000196)
Loangrowth	−0.000459	−0.000563*	−0.00358	−0.00507**
	(0.000317)	(0.000311)	(0.00236)	(0.00232)
ChangeHP	−0.195***		−0.164**	
	(0.0141)		(0.0665)	
DeviationHP		−0.0472***		0.00105
		(0.00331)		(0.0165)
Constant	3.125***	2.847***	2.241***	2.185***
	(0.00662)	(0.0186)	(0.0257)	(0.0573)
Observations	76,311	81,468	3,604	3,224
Number of banks	19,080	19,743	810	784
R^2-adjusted	0.632	0.634	0.634	0.665
F-test	6,552.63	7,118.79	320.48	321.09
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

functionally important during the financial recovery period from a bank stability perspective. Also the fluctuation of housing price and deviation of housing price negatively affects the overall z-score especially in OECD countries.

Table 10. Results of interaction effect for ROA model.

	OECD Countries		Emerging Asian Countries	
Dependent Variable: ROA	(1)	(2)	(3)	(4)
	(Pre-GFC 1990 - 2007)			
Loangrowth	0.0374***	0.0829**	0.0787**	0.129
	(0.00422)	(0.0329)	(0.0325)	(0.107)
Loangrowth × ChangeHP	−0.0319		0.399*	
	(0.0651)		(0.231)	
Loangrowth × DeviationHP		0.0092		0.0107
		(0.0067)		(0.0233)
Constant	2.457***	2.526***	1.336	2.689**
	(0.0965)	(0.172)	(1.216)	(1.289)
Observations	50,557	51,473	1,835	1,936
Number of banks	9,167	9,271	597	615
R2-adjusted	0.135	0.132	0.116	0.118
F-test	279.54	279.17	6.90	7.52
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)
	(Post-GFC 2008 - 2017)			
Loangrowth	0.0224***	0.135***	0.0223	0.0415
	(0.00389)	(0.0519)	(0.0200)	(0.0669)
Loangrowth × ChangeHP	−0.0396		0.508**	
	(0.0723)		(0.252)	
Loangrowth × DeviationHP		−0.0209**		−0.00728
		(0.0097)		(0.0167)
Constant	1.001***	−0.704***	1.453***	1.663***
	(0.0663)	(0.206)	(0.170)	(0.536)
Observations	76,358	81,520	3,604	3,224
Number of banks	19,100	19,762	810	784
R^2-adjusted	0.144	0.140	0.257	0.272
F-test	602.38	630.10	59.92	56.69
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. In this model we extend Equation (7) to include two interaction terms. For brevity we only include the coefficient result of loan growth and loan*change HP, and loangrowth * Deviation HP. All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses.

*, ** and *** denote significance at 10%, 5%, and 1%, respectively.

Interaction Effect from Fluctuation of Housing Price and Loan Growth

In this analysis, we expand previous models to include interaction terms between loan growth and housing market fluctuation variables to test financial accelerator theory, which implies that increases in loan growth are linked to rising housing prices, and also increases the value of underlying collateral assets held by individual banks. As denoted in Equation 6, we create two interaction terms between loan growth and change of house price (*loangrowth* × *changeHP*) and between loan growth and deviation in house price (*loangrowth* × *deviationHP*). If loan growth and change of house price simultaneously occurs, we expect the interaction effect to significantly, more so than that of a simple linear relationship, affect our dependent variables. Tables 10 and 11 presents the result of the interaction effect of loan growth and change of house price and deviation of house price with ROA and NPL. We find some evidence that loan growth coupled with an increase in house price increase ROA pre- and post-GFC. And the interaction of loan growth and change in house price deviation has a negative impact on banks' ROA post-GFC. Relatedly, in the post-GFC NPL model, decreased bank stability is associated with loan growth and house price deviations in OECD countries.

Table 11. Results of interaction effect for NPL model.

