House Prices and Bank Stability: Evidence from Emerging Countries

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การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อให้หลักฐานเชิงประจักษ์ว่าราคาอสังหาริมทรัพย์มีผลกระทบต่อความมั่นคงของธนาคารในประเทศเกิดใหม่ภายใต้ระดับที่แตกต่างกันของการเจริญเติบโตทางเศรษฐกิจ และเงินทุนไหลเข้า (เงินลงทุนโดยตรงจากต่างประเทศและการลงทุนในพอร์ตโฟลิโอ) ทั้งสองสมมติฐานการแข่งขันซึ่งเป็น collateral value hypothesis และ deviation hypothesis ที่ใช้ในการพยายามที่จะอธิบายความสัมพันธ์เหล่านี้ รูปแบบเกณฑ์ถูกนำไปใช้และผลที่แสดงให้เห็นว่าในช่วงภาวะเศรษฐกิจที่ไม่ดีและเงินทุนไหลออก (ด้านล่างผลกระทบเกณฑ์) สามารถให้เหตุผลตาม deviation hypothesis โดยใช้การเบี่ยงเบนของราคาบ้านเป็นปัจจัยของราคาบ้านราคาบ้านสูงเบี่ยงเบนไปจากมูลค่าพื้นฐานทำให้ ความมั่นคงของธนาคารลดลง ในขณะที่ในช่วงเวลาของการขยายหรือเงื่อนไขทางเศรษฐกิจที่ดี (สูงกว่าเกณฑ์ผลกระทบ) สามารถให้เหตุผลตาม collateral value hypothesis โดยใช้ดัชนีราคาบ้านเป็นปัจจัยของราคาบ้าน แต่เงินทุนไหลเข้าสูงและภาวะเศรษฐกิจที่ดีมีผลในเชิงบวกต่อความมั่นคงของธนาคาร

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This study aims to provide empirical evidence whether the real estate price affects bank stability in emerging countries under the different levels of economic growth (GDP per capita) and capital inflows (foreign direct investments and portfolio investments). The two competing hypotheses which are collateral value hypothesis and deviation hypothesis are used in attempt to explain these relationships. The threshold model is applied and the results show that during bad economic conditions and capital outflows (below threshold effects), only deviation hypothesis holds using house price deviations as house price determinant, the house prices highly deviate from their fundamental value and cause the lower bank stability. While in the period of expanding or good economic conditions (above threshold effects), collateral value hypothesis holds using house price index as house price determinant. However, high capital inflows and good economic conditions has a positive effect on bank stability.

Department:	Banking and Finance	Student's Signature	....
Field of Study:	Finance	Advisor's Signature	....
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1. Introduction

1.1 Background and motivation

The asset prices play important role in worldwide financial market. Many investors and lenders use it as collateral for lending and mortgage loans. Demand and supply are the driven factors of real estate prices and also the macroeconomic fundamentals such as GDP per capita, population growth, interest rate and national wealth. Therefore, the real estate prices should reflect economic factors (Collyns and Senhadji, 2002; Leamer, 2007).

The real estate as collateral on bank's lending plays important role, even though there are high costs of evaluation, utilization and liquidation (Hainz, 2003). During the boom market, the value of real estate owned by banks increase and also the value of collateral. The price appreciation decrease the chance of the borrower from default (Daglish, 2009). Therefore, appreciation in real estate prices increase the value of bank asset and their stability (Niinimaki, 2009). On the other hand, market recession, increasing in house prices could enhance the bank's risk because of moral hazard and adverse selection problems (Allen and Gale, 2001). Risky investors could use the mispriced collateral to demand more credit from banks. It leads to the large number of risky assets, which tend to be overvalued and do harm to bank stability (Von, 2009). The banking sector plays an important role of driven the deviation on fundamental value (Kiyotaki and Moore, 1997).

Moreover, the appreciation of asset prices can trigger the asset price bubble in which it can also trigger the financial crisis. This will certainly affect bank stability as mortgage lender that frequently use real estate as collateral. The statistical numbers show that over four hundreds bank failed during U.S. crisis (2008-2011)[1]. Moreover, the asset bubble is the origin of the worst financial crises that begin with the Asian financial crisis (1997) and then the subprime mortgage crisis (2007-2009). They had the overpriced collateral value that jeopardized the bank sector and lead to the bankruptcy in many financial markets.

[1] The number is based on the Failed Bank List from the Federal Deposit Insurance Corporation.

In the early 1990s, Thailand planned to be the leader of financial market in Southeast Asia. Thus, Thailand decided to establish the Bangkok International Banking Facility (BIBF) in 1993. The objective of BIBF was to borrow money from the United States, Japan and Europe to lend to neighbor countries. Since Thailand had higher interest rates than the neighbors, the foreign money was loaned to Thai speculators. This event caused excessive short-term capital inflows called “hot money”. Some inflows fueled a bubble in the Thai property market. The speculators used the real estate price as collateral value and required extended loans, while the financial institutes had to increase their lending by the inflows. When it became obvious that the price exceeded the real value of the property. They are quickly sold by speculators and caused the price collapse called the bubble burst (Leightner 1999).

In 1997, The Asian financial crisis started in Thailand with the collapse of the Thai baht after the Thai government was forced to float the baht because the lack of foreign-exchange reserves (FX reserves) to support fixed exchange rate. Thailand had acquired a burden of foreign debt that made the financial institutes including banks encountered bankruptcy and the collapse of currency[2]. The financial crisis in Thailand has triggered the financial crisis in many countries in Asia.

The subprime mortgage crisis (2007-2009) is considered as the worst financial crisis since the Great Depression in 1930s (Pendery, 2009). The origin of the crisis are the expansion of household debt that used devaluated real estate prices to demand more loans. The household debt was financed with mortgage-backed securities (MBS) and collateralized debt obligations (CDO). They offered attractive rates of return due to the higher interest rates on the mortgages. Nonetheless, the lower credit quality caused massive defaults. When real estate prices are continuously declined with increasing in household debt, several major financial institutions tend to be collapsed (Mian and Sufi 2014; Lemke and Picard 2013). In large areas, the real estate market suffered from this crisis. It played crucial role in the downturn of economic activity. Moreover, it contributed to the European sovereign-debt crisis and the global recession (Baily and Elliott, 2009). The housing bubble in United States caused the value of securities, which tied real estate price to be crushed and jeopardized to worldwide financial institutions and also

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[2] Article from www.euromoney.com. Asian financial crisis: When the world started to melt Full article: http://www.euromoney.com/Article/1005746/When-the-world-started-to-melt.html?copyrightInfo=true
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caused the international trade declined (Simkovic, 2011). The imperfect real estate markets can do harm to the financial sector because most of lenders are banks. They tend to use real estates as collateral for mortgage lending (Goodhart and Hofmann, 2007). The less liquid of collateral asset it is, the higher are the costs on lenders such as the evaluation, utilization and liquidation. They are the cost that depends on legal and institutional policy (La Porta et al., 1997, 1998). The spillover effects of the U.S. financial crisis on financial markets in emerging Asian countries are obviously found by Fratzscher M., et al. (2013) and Cho D., et al. (2013). Their paper found that QE1 made significant contributions to the capital inflows to the region after the global financial crisis. By lowering US yield rates, the capital flows toward Asia, which suffered from US dollar liquidity shortage during crisis. Housing prices in some Asian countries have increased. This also seems to be affected by the QE policies and capital flows, as housing prices rose more in the economies where currencies have not appreciated. Thus, the spillover of liquidity risk and volatile risk in capital flows were the main risk to Asian countries during the crisis.

To estimate the impact of house prices on bank stability, Non-performing loans[3] (NPLs) have been frequently used in many studies as bank stability indicator (Nkusu, 2011; Kauko, 2012, Pan and Wang 2013). From previous studies, there are two competing hypotheses about the effect of house price on bank stability, which are the collateral value hypothesis and the deviation hypothesis. The collateral value hypothesis argues that increasing in house prices improve bank stability by increasing the value of collateral own by banks during the boom market. Banks tend to extend the lending to borrowers while the collateral value keep rising along with bank stability. So, the collateral value hypothesis suggests the positive relationship between the house price changes and bank stability. Due to the decreasing in risky assets as knows as non-performing loans, it should suggest negative relationship between bank stability and NPLs (Daglish, 2009; Niinimaki, 2009). On the other hand, the deviation hypothesis argues that rising house price increase larger exposure of risky asset because of the excessive lending to risky borrowers who demand higher credits and bet on future rising in house prices. When the prices drop, borrower ability to refinance became harder. The borrowers who cannot pay higher monthly payments

[3]According to the definition by the IMF: ‘‘A loan is non-performing when payments of interest and principal are past due by 90 days or more, or 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 payments will be made in full’’.

in mortgage loans began to become default. Then, banks tend to have excessive risky assets and easily face the bankruptcy when house price dramatically drop in the bust market. Thus, the deviation hypothesis suggests the negative relationship between the house price changes and bank stability (Allen and Gale, 2001; Von, 2009).

Recent researchers have argued that house price deviation from long-run equilibrium should be considered as its relationship between house prices and bank stability (Koetter and Poghosyan, 2010). This paper addresses the questions of how the house prices affect the bank stability using the house prices and bank specific variables of five Asian countries: Indonesia, Malaysia, China, Taiwan, and Thailand from 2002Q1 to 2014Q4. According to recent paper, Kim, B.-H., et al. (2015) find a strong spillover effect in the foreign-exchange market in emerging Asian countries: Indonesia, Philippines, Taiwan, and Thailand during 2007-2009. These countries reflect the high capital inflows after U.S. financial crisis. The different between this study and previous studies is that the data collected from emerging countries to provide new empirical evidence from Asian countries. Furthermore, the capital flows from global crisis are considered as the economic change indicator along with national income growth.

The factors of demand and supply of real estate are important to determine house prices. The main factors on demand side are population, GDP per capita, interest rate, house price growth and the capital inflows. For supply side, the main factors are house prices, construction costs and financing source (DiPasquale and Wheaton, 1995). GDP per capita and population growth are used to determine house price changes and deviation as many recent studies that focus on the demand side (Stepanyanet al., 2010).

In this study, I focus on the two main factors that drive house prices, which are GDP per capita and capital flows. I expect the different relationship between bank stability and house prices at different level of GDP per capita growth. During the high GDP per capita growth, I expect the high bank stability, according to the collateral value hypothesis, banks tend to extend the lending to borrowers while the collateral value keep rising along with bank stability. On the other hand, during low GDP per capita growth, I expect low bank stability, according to the deviation hypothesis, banks can be exposed to risky borrowers along with risky assets on recession or asset bubble. Previous empirical evidence finds that human acts in a rational manner. They are subject to the limited ability to predict the prices and returns

(Kahneman et al., 1986; Smith, 1991). The decreases in house prices due to market (human) panic may result in the market collapse and do harm to the bank stability (Shleifer and Vishny, 2010; Stein, 2012). They are consistent with my motivation that the asset price bubble can trigger the financial crisis, which affect the bank stability as the mortgage lenders.

The other main objective is to investigate the impact of house price changes and deviation on bank stability with different capital flows which are foreign direct investments and portfolio investments. Due to the different inflow levels after QE policy from U.S. crisis 2007-2009, the house price changes and deviation may affect the bank stability differently in emerging countries. During inflows, house prices increase along with spillover effect from U.S. financial crisis (Kim, B.-H., et al. 2015), I expect high bank stability according to collateral value hypothesis. During low inflows or outflows, the capital flows affect differently in bank stability. Furthermore, banks can be exposed to the high deviation in house price of risky assets, which lends to high NPLs (low bank stability) according to deviation hypothesis.

To investigate my expectation, I use the threshold model to test the effect of house prices changes or deviation on bank stability under different economic growth levels using GDP per capita as indicator. Additional, I test the effect of house prices changes or deviation on bank stability under different capital flow levels using foreign direct investment (FDI) and portfolio investment as indicators. To estimate house price deviation, I use error correction model according to Koetter M., Poghosyan T. (2010) and Pan and Wang (2013).

1.2 Research questions

1. Do the real estate prices affect bank stability in emerging countries?
2. *If the real estate price do affect bank stability, whether collateral value hypothesis or deviation hypothesis hold under different economic condition?*
3. *Do the real estate price affect bank stability differently and whether collateral value hypothesis or deviation hypothesis hold under different level of capital flows?*

1.3 Objectives & Contributions

The main objectives of this study are the following:

1. To investigate how real estate prices affect bank stability to test whether collateral value hypothesis or deviation hypothesis hold in overall.
2. To investigate how real estate prices affect bank stability under different economic condition identified by using threshold model.
3. To investigate how real estate price affect bank stability under different level of capital inflow identified by using threshold model.