	OECD Countries		Emerging Asian Countries	
Dependent Variable: NPL	(1)	(2)	(3)	(4)
	(Pre-GFC 1990 - 2007)			
Loangrowth	−0.185***	−1.241***	−0.157	−1.151**
	(0.0223)	(0.156)	(0.167)	(0.526)
Loangrowth × ChangeHP	1.461**		−3.828**	
	(0.324)		(1.812)	
Loangrowth × DeviationHP		−0.225***		−0.177
		(0.0315)		(0.129)
Constant	6.009***	10.18***	6.699	−7.243
	(0.441)	(0.789)	(9.701)	(10.35)
Observations	21,917	22,352	868	914
Number of banks	4378	4,441	343	353
R2-adjusted	0.068	0.053	0.299	0.316
F-test	55.50	43.57	11.35	13.20
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)
	(Post-GFC 2008 - 2017)			
Loangrowth	−0.0907***	−1.361***	−0.221**	−0.379
	(0.00934)	(0.139)	(0.0942)	(0.259)
Loangrowth × ChangeHP	−0.202		−1.385	
	(0.179)		(1.200)	
Loangrowth × DeviationHP		0.235***		−0.0100
		(0.0260)		(0.0668)
Constant	1.247***	9.615***	3.025***	11.03***
	(0.201)	(0.574)	(0.804)	(2.145)
Observations	43,749	47,469	2,714	2,410
Number of banks	11,367	11,807	638	613
R^2-adjusted	0.059	0.066	0.040	0.060
F-test	125.98	156.53	5.34	7.14
(*p*-value)	(0.000)	(0.000)	(0.000)	(0.000)

Note. In this model we extend Equation (7) to include two interaction terms. For brevity we only include the coefficient result of loan growth and loan*change HP, and loangrowth * Deviation HP. All regressions include time fixed effects and R2-adjusted estimator reports within fixed-effects model. F-test denotes goodness of fit in regression model. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5%, and 1%, respectively.

Conclusion

In our study, we analyze the relationship between fluctuations of house price, deviation of house price from its fundamentals, and stability of individual banks for OECD and emerging Asian countries. Rather than adopting simple house price changes, we estimate the difference between house price and its fundamentals for OECD and emerging Asian countries using the PMG estimator suggested by Pesaran et al. (1999) and the Mean Group (MG) estimator introduced by Pesaran and Smith (1995). We expect deviation of house price from fundamentals to be a critical factor impacting bank stability, e.g., ROA and NPL.

We find the presence of house price deviations in each country, a significant positive long-run relationship between house price, GDP per worker, and population growth. While, decreasing interest rates increase housing prices. There is also a negative and significant speed adjustment, implying an equilibrium relationship between short- and long-run estimations, indicating that approximately 6% of disequilibrium over a one-year interval adjusts toward market equilibrium. Loan growth has positive impacts on ROA during our analysis. Pre-GFC (1990 to 2007), house price changes had a positive effect on bank ROA, especially in OECD countries. We attribute this result to the extended role of residential financial systems in OECD countries compared with emerging Asian

countries. Furthermore, it is interesting to note that housing market deviation is significant and negatively related to bank ROA post-GFC (2008–2017), but not pre-GFC. Similarly, in the NPL ratio model, deviation of house price has a significant positive relationship with a banks' NPL ratio, implying increased house price deviation negatively impacts a banks stability in both OECD and emerging Asian countries. This finding indicates that a possible over-reaction or housing market fluctuation unexplained by market fundamentals is directly related to increases in NPL loans in banks' portfolios. Thus, in both ROA and NPL models, we find that an overreaction as a proxy for deviation of house price can deteriorate bank stability and increase bank riskiness. The interaction effect of loan growth and change in house price deviation has a negative impact on banks' ROA post-GFC, suggesting soaring house prices and increases in loans are associated with induced financial losses in overall ROA. In the post-GFC NPL model we observe a similar finding resulting in decreased bank stability associated with loan growth and house price deviations.

To sum, the interdependence between residential and financial markets have tightened and, therefore, the fluctuation of residential markets has directly related to bank performance in both stability and riskiness. According to the financial accelerator theory, Bernanke et al. (1996), increased housing prices also positively affect the underlying collateralized asset value for the borrower, allowing additional equity loans. This loan growth becomes a catalyst for residential housing market price increases. However, the recent global financial crisis also shows how growth in residential mortgages can negatively affect the banking sector through low mortgage interest rates, loosened credit standards, and expansion of secondary mortgage markets. From a policy perspective, fundamental housing price growth can be viewed as a contributory factor increasing bank stability; however, beware of non-fundamental based price deviation as it has a negative impact on stability. Therefore, bank stability decreases during periods of non-fundamentally linked housing price fluctuations, but stability increases when price growth is an artifact of fundamental economic improvements. Additional source of price deviations stemming from capital inflows are of interest to future research in OECD and Emerging countries.

Notes

1. Bernanke and Gertler (1989) assert that firms' ability to borrow depends on the net worth of their underlying assets. Due to information asymmetry, lenders tend to have little information about the reliability of any given borrower such that banks require borrowers to collateralize their assets to secure the ability to repay. Thus, a decrease in asset value deteriorates the net worth of the underlying asset on the bank's balance sheets. The resulting deterioration of their ability to borrow has a negative impact on their investment. In response, the feedback cycle of falling asset prices tightens lending provisions, worsening financial conditions. This financial feedback loop occurs from a small change in financial markets that interplays with a large change in economic conditions.
2. Case and Shiller (2003) attribute the excess housing returns exceeding predicted values to an increase in sentiment. Shiller (2007) argues that fundamentals do not explain the recent housing boom. Rather, a type of psychological theory better explains the phenomenon: Wheaton and Nechayev (2008) note that the increase in housing prices from 1998 to 2005 could not be explained by demand fundamentals,. Jin et al. (2014) document that market sentiment has a sizable economic impact on residential real estate markets.

3. Two econometric techniques have been adopted to estimate nonstationary dynamic panels where the parameters are heterogeneous across groups: the mean-group (MG) and pooled mean-group (PMG) estimators. The MG estimators are the average coefficients from single time-series regressions for each component of the panel, whereas the PMG estimator depends on the combination of pooled coefficients for the long-run relationship and average coefficients for the short-run dynamics. The PMG estimator posits a homogeneity restriction on the long-run relationship between variables, whereas the MG estimator does not. The main advantage of using the PMG estimator in the context of real estate price analysis is that it relies on economic theory that links real estate price developments to their fundamental value and generates more efficient estimates compared with the MG estimator if the homogeneity restrictions imposed by the theory holds (Koetter & Poghosyan, 2010).
4. During and immediately subsequent to the global financial crisis (GFC), unconventional monetary policy also became commonplace, as financial and real estate markets in many countries experienced large financial losses and experienced a heightened risk environment.
5. A potential limitation of the MG model is that it is quite sensitive to outliers and small model permutations. We have annual data from 1990 to 2017 and thus we consider the time series of data included in our study satisfactory for reliability.
6. Similar to previous studies,our work adopts the measurement of ROA as a proxy for bank profitability and stability. We consider the ROA measurement to be unbiased measure from interest rate fluctuation and change of local or government tax policy on corporate taxation. Alternatively, ROE measure is reflective of country-level tax policy changes, and net interest margin is problematic due to management internal interest rate policy for each financial product. Thus we consider ROA to be an appropriate indicator for bank stability that is unbiased from capital structure preference, operational expenses, and individual bank-level internal interest policy (Kohlscheen et al. 2018).
7. The 8 Asian countries included in our study are China, Hong Kong, Indonesia, Philippines, Malaysia Korea, Thailand, and Singapore, and the 24 OECD countries are the United States, Canada, Japan, Australia, Israel, New Zealand, and European countries (Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom).
8. Analysis includes the country-level PMG estimates, however we only present results from full sample of both aggregated OECD, and emerging countries, respectively.
9. The results of panel cointegration estimator guided by Kao (1999) are omitted for concise presentation and are available upon request.
10. Results from the Hausman test indicated that the PMG model results are potentially more reliable.
11. We opted for panel fixed-effect models because pooled OLS is considered to be a highly restrictive model that assumes common intercept and coefficients for all cross sections without consideration of any individual heterogeneity. And the panel random effects model considers the model to be time invariant. The advantage of the fixed effects model is that is assumes the estimator has common slopes and variance, but it allows country-specific intercepts.
12. Liow and Ye (2017) suggest "regime change" during the financial crisis in public real estate market, increasing market volatility and risk spillover across the international market due to the contagion effect.
13. Clarification and elaboration of issues raised by the December 2004 meeting of the Advisory Expert Group of the Intersecretariat Working Group on National Accounts. International Monetary Fund. June 2005.
14. Since the financial recession (and even before), banks' equity-to-asset ratios have been increasing. The combination of higher minimum capital requirements and stringent stress tests has led to a sharp rise in banking system capital. This focus on bank capital is an international regulatory effort governing bank capital adequacy and stress testing, manifesting in the series of Basel Accords beginning in 1988. This to some degree also impacts the income-to-asset ratio due to higher capital requirements, i.e., less leverage. Both

OECD and emerging Asian banks experienced a negative NPL response to increased equity-to-asset ratios during our sample period that begins shortly after the first of three Basel Accords.