1.4 Hypothesis development

Hypothesis I: The real estate prices affect bank stability in emerging countries

There are two theoretical hypotheses proposed. First, the collateral value hypothesis proposes that increasing in real estate prices strengthen the bank stability. There is the evidence that increasing and decreasing in real estate prices have the effect on bank assets and collateral value of borrower. When the prices increase, the bank stability also increase and vice versa. (Daglish, 2009; Niinimaki, 2009). Banks tend to increase their lending because of strengthening in bank stability during boom market and vice versa.

Second, the deviation hypothesis proposes that the changes in real estate prices from their fundamental value increase the bank default. There is the negative relationship between the real estate price and bank stability because of moral hazard and adverse selection problems. There is the evidence that increasing in real estate prices could harm the bank stability: the risky borrower could pledge the overpriced collateral for excessive lending from bank and jeopardize the bank stability. Furthermore, they could demand more credit from banks. Eventually, the aggregation of risky asset could lend the real estate value to be mispriced and deviated from their fundamental value (Allen and Gale, 2001; Von, 2009). Banks tend to reduce their lending because of information asymmetry on risky assets.

Therefore, these hypotheses are competing with each other. Thus, I simply investigate whether collateral value hypothesis or deviation hypothesis hold in general.

Hypothesis II: Collateral value hypothesis should hold during high GDP per capita growth (economic expansion) and deviation hypothesis should hold during low GDP per capita growth (recession).

Since there are two competing hypotheses that can explain the relationship between house price and bank stability. My expectation is that during high GDP per capita growth the collateral value hypothesis should hold because high house prices improve bank stability by increasing the value of collateral hold by banks. During the economic expansion (good economic condition), the borrowers have higher ability to pay back debt. On the other hand, the deviation hypothesis should hold during the recession (bad economic condition). Even though house prices are high, the banks tend to expose to excessive risky assets from risky borrowers, who have lower ability to pay back the debt.

To examine the impact of house prices on the bank stability, threshold model is used to separate high and low economic growth period. I use two house price indicators, which are house price changes and house price deviation to test the two competing hypotheses with threshold effects (income growth, capital flows). To test the collateral value hypothesis, using house price index as indicator is suggested whereas, to test the deviation hypothesis, using house price deviation is suggested. The estimation proposed by Kick and Koetter (2007), Koetter and Poghosyan, (2010) and Pan and Wang, (2013).

Hypothesis III: Collateral value hypothesis should hold during high net capital flows and deviation hypothesis should hold during low net capital flow.

From previous study, they find the empirical evidence that there are capital flows to emerging countries after global financial crisis. The asset price increase because of the QE policy in United States (Ohno, S. and Shimizu, J., 2015). Additional, Fratzscher M., et al. (2013) and Cho D., et al. (2013) found that QE policy made significant contributions to the capital inflows to the region after the global financial crisis. By lowering US yield rates, the capital flows toward Asia countries, which suffered from US dollar liquidity shortage during crisis. House prices in some Asian countries increased dramatically. This also seems to be affected by the QE policy and capital flows. Therefore, the capital inflows have affect bank stability. Along with high capital inflows, house prices tend to increase and affect the collateral value whether in house price changes or deviation.

From two competing hypotheses, I expect the collateral value hypothesis hold during high net capital flows because house price appreciation improves bank stability by increasing the value of collateral hold by banks. On the other hand, the deviation hypothesis should hold during the period of low net capital flows since the banks have strong exposure to risky assets and risky borrowers.

To examine the impact of house price on the bank stability, I change the threshold variable to net capital flows to find the relationship between bank stability and house price indicators (house price change and house price deviation) under the different level of net capital flows toward emerging Asian countries.

This study organized as follows. Section 2 is literature review. Section 3 is data and methodologies to measure the deviations of house prices from fundamental values and to test the two competing hypotheses during different house price indicators and different economic indicators. For the result is explained in Section 4. Section 5 is conclusion and contribution.

2. Literature Review

In the real estate market imperfections, price is driven by demand factors, such as gross domestic product per capita, population growth, mortgage loan rates, and GDP per capita. Moreover, the market imperfections are suggested that high demand might lead to the deviation of real estate prices from their fundamental value (Iossifov et al., 2008; Hilbers et al., 2008). From most empirical studies, they use demand side for house price determinants due to the limitation of lands, time in construction and mortgage financing. Therefore, the data of real estate price and their determinants have low frequency in supply side. They apply panel data and pool time series for estimation (Terrones and Otrok, 2004; Almeida et al., 2006; Égert and Mihaljek, 2007; Holly et al., 2007; and Kholodilin et al., 2008; Iossifov et al., 2008, Koetter and Poghosyan, 2010).

According to recent studies, to examine the deviation of house price from fundamental value. The mean-group and pooled mean-group estimators are suggested by Pesaran et al. (1999). The mean-group estimator averages the coefficients from time-series regressions in panel. The pooled mean-group estimator averages the pooled coefficients for long-run relationship and averages the coefficients for short-run dynamics. To examine the two competing hypotheses hold in different levels of economic changes, the threshold estimation, which is developed and suggested by Hansen (1999), can also estimate the relationship between house prices and bank stability. This technique is applied in the recent study by Pan and Wang (2013).

In this study, I use house price index to analyze because it depends on the economic environment that can explain the relationship between real estate price and the fundamental value. It can be calculated more efficiency than the mean-group approach if there are any homogeneity restrictions (Muellbauer and Murphy, 1997; Kholodilin et al., 2008; Pan and Wang, 2013). From empirical studies, there are three fundamental determinants of real estate price used in estimators. These are gross domestic product per capita, population growth and interest rate. During the boom real estate market, the demand is high due to population growth and GDP per capita which increase the equilibrium real estate prices. The recent papers present the empirical evidence and find a significant positive long-run relationship between the GDP per worker and house prices (Koetter and Poghosyan, 2010; Pan and Wang, 2013). Nonetheless, real interest rates also affect the capital and the demand for real estate investment in the market. Moreover capital flows influence the supply and demand of real estate. Koetter and Poghosyan, (2010) find empirical evidence on house prices and bank stability in Germany during 1994-2004. Their objective is to support the deviation hypothesis and suggest that bank stability is attributed to house price deviations instead of the changes in nominal house prices. For addition on previous studies, I examine five emerging countries in Asian: Indonesia, Malaysia, China, Taiwan, and Thailand to provide the empirical evidence and the existing of two competing hypothesis in different type of markets and economic conditions. I also use the capital inflow as threshold variable to test these two competing hypotheses.

There are two main examples for crises of housing market that impact the worldwide financial markets. First, the case of Asian financial crisis, recent studies agree on three reasons for this crisis. The first reason is excessive short-term borrowing of foreign inflows convert to excessive long-term lending in the domestic economy. The regional banks fail to match loan maturities for borrowing and lending properly. The second reason is weak financial structure of risk management by banks. Increasing in credit based on the value of collateral is associated with asset price bubbles. When the bubbles burst, the assets that collateralize the loans are obviously mispriced (Sarno and Taylor, 1999). The third reason is moral hazard and government intervention in lending. Chen (1999) shows that moral hazard caused excessive inflows of international capital (hot money) to the Asian economies without the guarantee of government agencies on the credit risk of foreign loans (Chatterjee A. and Maniam S., 2003). These reasons are consistent with deviation hypothesis.

Second, spillover effects of the U.S. financial crisis over financial markets in emerging Asian countries are obviously found by Fratzscher M., et al. (2013) and Cho D., et al. (2013). Their paper found that QE1 (2008Q4 to 2010Q1) made significant contributions to the capital inflows to the region after the global financial crisis by lowering US yield rate. In the meantime, Asia was suffered by US dollar liquidity shortage. Housing prices in some Asian countries have increased. This also seems to be affected by the QE policy and capital flows, as housing prices rose more in the economies where currencies have not appreciated. Thus, the spillover of liquidity risk and volatile risk in capital flows were the main risk to Asian countries during the crisis.

Recent researchers, Tillmann (2013) and Kim, B.-H., et al. (2015) find a strong spillover effect in the asset markets and financial markets in Asian countries. Tillmann (2013) finds that capital inflow shocks significantly increase housing prices and stock prices as in OECD countries.

3. Data and Methodology

3.1 Data

House price index is the main house price indicator provided by World Bank Database and Bloomberg from period 2002Q1-2014Q4 to investigate the two hypotheses during the crisis. For macroeconomic data, I obtain the data from World Bank Database, Datastream and Bloomberg. For the bank-specific data, I obtain the data from Datastream and Bloomberg in Indonesia, Malaysia, China, Taiwan, and Thailand. Tillmann (2013) and Kim, B.-H., et al. (2015) find strong spillover effects in the foreign-exchange market and asset markets in emerging Asian countries: Indonesia, Philippines, Taiwan, Korea, Hong Kong and Thailand. These countries reflect the high capital inflows after U.S. financial crisis.

As previous studies Kick and Koetter (2007), Koetter and Poghosyan, (2010) and Pan and Wang, (2013), I choose the CAMEL measures to approximate banks' Capitalization (C), Asset quality (A), Management skills (M), Earning (E), and Liquidity (L).

I measure the effect of real estate price on bank stability by pool-mean group estimator. I use the financial covariates CAMEL to be control variables suggested by Kick and Koetter (2007). I use threshold estimation technique developed by Hansen (1999) to test whether collateral value hypothesis or deviation hypothesis hold under different level of economic condition and also different level of capital inflows.

3.1.1 House price deviation estimation

Klyuev (2008) applies the fundamental model to examine house prices. He finds there has been the overvaluation in housing market and that house prices can deviate from their equilibrium for long periods of times since 2001 in US housing market. Following Koetter and Poghosyan (2010), the pooled mean group estimators are applied to estimate the house price deviation from long-run fundamental values.

Dependent variables

- House price index (HP)

Independent variables

- GDP per capita (GDP)
- Population growth (POP)
- Real interest rate (REAL)

3.1.2 Economic changes and bank stability by threshold estimation

Dependent variables

- Non-performing loan ratio (NPL) as the proxy of bank stability

Independent variables

- House price index (HP) is the variable as house price indicator to test collateral value hypothesis
- House price deviation (HPD) is the variable as house price indicator to test deviation hypothesis
- GDP per capita (GDP)
- Real interest rate (INT) is the nominal interest rate adjusted for inflation annually
- Foreign direct investment (FDI) as the proxy of long-term net capital flow
- Portfolio investment (PI) as the proxy of short-term net capital flow

Control Variables

For bank-specific variables, I use the data from DataStream and Bloomberg. There are available data from 144 banks of five emerging countries: Indonesia, Malaysia, China, Taiwan, and Thailand. These followings list are the ratios for the control variables in threshold model. Since some data obtained from China are restricted and not reflected the true value of macro-economic variables, thus I analyze another dataset without China to compare the results.

- Capital to asset ratio $= \frac{Total\ equity\ capital}{Total\ assets}$
- Non-performing loan ratio $= \frac{Non-performing\ assets}{Loan\ volumn}$
- Bank efficiency ratio $= \frac{Expenses}{Revenue}$
- Return on assets $= \frac{Operating\ expense}{Total\ equity\ capital}$
- Liquidity $= \frac{Total\ loans}{Total\ assets}$

3.2 Summary statistics

Table 1
Summary statistics
(By countries)

	Mean	Max	Min	SD	P25	P50	P75	Obs
Malaysia								
GDP per capita (USD)	4,787.925	6,012.195	3,697.958	567.996	4,336.455	4,825.141	5,174.050	52
GDP per capita growth (%)	1.007	5.561	-8.278	3.160	-1.247	2.260	3.240	51

Foreign direct investment (Millions, USD)	1,780.072	4,993.737	-1,040.975	1,520.445	641.051	1,520.445	2,852.619	52
FDI changes (%)	52.003	743.181	-241.833	177.314	-33.826	-4.761	102.289	51
Portfolio investment (Millions, USD)	1,479.632	17,122.790	-15,312.810	5,351.227	-560.001	1,122.391	4,760.060	52
PI changes (%)	101.908	3,624.668	-2,520.700	712.162	-95.101	32.553	154.288	50
Taiwan								
GDP per capita (USD)	8,878.684	11,278.1	6,428.016	1,288.845	7,812.060	8,938.038	9,959.339	52
GDP per capita growth (%)	1.266	7.782	-10.350	5.614	-2.280	3.819	5.009	51
Foreign direct investment (Millions, USD)	750.577	290	-2,304	861.854	286.250	653.500	1,057.500	52
FDI changes (%)	22.612	305.822	-373.770	124.567	-58.424	12.296	116.670	47
Portfolio investment (Millions, USD)	334.288	1,017	46	182.842	238.500	308	376.750	52
PI changes (%)	13.632	171.739	-51.467	49.544	-15.457	-2.618	30.615	51
Thailand								
GDP per capita (USD)	2,928.641	3,625.524	2,241.914	387.632	2,637.797	2,913.218	3,240.218	52
GDP per capita growth (%)	0.782	9.348	-7.937	4.697	-2.038	0.398	4.743	50
Foreign direct investment (Millions, USD)	2,082.816	5,649.080	-6,915.930	1,720.685	1,386.798	2,131.490	2,826.048	52
FDI changes (%)	9.477	145.450	-73.303	52.624	-23.935	-8.657	34.013	48
Portfolio investment (Millions, USD)	750.373	6,300.300	-5,192.200	2,059.393	-324.425	732.361	1,694.475	52
PI changes (%)	24.670	357.015	-210.968	143.049	-82.476	46.327	162.316	43