Acknowledgments

The authors gratefully acknowledge valuable comments and suggestions from discussants and participants, especially Dr. Jon Wiley during the 2018 ARES meeting in Florida. The authors modified the unpublished PhD dissertation of Sangjun Lee with a research grant from Hanyang University.

References

Adams, Z. & Fuss, R. (2010). Macroeconomic determinants of international housing markets. *Journal of Housing Economics*, *19*(1), 38–50.

Ben-David, I. (2011). Financial constraints and inflated home prices during the real estate boom. *American Economic Journal: Applied Economics*, *3*(3), 55–87.

Bernanke, B. S. (1995). Inside of a black box: The credit channel of monetary policy transmission. *Journal of Economic Perspective*, *9*(4), 27–48.

Bernanke, B. S., & Gertler, M. (1989). Agency costs, net worth and business fluctuations. *American Economic Review*, *79*, 14–31.

Boyd, J. H., & Graham, S. L. (1986). Risk, regulation, and bank holding company expansion into nonbanking. *Quarterly Review*, *10*(Spr), 2–17.

Boyd, J. H., Graham, S. L., & Hewitt, R. S. (1993). Bank holding company mergers with nonbank financial firms: Effects on the risk of failure. *Journal of Banking & Finance*, *17*(1), 43–63.

Capozza, D. R., Hendershott, P. H., Mack, C., & Mayer, C. J. (2002). Determinants of real house price dynamics (No. w9262). National Bureau of Economic Research.

Case, K. E., & Shiller, R. J. (2003). Is there a bubble in the housing market? Brookings papers on Economic Activity, 2003(2), 299–362.

Davis, E. P., & Zhu, H. (2011). Bank lending and commercial property cycles: Some cross-country evidence. *Journal of International Money and Finance*, *30*(1), 1–21.

Elbourne, A. (2008). The UK housing market and the monetary policy transmission mechanism: An SVAR approach. *Journal of Housing Economics*, *17*(1), 65–87.

Foos, D., Norden, L., & Weber, M. (2010). Loan growth and riskiness of banks. *Journal of Banking & Finance*, *34*(12), 2929–2940.

Gerlach, S., & Peng, W. (2005). Bank lending and property prices in Hong Kong. *Journal of Banking & Finance*, *29*(2), 461–481.

Glindro, E. T., Subhanij, T., Szeto, J., & Zhu, H. (2018). Determinants of house prices in nine Asia-Pacific economies. *26th issue (September 2011) of the International Journal of Central Banking*.

Goodhart, C., & Hofmann, B. (2008). House prices, money, credit, and the macroeconomy. *Oxford Review of Economic Policy*, *24*(1), 180–205.

Hannan, T. H., & Hanweck, G. A. (1988). Bank insolvency risk and the market for large certificates of deposit. *Journal of Money, Credit and Banking*, *20*(2), 203–211.

Hott, C. (2011). Lending behavior and real estate prices. *Journal of Banking & Finance*, *35*(9), 2429–2442.

Huszar, R. Z., & Yu, W. (2019). Mortgage lending regulatory arbitrage: A cross-sectional analysis of nonbank lenders. *Journal of Real Estate Research*, *41*(2), 219–248.

Iacoviello, M., & Minetti, R. (2008). The credit channel of monetary policy: Evidence from the housing market. *Journal of Macroeconomics*, *30*(1), 69–96.

Jin, C., Soydemir, G., & Tidwell, A. (2014). The US housing market and the pricing of risk: Fundamental analysis and market sentiment. *Journal of Real Estate Research*, *36*(2), 187–220.