	Mean	**Max**	**Min**	**SD**	**P25**	**P50**	**P75**	**Obs**
Indonesia								
GDP per capita (USD)	1,931.148	2,542.016	1,467.016	321.855	1,649.444	1,911.871	2,194.131	52
GDP per capita growth (%)	1.069	4.147	-4.209	2.561	-0.941	1.867	3.170	51
Foreign direct investment (Millions, USD)	2,735.115	8,143	-479	2,355.936	841.250	1,956	4,993.500	52
FDI changes (%)	6.156	246.835	-287.166	78.508	-27.342	-3.122	32.935	49
Portfolio investment (Millions, USD)	2,181.269	9,036	-4,662	2,646.296	342.500	1,756	3,768.750	52
PI changes (%)	41.618	453.293	-201.090	153.472	-48.518	27.839	105.414	46
China								
GDP per capita (USD)	1,908.976	3,675.043	855.91	700.215	1,300.661	1,850.93	2,403.020	52
GDP per capita growth (%)	-2.736	26.941	-26.781	15.945	1.780	9.225	19.703	39
Foreign direct investment (Millions, USD)	42,171.577	105,237	8,332	24,404.78	19,548.500	39,348.5	59,209.25	52
FDI changes (%)	10.583	175.378	-47.201	39.282	-14.723	1.910	31.127	51
Portfolio investment (Millions, USD)	11,969.288	47,101	18	10,144.01	4,853.500	9,646.5	16,920.5	52

PI changes (%)	18.154	366.633	-95.964	89.813	-44.614	-5.356	73.424	48

Summary statistics of the macro variables are reported in Table 1, which separated by countries - Indonesia, Malaysia, China, Taiwan, and Thailand. The odd number of standard deviations in China are observed and supported that some data obtained from China are restricted and biased.

Table 1.1
Summary statistics (Overall)

	Mean	Max	Min	SD	P25	P50	P75	Obs
Macro variables								
House price index	131.637	297.780	71.367	48.270	101.543	115.000	146.785	260
GDP per capita (USD)	4,087.075	11,278.1	855.910	2,720.388	2,090.644	3,010.323	5,174.05	260
GDP per capita growth (%)	1.836	26.941	-26.781	9.586	-1.714	2.369	4.395	255
Population (000s)	335,734	1,372,859	22,435	503,178	25,813	66,179	244,74	260
Population growth (%)	0.247	0.496	0.031	0.141	0.0906	0.263	0.357	255
Foreign direct investment (Millions USD)	9,904.031	105,237	-6,915.93	19,526.23	795.763	1,974.56	5,264.25	260
FDI changes (%)	26.994	743.181	-373.770	130.618	-27.710	-1.280	46.950	255
HPI changes (%)	2.087	2.474	1.853	0.008	2.006	2.055	2.150	255
House price deviations	2.041	14.024	-10.067	0.125	-0.532	0.023	0.449	245
Portfolio investment (Millions USD)	3,342.970	47,101	-15,312.810	6,869.992	218.750	892.550	4,629.250	260
PI changes (%)	62.475	3,624.668	-2,520.700	389.280	-43.281	12.883	92.725	248
Real interest rate	0.842	3.075	-0.975	0.057	0.350	0.825	1.3	260
Unemployment rate	4.203	10.470	0.480	2.202	3.065	4.080	4.885	260
Bank-specific variables								
Capital to asset ratio	0.128	0.634	-0.033	0.094	0.087	0.112	0.141	2,579
Non-performing loan ratio	4.922	9.108	0.010	9.108	1.305	2.485	5.378	2,885
Bank efficiency ratio	7.573	4.507	1.670	4.507	4.530	5.870	10.660	2,951
Return on assets	1.157	1.625	-9.330	1.625	0.530	1.150	1.690	2,829
Liquidity	2.818	16.762	0.000	16.762	0.235	0.517	1.186	2,910

Note: The sample contains 17,487 observations

Table 1.2
Summary statistics (Excluding China)

	Mean	Max	Min	SD	P25	P50	P75	Obs
Macro variables								
House price index	140.286	297.780	76.043	49.957	105.542	124.950	159.858	208
GDP per capita (USD)	4,689.235	11,278.1	1,494.922	2,794.922	2,449.629	3,698.001	6,116.150	208
GDP per capita growth (%)	1.088	12.402	-10.350	4.222	-1.849	1.912	3.729	204
Population (000s)	88,064	256,428	22,434	87,071	24,078	47,170	104,153	208

Population growth (%)	0.244	0.496	0.031	0.158	0.087	0.284	0.367	204
Foreign direct investment (Millions USD)	2,808.685	74,284.01	-6,915.93	8,360.661	649.789	1,460.001	2,861.398	208
FDI changes (%)	31.117	743.181	-373.770	129.134	-31.123	-2.673	47.141	204
HPI changes (%)	2.087	2.474	1.853	0.008	2.006	2.055	2.150	204
House price deviations	1.871	14.024	-10.067	0.217	-0.626	0.020	0.455	196
Portfolio investment (Millions USD)	1,449.07	74,284.01	-15,312.81	3,583.136	138.5	524.95	2,861.398	208
PI changes (%)	73.166	3,624.668	-2,520.700	331.010	-41.885	19.697	91.615	199
Real interest rate	0.947	3.075	-0.975	0.939	0.412	0.9	1.425	208
Unemployment rate	4.223	10.350	0.480	2.461	2.838	3.835	5.723	208
Bank-specific variables								
Capital to asset ratio	0.206	0.640	-0.03	0.091	0.090	0.188	0.141	2,261
Non-performing loan ratio	4.732	8.104	0.010	8.820	1.321	2.440	5.046	2,567
Bank efficiency ratio	7.510	4.021	1.670	4.488	4.452	5.801	10.073	2,633
Return on assets	1.063	1.501	-5.510	1.310	0.501	1.188	1.722	2,511
Liquidity	2.743	15.431	0.000	15.768	0.228	0.499	1.175	2,592

Note: The sample contains 15,231 observations

Summary statistics of the macro variables and bank-specific variables in overall are reported in Table 1.1 and the datasets excluding China are reported in Table 1.2. To compare the two datasets, the standard deviation of GDP per capita growth, population, foreign direct investment and portfolio investment drop dramatically and some other variables slightly decrease as well. It means that the dataset excluding China are less biased and more reliable.

Table 1.3
Correlation statistics (Overall)

Variables	NPLs	HPI changes (%)	Population growth (%)	GDP per capita growth (%)	FDI changes (%)	PI changes (%)	Real interest rate	Unemployment rate	Capital to asset ratio	Bank efficiency ratio	Return on assets	Liquidity	House price deviations
NPLs	1.000000												

HPI changes (%)	-0.655701	1.000000											
	(0.0000)	-----											
Population growth	-0.158736	-0.264127	1.000000										
	(0.0136)	(0.0000)	-----										
GDP per capita growth (%)	-0.032751	-0.014304	0.094477	1.000000									
	(0.6129)	(0.8252)	(0.1437)	-----									
FDI changes (%)	0.032656	0.020181	-0.098048	0.050211	1.000000								
	(0.6139)	(0.7553)	(0.1291)	(0.4378)	-----								
PI changes (%)	0.052702	-0.046354	-0.039049	0.012596	0.024822	1.000000							
	(0.4154)	(0.4738)	(0.5463)	(0.8458)	(0.7014)	-----							
Real interest rate	-0.059624	-0.047720	-0.161424	0.007004	-0.017115	0.040419	1.000000						
	(0.3567)	(0.4609)	(0.0121)	(0.9139)	(0.7915)	(0.5323)	-----						
Unemployment rate	-0.054434	0.182059	0.282716	0.001508	0.030463	-0.039525	0.077408	1.000000					
	(0.4002)	(0.0046)	(0.0000)	(0.9814)	(0.6380)	(0.5414)	(0.2312)	-----					
Capital to asset	0.574452	-0.281007	-0.372851	-0.054160	0.004253	0.080569	0.146122	-0.170170	1.000000				
	(0.0000)	(0.0000)	(0.0000)	(0.4026)	(0.9476)	(0.2127)	(0.0233)	(0.0081)	-----				
Bank efficiency	0.314901	-0.246282	0.361731	-0.008787	-0.037850	0.014215	0.117855	0.699556	0.254431	1.000000			
	(0.0000)	(0.0001)	(0.0000)	(0.8921)	(0.5587)	(0.8262)	(0.0678)	(0.0000)	(0.0001)	-----			
Return on assets	0.372734	-0.153281	0.160995	-0.006485	-0.054703	0.087787	-0.118749	0.016007	0.542712	0.428595	1.000000		
	(0.0000)	(0.0173)	(0.0123)	(0.9202)	(0.3979)	(0.1743)	(0.0657)	(0.8047)	(0.0000)	(0.0000)	-----		

Liquidity	-0.047892	0.140481	0.267333	-0.009340	0.011782	-0.118137	-0.036262	0.759749	-0.181863	0.585853	0.120607	1.000000	
	(0.4593)	(0.0292)	(0.0000)	(0.8853)	(0.8556)	(0.0671)	(0.5753)	(0.0000)	(0.0046)	(0.0000)	(0.0616)	-----	
HP deviations	-0.040369	0.045740	0.030403	-0.051314	-0.080436	0.007326	0.097308	-0.048306	0.028717	-0.053761	0.093165	-0.070794	1.000000
	(0.5328)	(0.4797)	(0.6386)	(0.4278)	(0.2134)	(0.9099)	(0.1320)	(0.4554)	(0.6573)	(0.4061)	(0.1493)	(0.2737)	-----

Note: The sample contains 3,380 observations. The number in parenthesis is p-value of correlations.

Table 1.4
Correlation statistics (Excluding China)

Variables	NPLs	HPI changes (%)	Population growth (%)	GDP per capita growth (%)	FDI changes (%)	PI changes (%)	Real interest rate	Unemployment rate	Capital to asset ratio	Bank efficiency ratio	Return on assets	Liquidity	House price deviations
NPLs	1.000000												

HPI changes (%)	-0.745705	1.000000											
	(0.0000)	-----											
Population growth (%)	-0.210277	-0.264716	1.000000										
	(0.0033)	(0.0002)	-----										
GDP per capita growth (%)	0.011338	0.009390	0.023891	1.000000									
	(0.8753)	(0.8966)	(0.7409)	-----									
FDI changes (%)	0.010573	0.012070	-0.076483	-0.013916	1.000000								
	(0.8837)	(0.8673)	(0.2892)	(0.8473)	-----								
PI changes (%)	0.038035	-0.059762	0.016448	0.016274	0.019532	1.000000							
	(0.5985)	(0.4078)	(0.8199)	(0.8218)	(0.7869)	-----							
Real interest rate	-0.145144	-0.100516	0.043248	0.037916	-0.035896	0.028722	1.000000						
	(0.0435)	(0.1632)	(0.5493)	(0.5997)	(0.6193)	(0.6910)	-----						
Unemployment rate	-0.063531	0.192244	0.540988	0.007484	0.029561	-0.040591	0.080731	1.000000					
	(0.3788)	(0.0072)	(0.0000)	(0.9175)	(0.6824)	(0.5742)	(0.2631)	-----					

Note: The sample contains 2,740 observations. The number in parenthesis is p-value of correlations.

Capital to asset ratio	0.561167	-0.582224	0.354667	0.027007	-0.048920	0.058145	0.009068	-0.232591	1.000000				
	(0.0000)	(0.0000)	(0.0000)	(0.7085)	(0.4982)	(0.4206)	(0.9001)	(0.0011)	-----				
Bank efficiency ratio	0.303594	-0.313877	0.912320	0.016874	-0.047982	0.004714	0.090327	0.709614	0.196800	1.000000			
	(0.0000)	(0.0000)	(0.0000)	(0.8154)	(0.5064)	(0.9480)	(0.2104)	(0.0000)	(0.0060)	-----			
Return on assets	0.398121	-0.267685	0.572474	0.018181	-0.067174	0.080882	-0.182096	0.015159	0.553739	0.410431	1.000000		
	(0.0000)	(0.0002)	(0.0000)	(0.8013)	(0.3520)	(0.2622)	(0.0110)	(0.8338)	(0.0000)	(0.0000)	-----		
Liquidity	-0.079937	0.203177	0.479603	-0.010619	0.009810	-0.118793	-0.020016	0.775131	-0.200939	0.621841	0.167284	1.000000	
	(0.2679)	(0.0045)	(0.0000)	(0.8832)	(0.8920)	(0.0990)	(0.7818)	(0.0000)	(0.0050)	(0.0000)	(0.0197)	-----	
House price deviations	-0.063236	0.042773	0.002975	-0.083934	-0.104289	0.004453	0.125596	-0.055270	0.013574	-0.054693	0.104513	-0.086568	1.000000
	(0.3811)	(0.5537)	(0.9672)	(0.2446)	(0.1479)	(0.9509)	(0.0810)	(0.4440)	(0.8510)	(0.4488)	(0.1470)	(0.2301)	-----

3.2.1 Correlation statistics

Correlation statistics of variables are reported in Table 1.3 (in overall) and Table 1.4 (Excluding China). The two tables show the negative relationship between house price changes and non-performing loans. When the house prices increase the non-performing loans decrease which mean that bank stability increases. This relationship is consistent with collateral value hypothesis. Excluding China Table shows the stronger impact of house price and bank stability. As for population growth and bank stability, they also have positive relationship and stronger impact when China is excluded. For another concern variable, the liquidity of bank has positive relationship with house price changes and population growth which is also consistent with collateral value hypothesis. They have stronger impact without China.

3.2.2 Panel unit-root tests

Before I analyze the two datasets, I apply panel unit root tests (Levin, Lin and Chu test; and ADF Fisher-Chi-square test). The results for macro variables and bank-specific variables are reported in Table 1.5 (Panel unit roots tests in overall) and 1.6 (Panel unit roots tests excluding China), where all the tests have a unit root under the null hypothesis. Levin, Lin and Chu test is to test common unit roots with no unit root under the alternative hypothesis whereas ADF Fisher-Chi-square test is to test individual unit roots with some cross-sections without unit root under the alternative hypothesis. Thus, I suggest to test both common and individual unit roots because the datasets are cross-sections between countries.

Table 1.5
Panel unit-root tests
(Overall)

	Method	Statistics	Probability	Stationary
Macro variables				
GDP per capita growth (%)	Levin, Lin & Chu	-22.6277	0.0000	Stationary
	ADF – Fisher Chi-square	211.925	0.0000	Stationary
Population growth (%)	Levin, Lin & Chu	-2.9876	0.0000	1st difference ST
	ADF – Fisher Chi-square	77.0007	0.0000	1st difference ST
FDI changes (%)	Levin, Lin & Chu	-9.4528	0.0000	Stationary
	ADF – Fisher Chi-square	122.336	0.0000	Stationary
HPI changes (%)	Levin, Lin & Chu	-6.3684	0.0000	1st difference ST
	ADF – Fisher Chi-square	74.9989	0.0000	1st difference ST
House price deviations	Levin, Lin & Chu	-5.5668	0.0000	Stationary
	ADF – Fisher Chi-square	62.3848	0.0000	Stationary
PI changes (%)	Levin, Lin & Chu	-5.4547	0.0000	Stationary
	ADF – Fisher Chi-square	104.315	0.0000	Stationary
Real interest rate	Levin, Lin & Chu	-4.0006	0.0000	1st difference ST
	ADF – Fisher Chi-square	83.1683	0.0000	1st difference ST
Unemployment rate	Levin, Lin & Chu	-11.6255	0.0000	1st difference ST
	ADF – Fisher Chi-square	92.4531	0.0000	1st difference ST
Bank-specific variables				
Capital to asset ratio	Levin, Lin & Chu	-3.22371	0.0006	1st difference ST
	ADF – Fisher Chi-square	46.2327	0.0000	1st difference ST
Non-performing loan ratio	Levin, Lin & Chu	-5.0783	0.0000	1st difference ST
	ADF – Fisher Chi-square	96.4351	0.0000	1st difference ST
Bank efficiency ratio	Levin, Lin & Chu	-5.5793	0.0000	Stationary
	ADF – Fisher Chi-square	66.0280	0.0000	Stationary
Return on assets	Levin, Lin & Chu	-3.3858	0.0004	1st difference ST
	ADF – Fisher Chi-square	53.2819	0.0000	1st difference ST
Liquidity	Levin, Lin & Chu	-5.5141	0.0000	Stationary
	ADF – Fisher Chi-square	55.6116	0.0000	Stationary

Table 1.6
Panel unit-root tests
(Excluding China)

	Method	Statistics	Probability	Stationary
Macro variables				
GDP per capita growth (%)	Levin, Lin & Chu	-16.5313	0.0000	Stationary
	ADF – Fisher Chi-square	147.192	0.0000	Stationary
Population growth (%)	Levin, Lin & Chu	-47.6829	0.0000	Stationary
	ADF – Fisher Chi-square	129.120	0.0000	Stationary
FDI changes (%)	Levin, Lin & Chu	-20.5324	0.0000	Stationary
	ADF – Fisher Chi-square	178.894	0.0000	Stationary
HPI changes (%)	Levin, Lin & Chu	-10.3513	0.0000	1st difference ST
	ADF – Fisher Chi-square	92.9611	0.0000	1st difference ST
House price deviations	Levin, Lin & Chu	-10.6159	0.0000	Stationary
	ADF – Fisher Chi-square	99.4796	0.0000	Stationary
PI changes (%)	Levin, Lin & Chu	-18.7441	0.0000	Stationary
	ADF – Fisher Chi-square	193.817	0.0000	Stationary
Real interest rate	Levin, Lin & Chu	-11.4442	0.0000	1st difference ST
	ADF – Fisher Chi-square	122.631	0.0000	1st difference ST
Unemployment rate	Levin, Lin & Chu	-12.5342	0.0000	1st difference ST
	ADF – Fisher Chi-square	110.728	0.0000	1st difference ST
Bank-specific variables				
Capital to asset ratio	Levin, Lin & Chu	-5.7698	0.0000	1st difference ST
	ADF – Fisher Chi-square	86.9535	0.0000	1st difference ST
Non-performing loan ratio	Levin, Lin & Chu	-2.8864	0.0019	1st difference ST
	ADF – Fisher Chi-square	63.5119	0.0000	1st difference ST
Bank efficiency ratio	Levin, Lin & Chu	-4.39449	0.0000	Stationary
	ADF – Fisher Chi-square	23.4870	0.0028	Stationary
Return on assets	Levin, Lin & Chu	-1.2172	0.0018	1st difference ST
	ADF – Fisher Chi-square	34.5511	0.0000	1st difference ST
Liquidity	Levin, Lin & Chu	-1.2509	0.0001	Stationary
	ADF – Fisher Chi-square	32.3539	0.0001	Stationary

3.3 Methodology

House price changes and deviation

First, I analyze house price index by using the pooled mean-group (PMG) estimators suggested by Pesaran and Smith (1995) and Pesaran et al. (1999). PMG estimator is used to estimate non-stationary dynamic panels in which the parameters are heterogeneous across groups. As previous study (Koetter and Poghosyan, 2010), the PMG estimator imposes a homogeneity restriction on the long-run relationship between variables. The long-run relationship between house price index and their fundamentals[4] describe as:

$$HP_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 POP_{it} + \mu_i + \epsilon_{it}, \qquad (1)$$

where i and t subscript indicate country-specific and time; HP is log of house price index; GDP is the log of gross domestic product per capita; POP is the population growth rate; and μ_i is the country-specific fixed effect, then ϵ_{it} is the error term and stationary for all i. The economic meaning of the term ϵ_{it} equals the deviation of house prices in long-run relationship.

The autoregressive distributed lags (ARDL(1,1,1)) dynamic representation of the long-run Eq. (1) is:

$$HP_{it} = \rho_i HP_{it-1} + \theta_1 GDP_{it} + \theta_2 GDP_{it-1} + \theta_3 POP_{it} + \theta_4 POP_{it-1} + \mu_i + \epsilon_{it}. \qquad (2)$$

Given the short time dimension of the panel, I lag house price determinants by one to observe the adjustment in one period quarterly.

The error-correction representation of Eq. (2) as:

$$\Delta HP_{it} = \delta_i (HP_{it-1} - \beta_0 - \beta_1 GDP_{it-1} - \beta_2 POP_{it-1}) + \theta_1 \Delta GDP_{it} + \theta_3 \Delta POP_{it} + \epsilon_{it}, \qquad (3)$$

---

[4] Nominal gross domestic product (GDP) per capita, population growth, and the interest rate are commonly used in the previous literature as the fundamental determinants of house prices cited by Koetter and Poghosyan, (2010).

where $\delta_i = -(1 - \rho_i)$, $\beta_0 = \frac{\mu_i}{1-\rho_i}$, $\beta_1 = \frac{\theta_1 + \theta_2}{1-\rho_i}$, and $\beta_2 = \frac{\theta_3 + \theta_4}{1-\rho_i}$.

The homogeneity restriction is on the coefficients of long-run house price index determinants β_1 and β_2, whereas the intercept β_{0i}, the error-correction speed of adjustment parameter δ and the short-run coefficients θ_1 and θ_3 vary across countries. I expect the negative value in speed of adjustment parameter δ, because it reflects the convergence of house price adjusted to equilibrium over time. If the parameter is positive, it means that the price is diverging from equilibrium. The main objective is to extract the error-correction terms which are the residuals that can be taken as estimates of the error terms;

$$HPD_{it-1} = HP_{it-1} - \hat{\beta}_0 - \hat{\beta}_{1i}GDP_{it-1} - \hat{\beta}_{2i}POP_{it-1} \quad (4)$$

This error-correction term estimated shows the temporary deviations of house price index from their fundamental values at the macro-level and can be used in the analysis as determinant of non-performing loans in because the bank stability is tied to the real estate mortgage quality (Pan and Wang, 2013).

House prices affect bank stability

To test the hypothesis I, I test panel regression of house prices and house price deviations affect the bank stability in overall without economic changes and capital flows.

$$NPL_{it} = \beta_0 + \beta_1 HP_{it-1} + \beta_2 GDP_{it-1} + \beta_3 FDI_{it-1} + \beta_4 PI_{it-1} + \beta_5 Z_{it-1} + e_{it} \quad (5)$$

$$NPL_{it} = \beta_0 + \beta_1 HPD_{it-1} + \beta_2 GDP_{it-1} + \beta_3 FDI_{it-1} + \beta_4 PI_{it-1} + \beta_5 Z_{it-1} + e_{it} \quad (6)$$

where i and t indicate countries and time. NPL is the ratio of non-performing loans to total loans of banks in country i at time t; HP_{it-1} is the (lagged) variable of the log of house price index; HPD_{it-1} is the (lagged) variable of the deviations of house prices from their fundamental values at the country-specific level; GDP_{it-1} is the (lagged) log of GDP per capita; Z_{it-1} is (lagged) bank-specific variables and explanatory variables including real interest rate and unemployment rate quarterly; FDI_{it-1} is the (lagged) log of foreign direct investment; PI_{it-1} is the (lagged) log of portfolio investment.

The negative coefficient between house price changes or house price deviations and the banks' NPLs would support the collateral value hypothesis, which argues that rising house prices improve bank stability by increasing the collateral value of lenders.

The positive coefficient between house price changes or house price deviations and the banks' NPLs would support the deviation hypothesis which argues that the exceeding house prices deviate from their fundamental values then reverse correction will follow and banks may be exposed to risky assets.

Economic changes and bank stability

The bank stability response many ways to the changes in boom housing market to bust housing market. The responses can be attributed to rationality or local thinking (Gennaioli, N., Shleifer, A., 2010; and Gennaioli et al. 2012). Banks may hold many risky assets, since they avoid the risk of holding overvalued collateral. During the bust market, the house price drop could jeopardize bank stability due to excessive risky and mispriced asset that hold by banks. In contrast, during the boom market the house price changes may not impact on bank stability because of rising collateral value that hold by banks. Thus, I expect the impact of house prices on bank stability would be different under many economic growth levels.

Therefore, I split the sample along GDP per capita levels and use the threshold estimation technique developed by Hansen (1999). I estimate NPLs a function of house price deviations income growth, and a vector of bank-specific characteristics. The threshold model is given by

$$NPL_{it} = \begin{cases} \alpha_i + \beta_1 HP_{it-1} + \eta_1 GDP_{it-1} + \varphi_1 Z_{it-1} + e_{it} \quad if \quad GDP_{it-1} \le \tau \\ \alpha_i + \beta_2 HP_{it-1} + \eta_1 GDP_{it-1} + \varphi_1 Z_{it-1} + e_{it} \quad if \quad GDP_{it-1} > \tau' \end{cases}$$

(7)

$$NPL_{it} = \begin{cases} \alpha_i + \beta_1 HPD_{it-1} + \eta_1 GDP_{it-1} + \varphi_1 Z_{it-1} + e_{it} \quad if \quad GDP_{it-1} \le \tau \\ \alpha_i + \beta_2 HPD_{it-1} + \eta_1 GDP_{it-1} + \varphi_1 Z_{it-1} + e_{it} \quad if \quad GDP_{it-1} > \tau' \end{cases}$$

(8)

where i and t indicate countries and time. NPL is the ratio of non-performing loans to total loans of banks in country i at time t; HP_{it-1} is the (lagged) variable of the log of house price index; HPD_{it-1} is the (lagged) variable of the deviations of house prices from their fundamental values at the country-specific level; GDP_{it-1} is the (lagged) log of GDP per capita; Z_{it-1} is (lagged) bank-specific variables and explanatory variables.