Kao, C. (1999). Spurious regression and residual based tests for cointegration in panel data. *Journal of Econometrics*, *90*(1), 1–44. (1999)

Kim, S., & Yang, D. Y. (2011). The impact of capital inflows on asset prices in emerging Asian economies: Is too much money chasing too little good? *Open Economies Review*, *22*(2), 293–315.
Kiyotaki, N., & Moore, J. (1997). Credit cycles. *Journal of Political Economy*, *105*(2), 211–248.
Koetter, M., & Poghosyan, T. (2010). Real estate prices and bank stability. *Journal of Banking & Finance*, *34*(6), 1129–1138.
Kohlscheen, E., Murcia Pabón, A., & Contreras, J. (2018). Determinants of bank profitability in emerging markets.
Kok, S. H., Ismail, N. W., & Lee, C. (2018). The sources of house price changes in Malaysia. *International Journal of Housing Markets and Analysis*.
Lepetit, L., & Strobel, F. (2013). Bank insolvency risk and time-varying Z-score measures. *Journal of International Financial Markets, Institutions and Money*, *25*, 73–87.
Liang, Q., & Cao, H. (2007). Property prices and bank lending in China. *Journal of Asian Economics*, *18*(1), 63–75.
Liow, K. H., & Ye, Q. Switching regime beta analysis of global financial crisis: Evidence from international public real estate market. *Journal of Real Estate Research*, *39*(1), 127–164.
McDonald, J. F., & Stokes, H. H. (2013). Monetary policy and the housing bubble. *The Journal of Real Estate Finance and Economics*, *46*, 437–451.
Pan, H., & Wang, C. (2013). House prices, bank instability, and economic growth: Evidence from the threshold model. *Journal of Banking & Finance*, *37*(5), 1720–1732.
Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, *94*(446), 621–634.
Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, *68*(1), 79–113.
Shiller, R. J. (2007). *Understanding recent trends in house prices and home ownership* (No. w13553). National Bureau of Economic Research.
Tillmann, P. (2013). Capital inflows and asset prices: Evidence from emerging Asia. *Journal of Banking & Finance*, *37*(3), 717–729.
Warnock, V. C., & Warnock, F. E. (2008). Markets and housing finance. *Journal of Housing economics*, *17*(3), 239–251.
Wheaton, W., & Nechayev, G. (2008). The 1998–2005 housing "bubble" and the current "correction": What's different this time? *Journal of Real Estate research*, *30*(1), 1–26.
Wong, W. L., Lee, C., & Koong, S. S. (2019). Housing prices in peninsular Malaysia: supported by income, foreign inflow or speculation? *International Journal of Housing Markets and Analysis*.

Appendix 1. Top 5 banks for selected countries.

Countries	Top 5 banks				
Germany	Deutscher Sparkassen-und Giroverband	Deutsche Bank AG	Sparkassen-Finanzgruppen (Combined)-Sparkassen	Commerzbank AG	DZ Bank AG-Deutsche Zentral-Genossenschaftsbank
United States	Freddie Mac	JP Morgan Chase Bank, NA	Bank of America,	Citibank NA	Wells Fargo Bank, NA
Italy	UniCredit SpA	Intesa Sanpaolo	Banca Monte dei Paschi di Siena SpA	Banca IMI SpA	Unione di Banche Italiane Scpa-UBI Banca
Japan	Japan Post Bank Co. Ltd	Bank of Tokyo-Mitsubishi UFJ	Sumitomo Mitsui Banking Corporation	Mizuho Bank	Norinchuk in Bank
France	Credit Agricole	BNP Paribas	Credit Agricole S.A.	Societe Generale	BPCE SA
United kingdom	Barclays Bank Plc	Royal Bank of Scotland Plc	Lloyds Bank Plc	HSBC Bank Plc	Goldman Sachs International
Switzerland	UBS AG	Credit Suisse AG	Raiffeisen Schweiz Genossenschaft	DieSchweizerische Post AG	PostFinance AG
Hong Kong	Hongkong and Shanghai Banking Corporation	Bank of China (HongKong)	HangSeng Bank Ltd	Standard Chartered Bank (Hong Kong)	Bank of East Asia Ltd
Malaysia	Malayan Banking Berhad-Maybank	Public Bank Berhad	CIMB Bank Berhad	Hong Leong Bank Berhad	Maybank Islamic Berhad
China	Industrial & Commercial Bank of China (ICBC)	China Construction Bank Corporation	Agricultural Bank of China	Bank of China Ltd	China Development Bank Corporation
Korea	KB Kookmin Bank	Woori Bank	Shinhan Bank	Industrial Bank of Korea	Hana Bank