The observations are divided depending on whether the threshold variable GDP_{it-1} is smaller or larger than threshold level τ. If the regression slopes $\beta_1$and β_2 are different, then Eq. (7) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HP_{it-1} I(GDP_{it-1} \leq \tau) + \beta_2 HP_{it-1} I(GDP_{it-1} > \tau) + e_{it}, \quad (9)$$

If there exist two threshold levels τ_1 and τ_2 then Eq. (7) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HP_{it-1} I(GDP_{it-1} \leq \tau_1) + \beta_2 HP_{it-1} I(\tau_1 < GDP_{it-1} \leq \tau_2) + \beta_3 HP_{it-1} I(\tau_2 < GDP_{it-1}) + e_{it}, \quad (10)$$

where I(.) is the indicator function.

To determine the number of thresholds, I estimate the fixed effect model allowing for zero, one, two, and three thresholds. First, I estimate τ_1 by least squares. It is the minimum value of the squared residuals from the estimation of Eq. (6). I test the hypothesis of no threshold by $H_0: \beta_1 = \beta_2$. The likelihood ratio test of H_0 is based on statistic $F_1 = \frac{S_0 - S_1(\hat{\tau})}{\widehat{\sigma^2}}$ where S_0 and S_1 are respectively the constrained and unconstrained sum of squared residuals, and $\hat{\sigma} = \frac{1}{n(T-1)} \widehat{e^*}' \widehat{e^*} = \frac{1}{n(T-1)} S_1(\hat{\tau})$, where $\widehat{e^*}$ are the unconstrained residuals at $\tau = \hat{\tau}$. The likelihood ratio statistic is attained by a bootstrap procedure[5].

As I did to determine the number of thresholds by HP_{it-1}, the observations are divided depending on whether the threshold variable GDP_{it-1} is smaller or larger than threshold level τ. If the regression slopes $\beta_1$and β_2 are different, then Eq. (8) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HPD_{it-1} I(GDP_{it-1} \leq \tau) + \beta_2 HPD_{it-1} I(GDP_{it-1} > \tau) + e_{it}, \quad (11)$$

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[5] See Hansen (1999) for more details.

If there exist two threshold levels τ_1 and τ_2 then Eq. (8) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HPD_{it-1} I(GDP_{it-1} \leq \tau_1) + \beta_2 HPD_{it-1} I(\tau_1 < GDP_{it-1} \leq \tau_2) + \beta_3 HPD_{it-1} I(\tau_2 < GDP_{it-1}) + e_{it},$$

(12)

where I(.) is the indicator function.

To determine the number of thresholds, I estimate the fixed effect model allowing for zero, one, two, and three thresholds. First, I estimate τ_1 by least squares. It is the minimum value of the squared residuals from the estimation of Eq. (6). I test the hypothesis of no threshold by $H_0: \beta_1 = \beta_2$. The likelihood ratio test of H_0 is based on statistic $F_1 = \frac{S_0 - S_1(\hat{\tau})}{\widehat{\sigma^2}}$ where S_0 and S_1 are respectively the constrained and unconstrained sum of squared residuals, and $\hat{\sigma} = \frac{1}{n(T-1)} \widehat{e^*}' \widehat{e^*} = \frac{1}{n(T-1)} S_1(\hat{\tau})$, where $\widehat{e^*}$ are the unconstrained residuals at $\tau = \hat{\tau}$. The likelihood ratio statistic is attained by a bootstrap procedure.

The coefficients of house price indicators estimate the impact of house prices on bank stability under different GDP per capita thresholds and used to test the two competing hypotheses, which collateral value hypothesis or deviation hypothesis hold.

For the first hypothesis, the negative coefficient between house price changes and the banks' NPLs would support the collateral value hypothesis, which argues that rising house prices improve bank stability by increasing the collateral value of lenders.

For the second hypothesis, the positive coefficient between house price deviations and the banks' NPLs would support the deviation hypothesis which argues that the exceeding house prices deviate from their fundamental values then reverse correction will follow and banks may be exposed to risky assets with high bank instability.

Capital flows and Bank Stability

I split the sample along foreign investment levels and use the threshold estimation technique. I estimate NPLs a function of house price deviations income growth, and a vector of bank-specific characteristics. The threshold model is given by

$$NPL_{it} = \begin{cases} \alpha_i + \beta_1 HP_{it-1} + \eta_1 FDI_{it-1} + \varphi_1 Z_{it-1} + e_{it} & if \quad FDI_{it-1} \leq \tau \\ \alpha_i + \beta_2 HP_{it-1} + \eta_1 FDI_{it-1} + \varphi_1 Z_{it-1} + e_{it} & if \quad FDI_{it-1} > \tau' \end{cases}$$

(13)

$$NPL_{it} = \begin{cases} \alpha_i + \beta_1 HPD_{it-1} + \eta_1 FDI_{it-1} + \varphi_1 Z_{it-1} + e_{it} & if \quad FDI_{it-1} \leq \tau \\ \alpha_i + \beta_2 HPD_{it-1} + \eta_1 FDI_{it-1} + \varphi_1 Z_{it-1} + e_{it} & if \quad FDI_{it-1} > \tau' \end{cases}$$

(14)

where i and t indicate countries and time. NPL is the ratio of non-performing loans to total loans of banks in country i at time t; HP_{it-1} is the (lagged) variable of the log of house price index; HPD_{it-1} is the (lagged) variable of the deviations of house prices from their fundamental values at the country-specific level; FDI_{it-1} is the (lagged) change in net capital flows as foreign direct investment; Z_{it-1} is bank-specific variables and explanatory variables. The observations are divided depending on whether the threshold variable FDI_{it-1} is smaller or larger than threshold level τ. If the regression slopes $\beta_1$and β_2 are different, then Eq. (13) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HP_{it-1} I(FDI_{it-1} \leq \tau) + \beta_2 HP_{it-1} I(FDI_{it-1} > \tau) + e_{it},$$

(15)

If there exist two threshold levels τ_1 and τ_2 then Eq. (13) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HP_{it-1} I(FDI_{it-1} \leq \tau_1) + \beta_2 HP_{it-1} I(\tau_1 < FDI_{it-1} \leq \tau_2) + \beta_3 HP_{it-1} I(\tau_2 < FDI_{it-1}) + e_{it},$$

(16)

where I(.) is the indicator function.

To determine the number of thresholds, I estimate the fixed effect model allowing for zero, one, two, and three thresholds. First, I estimate τ_1 by least squares. It is the minimum value of the squared residuals from the estimation of Eq. (6). I test the hypothesis of no threshold by $H_0: \beta_1 = \beta_2$. The likelihood ratio test of H_0 is based on statistic $F_1 = \frac{S_0 - S_1(\hat{\tau})}{\widehat{\sigma^2}}$ where S_0 and S_1 are respectively the constrained and unconstrained sum of squared residuals, and $\hat{\sigma} = \frac{1}{n(T-1)} \widehat{e^*}' \widehat{e^*} = \frac{1}{n(T-1)} S_1(\hat{\tau})$, where $\widehat{e^*}$ are the unconstrained residuals at $\tau = \hat{\tau}$. The likelihood ratio statistic is attained by a bootstrap procedure.

As I did to determine the number of thresholds by HP_{it-1}, the observations are divided depending on whether the threshold variable FDI_{it-1} is smaller or larger than threshold level τ. If the regression slopes $\beta_1$and β_2 are different, then Eq. (14) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HPD_{it-1} I(FDI_{it-1} \le \tau) + \beta_2 HPD_{it-1} I(FDI_{it-1} > \tau) + e_{it}, \quad (17)$$

If there exist two threshold levels τ_1 and τ_2 then Eq. (14) is

$$NPL_{it} = \alpha_i + \varphi_1 Z_{it-1} + \beta_1 HPD_{it-1} I(FDI_{it-1} \le \tau_1) + \beta_2 HP_{it-1} I(\tau_1 < FDI_{it-1} \le \tau_2) + \beta_3 HPD_{it-1} I(\tau_2 < FDI_{it-1}) + e_{it}, \quad (18)$$

where I(.) is the indicator function.

To determine the number of thresholds, I estimate the fixed effect model allowing for zero, one, two, and three thresholds. First, I estimate τ_1 by least squares. It is the minimum value of the squared residuals from the estimation of Eq. (6). I test the hypothesis of no threshold by $H_0: \beta_1 = \beta_2$. The likelihood ratio test of H_0 is based on statistic $F_1 = \frac{S_0 - S_1(\hat{\tau})}{\widehat{\sigma^2}}$ where S_0 and S_1 are respectively the constrained and unconstrained sum of squared residuals, and $\hat{\sigma} = \frac{1}{n(T-1)} \widehat{e^*}' \widehat{e^*} = \frac{1}{n(T-1)} S_1(\hat{\tau})$, where $\widehat{e^*}$ are the unconstrained residuals at $\tau = \hat{\tau}$. The likelihood ratio statistic is attained by a bootstrap procedure.

The coefficients of house price indicators estimate the impact of house prices on bank stability under different capital inflow levels and test two competing hypotheses.

For the first hypothesis, the negative coefficient between house price changes or house price deviations and the banks' NPLs would support the collateral value hypothesis, which argues that rising house prices improve bank stability by increasing the collateral value.

For the second hypothesis, the positive coefficient between house price changes or house price deviations and the banks' NPLs would support the deviation hypothesis which argues that the exceeding house prices deviate from their fundamental values then reverse correction will follow and banks may be exposed to risky assets with high bank instability.

To examine the capital inflow and bank stability relationship, another proxy of net capital flows is portfolio investments which represent the short-term flows with more volatile whereas, foreign direct investments represent the long-term flows over period of time.

4. Empirical Results

4.1. House price deviation

Table 2
Deviation of house prices

	Coefficient estimate	SE (Standard Error)
Long-run coefficients		
GDP per capita	0.024** (0.0452)	0.010
Population growth	0.426*** (0.0000)	0.004
Short-run coefficients		
Speed of adjustment	-0.016** (0.0201)	0.026
Change in GDP per capita	0.007*** (0.0000)	0.006
Change in population growth	-0.267 (0.2213)	0.197
Statistics		
Fstat p-value	0.050	
R-squared	0.3915	
Adjusted R-squared	0.3742	
Obs	250	

Note: * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 2 shows the estimation results of PMG for house price deviation. The upper table shows the average long-run coefficient estimates and the lower table shows the average short-run coefficient estimates. The p-value of 0.05 suggests that the PMG estimator is preferable. For my expectation and the previous literature, I find a significant positive long-run relationship between GDP per capita and house prices; population growth and house prices. The results confirm that equilibrium house prices increase with rising in demand, because of GDP per capita and population growth. The coefficient of average speed of adjustment is -0.016, which suggests that 1.6% of previous quarter's house price deviations from long-run equilibrium are adjusted this quarter. Generally, the results provide evidence of house price adjustment and deviation quarterly.

4.2 House prices affect bank stability: results

Table 3
Regression estimates overall

Dependent variable: NPLs (Non-performing loans)	Model A (House price index)	Model B (House price deviation)
Macro variables		
House price index changes (%)	-1.2631*** (0.0001)	-
House price deviation	-	0.0395** (0.0054)
Population	0.3521*** (0.0044)	-0.1163* (0.0342)
GDP per capita growth (%)	-0.0013 (0.9059)	-0.0006 (0.1142)
FDI changes (%)	0.0012 (0.3554)	0.0009 (0.5282)
Portfolio investment changes (%)	0.0007 (0.8695)	0.0003 (0.9995)
Real interest rate	-0.2866 (0.3914)	-0.3266 (0.0142)
Unemployment rate	0.0661 (0.2923)	1.1489* (0.0883)
Bank-specific variables		
Capital to asset ratio	0.4592*** (0.0000)	0.3283*** (0.0000)
Bank efficiency ratio	0.1429** (0.0096)	0.2736*** (0.0008)
Return on assets	-0.1787 (0.5955)	0.2314 (0.5022)
Liquidity	-0.0817 (0.8289)	-0.5853 (0.1042)
Statistics		
Durbin-Watson stat p-value	0.042	0.049
R-squared	0.4195	0.3792
Adjusted R-squared	0.3943	0.3516
Obs	241	236

Note: * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 3 shows the estimates of macro variables and bank-specific variables effect the bank stability in emerging countries: Indonesia, Malaysia, China, Taiwan, and Thailand. To test the two competing hypothesis in overall, model (A), the result is consistent with collateral value hypothesis and, model (B), the result is consistent with deviation hypothesis. In model (A) with significant negative coefficient, when the house prices increase, the non-performing loans decrease along with higher bank stability. In model (B) with significant positive coefficient, when the house price deviations increase, the non-performing loans increase along with lower bank stability. The results support my first hypothesis and provide the evidence of house prices and house prices deviations affect bank stability in emerging countries. The result also provides the evidence which can be concluded that the collateral value hypothesis holds when using the house price index as house price proxy whereas the deviation hypothesis holds when using the house price deviation as house price determinant.

When house price increases in general, it causes bank stability to improve according to collateral value hypothesis. However, when the house price deviates from fundamental value, the bank stability reduces. Thus, I investigate further how the bank stability change when the house price changes under different economic condition and different level of net capital flows.

4.3 Threshold estimation with GDP per capita growth: results

To test the two competing hypotheses (collateral hypothesis and deviation hypothesis), I use two main models which are model (A) the house price changes interact with GDP per capita growth(threshold variable) and model (B) house price deviation in interact with GDP per capita. To find the number of thresholds, we use bootstrap[6] method suggested by Hansen 1999.

Table 4
Tests for threshold effects (HP and HPD interact with GDP)

	Model A	**Model B**
Single threshold		
p-value	0.028	0.049
Double threshold		
p-value	0.083	0.078
Triple threshold		
p-value	0.094	0.068

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita.

Table 4 shows the test of F-statistics with bootstrap p-value for each model. For single threshold, model (A) is significant at the 5% level in the model whereas model (B) is significant at the 5% level in the model. For double and triple threshold, both model (A) and model (B) are significant at the 10% level

[6] I use three-hundred bootstrap replications for each of three bootstrap tests to find number of thresholds

which are weakly significant. Therefore, there are single threshold in the regression of model (A) and model (B).

Table 5
Threshold estimates

	Model A		**Model B**	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	9.2330	[9.2250, 9.2340]	-25.1300	[-25.6050, -25.1210]

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita.

Table 5 shows the threshold estimates. For model (A), the point estimates of one GDP per capita growth threshold is 9.233% whereas model (B) is -25.13% when HP and HPD interact with the threshold variable. The asymptotic 95% confidence intervals are consistent in both models.

Table 6
Regression estimates (HP and HPD interact with GDP)

Dependent variable: NPL (Non-performing loans)	**Model A**	**Model B**
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.0371** (0.040)	-0.0051** (0.043)
FDI changes (%)	0.0004 (0.720)	0.0007 (0.504)
Portfolio investment changes (%)	0.0002 (0.594)	0.0001 (0.674)
Real interest rate	-0.4524*** (0.008)	-0.1458 (0.439)
Unemployment rate	0.8463*** (0.000)	1.2552*** (0.000)
Bank-specific variables		
Bank efficiency ratio	0.4662*** (0.004)	0.7371*** (0.000)
Capital to asset ratio	0.1989*** (0.000)	0.2599*** (0.000)
Return on assets	0.0122** (0.042)	-0.4174 (0.223)
Liquidity	-0.2499 (0.427)	-0.0504 (0.887)
House price index changes (%) (GDP $\leq$ Th1)	-0.0374*** (0.000)	-
House price index changes (%) (GDP $>$ Th1)	-0.0528*** (0.000)	-
House price deviation (GDP $\leq$ Th1)	-	0.7732** (0.043)
House price deviation (GDP $>$ Th1)	-	-0.1210* (0.088)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5257	0.3977
Obs	255	255

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 6 shows the estimates for the single threshold model of both model (A) and (B) which are HP and HPD interact with the GDP per capita growth. The estimates of interest are house price and house price deviation indicators interacting with the threshold variable. Model (A) using house price change as the indicator, the coefficient equals -0.0374 when GDP per capita growth is below 9.233% and -0.0528 when GDP per capita growth is above 9.233%. According to the magnitude of coefficient from the result, when the economic condition higher than threshold value, the economic condition has stronger impact on bank stability while, the reduction in NPL is smaller when the economic condition is lower.

The result is consistent with the collateral value hypothesis since the high GDP per capita, the house price changes have negative relationship with non-performing loans (NPL). During the high or low economic changes, the house price increase along with bank stability. Furthermore, the result also shows the consistent of my second hypothesis argued that the collateral value hypothesis should hold because high house prices improve bank stability by increasing the value of collateral hold by banks during the expanding (good economic condition).

Model (B) using house price deviation as the indicator, shows that during GDP per capita growth is greater -25.13% the NPL decreases, which mean that the bank stability is higher during this economic level (when HPD increases by 1% NPL decreases by 0.121%). If the GDP per capita growth is lower than or equal -25.13% the NPL will increase which means that banks tend to be default. According to the magnitude of coefficient from the result, when the economic condition is bad (lower than threshold value), the increase in NPL is larger the more house price deviate from fundamental value.

The result is consistent with deviation hypothesis during low economic changes. During low GDP per capita growth, banks are likely to have high non-performing loan ratio, which can cause the high banks' instability. During bad economic condition, the borrowers have lower ability to pay back the loans. Nonetheless, this result is consistent with collateral value hypothesis during high economic changes with less impact to bank stability.

4.4 Threshold estimation with different of capital flow levels: results

Table 7
Tests for threshold effects (HP and HPD interact with FDI)

	Model A	**Model B**
Single threshold		
p-value	0.000	0.003
Double threshold		
p-value	0.760	0.710
Triple threshold		
p-value	0.977	0.730

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI.

Table 7 shows the test of F-statistics with bootstrap p-value for each model. For single threshold, model (A) is significant at significant at the 1% level whereas model (B) is significant at the 1% level. For double and triple threshold, both model (A) and model (B) are not significant at all levels. Therefore, there is singe threshold in the regression of model (A) and (B).

Table 8
Threshold estimates

	Model A		**Model B**	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	-81.3460	[-81.1640, -81.9730]	16.2210	[16.145, 16.284]

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI.

Table 8 shows the threshold estimates. For model (A), the point estimates of one FDI threshold is -81.346% whereas model (B) is 16.221% when HP and HPD interact with the threshold variable (FDI). The asymptotic 95% confidence intervals is consistent.

Table 9
Regression estimates (HP and HPD interact with FDI)

Dependent variable: NPL (Non-performing loans)	**Model A**	**Model B**
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.0054 (0.685)	-0.0076 (0.611)
FDI changes (%)	-0.0006 (0.621)	-0.0008 (0.462)
Portfolio investment changes (%)	-0.0003 (0.418)	-0.0001 (0.732)
Real interest rate	-0.4259** (0.013)	-0.1822 (0.334)
Unemployment rate	0.9093*** (0.000)	1.2954*** (0.000)
Bank-specific variables		

Bank efficiency ratio	0.3952** (0.013)	0.7045*** (0.000)
Capital to asset ratio	0.1925*** (0.000)	0.2679*** (0.000)
Return on assets	0.6496* (0.053)	-0.4928 (0.148)
Liquidity	-0.2269 (0.474)	-0.0122 (0.972)
House price index changes (%) (FDI ≤ Th1)	-0.0460*** (0.000)	-
House price index changes (%) (FDI > Th1)	-0.0389*** (0.000)	-
House price deviation (FDI ≤ Th1)	-	0.1541** (0.020)
House price deviation (FDI > Th1)	-	-0.0883** (0.043)
Statistics		
F-stat p-value	0.042	0.049
R-squared	0.4195	0.3792
Obs	255	255

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 8 shows the estimates for the single threshold model of both model (A) and model (B) which is HP and HPD interact with the FDI changes. The coefficient in model (A) equals -0.0460 when FDI change is below -81.346% and -0.0389 when FDI change is above -81.346%. This result is consistent with the collateral value hypothesis. Whether high or low net capital flows, the house price increase along with bank stability by using house price index as house price determinant.

On the other hand, model (B) shows that during FDI change is above 16.221% the NPL decreases, which mean that the bank stability is higher during this net capital flows (when HPD increases by 1% NPL decreases by 0.088%). If the FDI change is below 16.221% the NPL will increase which means that banks tend to have low stability. The result is consistent with deviation hypothesis during high capital outflows. Banks are likely to have higher non-performing loan ratio, which can cause the high banks' instability. The risky borrowers have lower ability to pay back the loans and debt. However, the impact is opposite when net capital flow is above the threshold. Therefore, the result is consistent of my third hypothesis argued that the collateral value hypothesis should hold during high net capital flows and the deviation hypothesis should hold during low net capital flows.

Moreover, to provide another new evidence to support the third hypothesis, I also investigate the portfolio investment, which represents the short-term flows as the capital flows determinant.

Table 10
Tests for threshold effects (HP and HPD interact with PI)

	Model A	Model B
Single threshold		
p-value	0.011	0.007
Double threshold		
p-value	0.277	0.078
Triple threshold		
p-value	0.576	0.933

Note: Model A is the threshold that HP interact with PI. Model B is the threshold that HPD interact with FDI.

Table 9 shows model (A) is significant at the 5% level in the model whereas model (B) is significant at the 1% level in the model. For double and triple threshold, both model (A) and model (B) are not significant at the 5% level. Therefore, there are one threshold in the regression of model (A) and model (B).

Table 11
Threshold estimates

	Model A		Model B	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	-103.344	[-103.913, -99.500]	-190.968	[-201.090, -189.163]

Note: Model A is the threshold that HP interact with portfolio investment changes. Model B is the threshold that HPD interact with portfolio investment changes.

Table 10 shows the threshold estimates. For model (A), the point estimates of single threshold is -103.344% whereas model (B) is -190.963% when HP and HPD interact with the threshold variable. The asymptotic 95% confidence intervals are consistent in both models.

Table 12
Regression estimates (HP and HPD interact with PI)

Dependent variable: NPL (Non-performing loans)	Model A	Model B
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.0064 (0.634)	-0.0062 (0.681)
FDI changes (%)	0.0009 (0.990)	0.0007 (0.493)
Portfolio investment changes (%)	-0.0006* (0.100)	-0.0003 (0.351)
Real interest rate	-0.4390*** (0.010)	-0.1598 (0396)
Unemployment rate	0.0894*** (0.000)	1.2699*** (0.000)
Bank-specific variables		
Bank efficiency ratio	0.4155*** (0.009)	0.6841*** (0.000)
Capital to asset ratio	0.2008*** (0.000)	0.2579*** (0.000)

Return on assets	0.5759** (0.081)	-0.5058 (0.137)
Liquidity	-0.0515 (0.872)	-0.1298 (0.720)
House price index changes (%) (PI ≤ Th1)	-0.0463*** (0.000)	-
House price index changes (%) (PI > Th1)	-0.0369*** (0.000)	-
House price deviation (PI ≤ Th1)	-	0.1816*** (0.009)
House price deviation (PI > Th1)	-	-0.1259** (0.038)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5248	0.3955
Obs	255	255

Note: Model A is the threshold that HP interact with portfolio investment changes. Model B is the threshold that HPD interact with portfolio investment changes. * Significance at 10% level, ** Significance at 5% level, ** * Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 11 shows the estimates for the single threshold model of both model (A) and (B) which are HP and HPD interact with portfolio investment changes. The estimates of interest are house price and house price deviation indicators interacting with the threshold variable. The coefficient in model (A) equals -0.0463 when portfolio investment changes is below -103.344% % and -0.0369 when portfolio investment changes is above threshold effects. This result is consistent with the collateral value hypothesis using house price index as house price indicator. During the high or low net capital flows of portfolio investment, the house price increase along

with bank stability. House price appreciation improves bank stability by increasing the value of collaterals hold by banks. It also supports the previous FDI result.

On the other hand, model (B) shows that during portfolio investment changes is above -190.963% the NPL decreases, which mean that the bank stability is higher during this portfolio investment changes. If the portfolio investment changes is below -190.963%, the NPL will increase which means that banks tend to be default. The result is consistent with deviation hypothesis during high outflows. Banks are likely to have high non-performing loan ratio. This result is also consistent with collateral value hypothesis during high net capital flow of portfolio investment with less impact to bank stability. Therefore, these two results are consistent with the third hypothesis and support the previous result of FDI as long-term capital flow.

4.5 Empirical Results (Excluding China)

Since some variables obtained from China are restricted and biased, thus I check the robustness without data obtained from China to compare with the previous results.

4.5.1 House price deviation

Table 13
Deviation of house prices

	Coefficient estimate	SE (Standard Error)
Long-run coefficients		
GDP per capita	0.027** (0.0431)	0.013
Population growth	0.427*** (0.0000)	0.005
Short-run coefficients		
Speed of adjustment	-0.013*** (0.0067)	0.026
Change in GDP per capita	0.001*** (0.0024)	0.001
Change in population growth	2.821 (0.5283)	0.465
Statistics		
Fstat p-value	0.048	
R-squared	0.4114	
Adjusted R-squared	0.3857	
Obs	200	

Note: * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 13 shows the estimation results of PMG for house price deviation. I find a significant positive long-run relationship between GDP per capita and house prices; population growth and house prices as same as previous results. The results confirm that equilibrium house prices increase with rising in demand, because of GDP per capita and population growth. The coefficient of average speed of adjustment is -0.013, which suggests that 1.3% of previous quarter's house price deviations from long-run equilibrium are adjusted this quarter. The results provide evidence of house price adjustment and deviation quarterly.

4.5.2 House prices affect bank stability: results

Table 14
Regression estimates overall

Dependent variable: NPLs (Non-performing loans)	Model A (House price index)	Model B (House price deviation)

Macro variables		
House price index changes (%)	-0.8782*** (0.0039)	-
House price deviation	-	0.0550*** (0.0054)
Population	0.2085*** (0.0073)	-0.3117*** (0.0011)
GDP per capita growth (%)	0.0065 (0.8451)	0.0117 (0.7274)
FDI changes (%)	0.0012 (0.3825)	0.0012 (0.4127)
Portfolio investment changes (%)	0.0001 (0.8541)	0.0001 (0.8748)
Real interest rate	-0.2308 (0.5471)	-0.2343 (0.5367)
Unemployment rate	0.7711 (0.2546)	1.1038 (0.1210)
Bank-specific variables		
Capital to asset ratio	0.3990*** (0.0000)	0.4307*** (0.0000)
Bank efficiency ratio	0.2487** (0.0203)	0.3749*** (0.0000)
Return on assets	0.2472 (0.5066)	0.3956 (0.2864)
Liquidity	-0.7466 (0.1144)	-0.8871** (0.0274)
Statistics		
Durbin-Watson stat p-value	0.0453	0.0473
R-squared	0.4093	0.4084
Adjusted R-squared	0.3769	0.3753
Obs	194	190

Note: * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 14 shows the estimates of macro variables and bank-specific variables effect the bank stability in emerging countries. To test the two competing hypothesis excluding China, model (A), the result is consistent with collateral value hypothesis and, model (B), and the result is consistent with deviation hypothesis as same as the overall results. In model (A) with significant negative coefficient, when the house prices increase, the non-performing loans decrease along with higher bank stability. In model (B) with significant positive coefficient, when the house price deviations increase, the non-performing loans increase along with lower bank stability. The results support my first hypothesis and provide the evidence of house prices and house prices deviations affect bank stability. The result also provides the evidence which can be concluded that the collateral value hypothesis holds when using the house price index as house price proxy while the deviation hypothesis holds when using the house price deviation as house price determinant. This result is consistent and same as previous results.

I investigate further how the bank stability change when the house price changes under different economic condition and different level of net capital flows.

4.5.3 Threshold estimation with GDP per capita growth: results

To test the two competing hypotheses, I use two main models which are model (A) the house price changes interact with GDP per capita growth (threshold variable) and model (B) house price deviation in interact with GDP per capita. To find the number of thresholds, we use bootstrap method suggested by Hansen 1999.

Table 15
Tests for threshold effects (HP and HPD interact with GDP)

	Model A	**Model B**
Single threshold		
p-value	0.009	0.018
Double threshold		
p-value	0.093	0.076
Triple threshold		
p-value	0.820	0.873

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita.

Table 15 shows the test of F-statistics with bootstrap p-value for each model. For single threshold, model (A) is significant at the 1% level in the model whereas model (B) is significant at the 5% level in the model. For double and triple threshold, both model (A) and model (B) are not significant. Thus, there are single threshold in the regression of model (A) and model (B).

Table 16
Threshold estimates

	Model A		**Model B**	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	0.6610	[0.6450, 0.6720]	2.8100	[2.8010, 2.8380]

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita.

Table16 shows the threshold estimates. For model (A), the point estimates of one GDP per capita growth threshold is 0.661% whereas model (B) is 2.81% when HP and HPD interact with the threshold variable. The asymptotic 95% confidence intervals are consistent in both models. To compare with previous results, including China, these threshold values are both positive and more reasonable unlike the overall results.

Table 17
Regression estimates (HP and HPD interact with GDP)

Dependent variable: NPL (Non-performing loans)	**Model A**	**Model B**
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.1039** (0.049)	-0.0103** (0.077)
FDI changes (%)	0.0004 (0.717)	0.0008 (0.443)
Portfolio investment changes (%)	-0.0002 (0.267)	-0.0001 (0.329)
Real interest rate	-0.6231*** (0.001)	-0.5317*** (0.007)
Unemployment rate	0.6231*** (0.009)	0.5971** (0.015)
Bank-specific variables		
Bank efficiency ratio	1.3182*** (0.000)	1.5406** (0.011)
Capital to asset ratio	0.2771*** (0.000)	0.3375*** (0.000)
Return on assets	1.3182*** (0.000)	0.9231*** (0.000)
Liquidity	-1.0132*** (0.004)	-1.1539*** (0.002)
House price index changes (%) (GDP ≤ Th1)	-0.0191*** (0.004)	-
House price index changes (%) (GDP > Th1)	-0.0521*** (0.000)	-
House price deviation (GDP ≤ Th1)	-	0.1875** (0.049)
House price deviation (GDP > Th1)	-	-0.0332** (0.029)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5903	0.5581
Obs	204	204

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 17 shows the estimates for the single threshold model of both model (A) and (B) which are HP and HPD interact with the GDP per capita growth. The estimates of interest are house price and house price deviation indicators interacting with the threshold variable. Model (A) using house price change as the indicator, the coefficient equals -0.0191 when GDP per capita growth is below 0.661% and -0.0521 when GDP per capita growth is above 0.661%. According to the magnitude of coefficient from the result, when the economic condition higher than threshold value, the economic condition has stronger impact on bank stability while, the reduction in NPL is smaller when the economic condition is lower. During the high or low economic changes, the house price increase along with bank stability. The result also shows the consistent of my second hypothesis argued that the collateral value hypothesis should hold because high house prices improve bank stability by increasing the value of collateral hold by banks during the expanding economic. The result is consistent with the collateral value hypothesis.

Model (B) using house price deviation as the indicator, shows that during GDP per capita growth is greater 2.81% the NPL decreases, which mean that the bank stability is higher during this economic level (when HPD increases by 1% NPL decreases by 0.033%). If the GDP per capita growth is lower than or equal 2.81% the NPL will increase which means that banks tend to be default. According to the magnitude of coefficient from the result, when the economic condition is lower than threshold value, the increase in NPL is larger the more house price deviate from fundamental value. The result is consistent with deviation hypothesis during low economic changes. During low GDP per capita growth, banks are likely to have high non-performing loan ratio, which can cause the high banks' instability. During bad economic condition, the borrowers have lower ability to pay back the loans. On the other hand, the result is consistent with collateral value hypothesis during high economic changes with less impact to bank stability.

Compare excluding China results to previous results, the threshold variables are positive and reasonable with more significant coefficient of bank-specific variables in both Model A and Model B. Thus, the dataset without China is more preferable than the dataset including China.

4.5.4 Threshold estimation with different of capital flow levels: results

Table 18
Tests for threshold effects (HP and HPD interact with FDI)

	Model A	Model B
Single threshold		
p-value	0.043	0.000
Double threshold		
p-value	0.220	0.065
Triple threshold		
p-value	0.473	0.913

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI.

Table 18 shows the test of F-statistics with bootstrap p-value for each model. For single threshold, model (A) is significant at significant at the 5% level whereas model (B) is significant at the 1% level. For double and triple threshold, both model (A) and model (B) are not significant at all levels. Therefore, there is singe threshold in the regression of model (A) and (B). To compare with previous results, including China, this threshold value is both positive and more reasonable unlike the overall results.

Table 19
Threshold estimates

	Model A		**Model B**	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	43.4080	[43.1430, 43.4100]	16.3500	[16.9550, 16.3690]

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI.

Table 8 shows the threshold estimates. For model (A), the point estimates of one FDI threshold is 43.408% whereas model (B) is 15.35% when HP and HPD interact with the threshold variable (FDI). The asymptotic 95% confidence intervals is consistent. To compare with previous results, including China, these threshold values are both positive and more reasonable unlike the overall results.

Table 20
Regression estimates (HP and HPD interact with FDI)

Dependent variable: NPL (Non-performing loans)	**Model A**	**Model B**
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.0224 (0.504)	-0.0184 (0.610)
FDI changes (%)	-0.0025* (0.079)	-0.0005 (0.587)
Portfolio investment changes (%)	-0.0003 (0.385)	-0.0003 (0.297)
Real interest rate	-0.6186*** (0.001)	-0.4714** (0.018)
Unemployment rate	0.6022** (0.011)	0.7011*** (0.005)
Bank-specific variables		
Bank efficiency ratio	1.1489*** (0.000)	1.5144*** (0.000)
Capital to asset ratio	0.2677*** (0.000)	0.3309*** (0.000)
Return on assets	1.3849*** (0.000)	0.8795** (0.016)
Liquidity	-1.0123*** (0.004)	-1.1420*** (0.002)
House price index changes (%) (FDI ≤ Th1)	-0.0391*** (0.000)	-
House price index changes (%) (FDI > Th1)	-0.0311*** (0.000)	-

House price deviation (FDI ≤ Th1)	-	0.2594** (0.016)
House price deviation (FDI > Th1)	-	-0.0531** (0.039)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5943	0.5449
Obs	204	204

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 20 shows the estimates for the single threshold model of both model (A) and model (B) which is HP and HPD interact with the FDI changes. The coefficient in model (A) equals -0.0391 when FDI change is below 43.408% and -0.0311 when FDI change is above 43.408%. This result is consistent with the collateral value hypothesis. Whether high or low net capital flows, the house price increase along with bank stability by using house price index as house price determinant.

On the other hand, model (B) shows that during FDI change is above 16.35% the NPL decreases, which mean that the bank stability is higher during this net capital flows (when HPD increases by 1% NPL decreases by 0.053%). If the FDI change is below 16.35% the NPL will increase which means that banks tend to have low stability. The result is consistent with deviation hypothesis during high capital outflows. Banks are likely to have higher non-performing loan ratio, which can cause the high banks' instability. The risky borrowers have lower ability to pay back the loans and debt. However, the impact is opposite when net capital flow is above the threshold. Therefore, the result is consistent of my third hypothesis argued that the collateral value hypothesis should hold during high net capital flows and the deviation hypothesis should hold during low net capital flows.

To compare with previous results, the threshold variables are both positive and reasonable with more significant coefficient of bank-specific variables in both Model A and Model B. Thus, the dataset without China is more preferable than the dataset including China. To provide another new evidence to support the third hypothesis, I also investigate the portfolio investment, which represents the short-term flows as the capital flows determinant.

Table 21
Tests for threshold effects (HP and HPD interact with PI)

	Model A	Model B
Single threshold		
p-value	0.018	0.008
Double threshold		
p-value	0.227	0.160
Triple threshold		
p-value	0.666	0.553

Note: Model A is the threshold that HP interact with PI. Model B is the threshold that HPD interact with FDI.

Table 21 shows model (A) is significant at the 5% level in the model whereas model (B) is significant at the 1% level in the model. For double and triple threshold, both model (A) and model (B) are not significant at the 5% level. Therefore, there are one threshold in the regression of model (A) and model (B).

Table 22
Threshold estimates

	Model A		Model B	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	42.5800	[42.2020, 42.9700]	53.5080	[53.2060, 53.8100]

Note: Model A is the threshold that HP interact with portfolio investment changes. Model B is the threshold that HPD interact with portfolio investment changes.

Table 22 shows the threshold estimates. For model (A), the point estimates of single threshold is 42.58% whereas model (B) is 53.5% when HP and HPD interact with the threshold variable. The asymptotic 95% confidence intervals are consistent in both models.

Table 23
Regression estimates (HP and HPD interact with PI)

Dependent variable: NPL (Non-performing loans)	Model A	Model B
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.0276 (0.410)	-0.0226 (0.530)
FDI changes (%)	0.0001 (0.902)	0.0007 (0.478)
Portfolio investment changes (%)	-0.0007** (0.054)	-0.0004 (0.329)
Real interest rate	-0.6456*** (0.001)	-0.5137*** (0.010)
Unemployment rate	0.5733**	0.6774***

	(0.014)	(0.006)
Bank-specific variables		
Bank efficiency ratio	1.1587*** (0.000)	1.5010*** (0.000)
Capital to asset ratio	0.2830*** (0.000)	0.3419*** (0.000)
Return on assets	1.2611*** (0.000)	0.8410** (0.022)
Liquidity	-0.8451** (0.017)	-1.0891*** (0.004)
House price index changes (%) (PI ≤ Th1)	-0.0329*** (0.000)	-
House price index changes (%) (PI > Th1)	-0.0233*** (0.000)	-
House price deviation (PI ≤ Th1)	-	0.7378** (0.049)
House price deviation (PI > Th1)	-	-0.1863** (0.021)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5982	0.5443
Obs	204	204

Note: Model A is the threshold that HP interact with portfolio investment changes. Model B is the threshold that HPD interact with portfolio investment changes. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 23 shows the estimates for the single threshold model of both model (A) and (B) which are HP and HPD interact with portfolio investment changes. The estimates of interest are house price and house price deviation indicators interacting with the threshold variable. The coefficient in model (A) equals -0.0233 when portfolio investment changes is below 42.58% % and -0.0329 when portfolio investment changes is above threshold effects. This result is consistent with the collateral value hypothesis using house price index as house price indicator. During the high or low net capital flows of portfolio investment, the house price increase along with bank stability. House price appreciation improves bank stability by increasing the value of collaterals hold by banks. It also supports the previous FDI result.

On the other hand, model (B) shows that during portfolio investment changes is above 53.5% the NPL decreases, which mean that the bank stability is higher during this portfolio investment changes. If the portfolio investment changes is below 53.5%, the NPL will increase which means that banks tend to be default. The result is consistent with deviation hypothesis during high outflows. Banks are likely to have high non-performing loan ratio. This result is also consistent with collateral value hypothesis during high net capital flow of portfolio investment with less impact to bank stability. Therefore, these two results are consistent with the third hypothesis and support the previous result of FDI as long-term capital flow.

To compare with previous results, the threshold values are both positive and more reasonable with more significant coefficient of bank-specific variables in both Model A and Model B. Thus, the dataset without China is more preferable and trustable since some data from China is biased and limited to reflect the real value of banks and economic.

4.6 Empirical Results (Including real interest rate)

To consider real interest as the factor which drive house price deviate from fundamental value, I provide another new evidence to investigate the dataset excluding China with real interest rate as driven factors to house price deviation.

4.6.1 House price deviation

Table 24
Deviation of house prices

House price model	Coefficient estimate	SE (Standard Error)
Long-run coefficients		
GDP per capita	0.027** (0.046)	0.013
Population growth	0.427*** (0.0000)	0.005
Real interest rate	-0.002 (0.9228)	0.071
Short-run coefficients		
Speed of adjustment	-0.013*** (0.0068)	0.026
Change in GDP per capita	0.001*** (0.0021)	0.001
Change in population growth	2.823 (0.5249)	0.636
Change in real interest rate	-0.002 (0.6620)	0.003
Statistics		
Fstat p-value	0.045	
R-squared	0.4523	
Adjusted R-squared	0.3977	
Obs	200	

Note: * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 24 shows the estimation results of PMG for house price deviation. The upper table shows the average long-run coefficient estimates and the lower table shows the average short-run coefficient estimates. The p-value of 0.045 suggests that the PMG estimator is preferable. The Table shows significant positive long-run relationship between house prices and three variables, which are GDP per capita, population growth and real interest rate. The results confirm that equilibrium house prices increase with rising in demand, because of GDP per capita, population growth and real interest rate. The coefficient of average speed of adjustment is -0.013, which suggests that 1.3% of previous quarter's house price deviations from long-run equilibrium are adjusted this quarter. The results provide evidence of house price adjustment and deviation quarterly. Compare to previous result excluding China, this result has the same value of the speed of adjustment and the number of coefficient are slightly changes with no significant of real interest rate. This is consistent with correlation statistics that report no significant relationship between house price and real interest rate.

4.6.2 House prices affect bank stability: results

Table 25
Regression estimates overall

Dependent variable: NPLs (Non-performing loans)	Model A (House price index)	Model B (House price deviation)
Macro variables		
House price index changes (%)	-0.8782*** (0.0039)	-
House price deviation	-	0.0519*** (0.005)
Population	0.2085*** (0.0073)	-0.3116*** (0.0011)
GDP per capita growth (%)	0.0065 (0.8451)	0.0114 (0.7336)
FDI changes (%)	0.0012 (0.3825)	0.0012 (0.4181)
Portfolio investment changes (%)	0.0001 (0.8541)	0.0001 (0.8711)
Real interest rate	-0.2308 (0.5471)	-0.2356 (0.5346)
Unemployment rate	0.7711 (0.2546)	1.0984 (0.1226)
Bank-specific variables		
Capital to asset ratio	0.3990*** (0.0000)	0.4308*** (0.0000)
Bank efficiency ratio	0.2487** (0.0203)	0.3750*** (0.0000)
Return on assets	0.2472 (0.5066)	0.3952 (0.2870)
Liquidity	-0.7466 (0.1144)	-0.8875** (0.0273)
Statistics		
Durbin-Watson stat p-value	0.0453	0.0475
R-squared	0.4093	0.4083
Adjusted R-squared	0.3769	0.3752
Obs	194	190

Note: * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 25 shows the estimates of macro variables and bank-specific variables effect the bank stability in emerging countries: Indonesia, Malaysia, Taiwan, and Thailand. To test the two competing hypothesis in overall, model (A), the result is consistent with collateral value hypothesis and, model (B), the result is consistent with deviation hypothesis. In model (A) with significant negative coefficient, when the house prices increase, the non-performing loans decrease along with higher bank stability. In model (B) with significant positive coefficient, when the house price deviations increase, the non-performing loans increase along with lower bank stability. The results provide the evidence of house prices and house prices deviations affect bank stability in emerging countries. It can be concluded that the collateral value hypothesis holds when using the house price index as house price proxy while the deviation hypothesis holds when using the house price deviation as house price proxy.

When house price increases in general, it causes bank stability to improve according to collateral value hypothesis. However, when the house price deviates from fundamental value, the bank stability reduces. Compare with the previous result excluding China, there are some slightly changes in p-value and coefficient because of the changes in house price deviation by adding real interest rate as the driven factor of house price.

To investigate further how the bank stability change when the house price changes under different economic condition and different level of net capital flows, I use threshold model to find the threshold effects and estimation.

4.6.3 Threshold estimation with GDP per capita growth: results

To test the two competing hypotheses, I use two main models which are model (A) the house price changes interact with GDP per capita growth as threshold variable and model (B) house price deviation in interact with GDP per capita. To find the number of thresholds, we use bootstrap method suggested by Hansen 1999.

Table 26
Tests for threshold effects (HP and HPD interact with GDP)

	Model A	Model B
Single threshold		
p-value	0.009	0.018
Double threshold		
p-value	0.093	0.053
Triple threshold		
p-value	0.820	0.823

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita.

Table 26 shows the test of F-statistics with bootstrap p-value for each model. For single threshold, model (A) is significant at the 1% level in the model whereas model (B) is significant at the 5% level in the model. For double, both model (A) and model (B) are significant at the 10% level which are weakly significant. Thus, there are single threshold in the regression of model (A) and model (B).

Table 27
Threshold estimates

	Model A		Model B	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	0.6610	[0.6450, 0.6720]	2.8100	[2.8010, 2.8380]

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita.

Table 27 shows the threshold estimates. For model (A), the point estimates of one GDP per capita growth threshold is 0.661% whereas model (B) is 2.81% when HP and HPD interact with the threshold variable. The asymptotic 95% confidence intervals are consistent in both models. Compare with previous result excluding China, the threshold value are the same.

Table 28
Regression estimates (HP and HPD interact with GDP)

Dependent variable: NPL (Non-performing loans)	Model A	Model B
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.1039** (0.049)	-0.0098** (0.077)
FDI changes (%)	0.0004 (0.717)	0.0008 (0.443)
Portfolio investment changes (%)	-0.0002 (0.267)	-0.0003 (0.329)
Real interest rate	-0.6231*** (0.001)	-0.5281*** (0.007)
Unemployment rate	0.6231*** (0.009)	0.6025** (0.014)

Bank-specific variables		
Bank efficiency ratio	1.3182*** (0.000)	1.5364** (0.012)
Capital to asset ratio	0.2771*** (0.000)	0.3373*** (0.000)
Return on assets	1.3182*** (0.000)	0.9081*** (0.000)
Liquidity	-1.0132*** (0.004)	-1.1395*** (0.002)
House price index changes (%) (GDP ≤ Th1)	-0.0191*** (0.004)	-
House price index changes (%) (GDP > Th1)	-0.0521*** (0.000)	-
House price deviation (GDP ≤ Th1)	-	0.1869** (0.042)
House price deviation (GDP > Th1)	-	-0.0350** (0.023)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5903	0.5588
Obs	204	204

Note: Model A is the threshold that HP interact with GDP per capita. Model B is the threshold that HPD interact with GDP per capita. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 28 shows the estimates for the single threshold model of both model (A) and (B) which are HP and HPD interact with the GDP per capita growth. Model (A) using house price change as the indicator, the coefficient equals -0.0191 when GDP per capita growth is below 0.661% and -0.0521 when GDP per capita growth is above 0.661%. According to the magnitude of coefficient from the result, when the economic condition higher than threshold value, the economic condition has stronger impact on bank stability while, the reduction in NPL is smaller when the economic condition is lower.

The result is consistent with the collateral value hypothesis since the high GDP per capita, the house price changes have negative relationship with non-performing loans. During the high or low economic changes, the house price increase along with bank stability. Furthermore, the result also shows the consistent of my second hypothesis argued that the collateral value hypothesis should hold because high house prices improve bank stability by increasing the value of collateral hold by banks during the expanding economic.

Model (B) using house price deviation as the indicator, shows that during GDP per capita growth is greater 2.81% the NPL decreases, which mean that the bank stability is higher during this economic level (when HPD increases by 1% NPL decreases by 0.035%). If the GDP per capita growth is lower than or equal 2.81% the NPL will increase which means that banks tend to be default. According to the magnitude of coefficient from the result, when the economic condition is lower than threshold value, the increase in NPL is larger the more house price deviate from fundamental value.

The result is consistent with deviation hypothesis during low economic changes. During low GDP per capita growth, banks are likely to have high non-performing loan ratio, which can cause the high banks' instability. During bad economic condition, the borrowers have lower ability to pay back the loans. Nonetheless, this result is consistent with collateral value hypothesis during high economic changes with less impact to bank stability. Compare to previous result without China in the dataset, some coefficients slightly change with the same significant levels.

4.6.4 Threshold estimation with different of capital flow levels: results

Table 29
Tests for threshold effects (HP and HPD interact with FDI)

	Model A	**Model B**
Single threshold		
p-value	0.043	0.000
Double threshold		
p-value	0.220	0.060
Triple threshold		
p-value	0.473	0.906

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI.

Table 29 shows the test of F-statistics with bootstrap p-value for each model. For single threshold, model (A) and model (B) are significant the 1% level. For double threshold, model (B) are weakly significant. Therefore, there is singe threshold in the regression of model (A) and (B).

Table 30
Threshold estimates

	Model A		**Model B**	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	43.4080	[43.1430, 43.4100]	16.4800	[16.9780, 16.4720]

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI.

Table 30 shows the threshold estimates. For model (A), the point estimates of one FDI threshold is 43.41% whereas model (B) is 16.48% when HP and HPD interact with the threshold variable (FDI). The asymptotic 95% confidence intervals is consistent.

Table 31
Regression estimates (HP and HPD interact with FDI)

Dependent variable: NPL (Non-performing loans)	**Model A**	**Model B**
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.0224 (0.504)	-0.0175 (0.628)
FDI changes (%)	-0.0025* (0.079)	-0.0005 (0.578)
Portfolio investment changes (%)	-0.0003 (0.385)	-0.0003 (0.295)
Real interest rate	-0.6186*** (0.001)	-0.4627** (0.021)
Unemployment rate	0.6022** (0.011)	0.7086*** (0.004)
Bank-specific variables		
Bank efficiency ratio	1.1489*** (0.000)	1.5123*** (0.000)
Capital to asset ratio	0.2677*** (0.000)	0.3301*** (0.000)
Return on assets	1.3849*** (0.000)	0.8712** (0.017)
Liquidity	-1.0123*** (0.004)	-1.1359*** (0.002)
House price index changes (%) (FDI ≤ Th1)	-0.0391*** (0.000)	-
House price index changes (%) (FDI > Th1)	-0.0311*** (0.000)	-
House price deviation (FDI ≤ Th1)	-	0.2728** (0.028)
House price deviation (FDI > Th1)	-	-0.0587** (0.041)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5943	0.5452
Obs	204	204

Note: Model A is the threshold that HP interact with FDI. Model B is the threshold that HPD interact with FDI. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 31 shows the estimates for the single threshold model of both model (A) and model (B) which is HP and HPD interact with the FDI changes. The coefficient in model (A) equals -0.0391 when FDI change is below 43.41% and -0.0311 when FDI change is above 43.41%. This result is consistent with the collateral value hypothesis. Whether high or low net capital flows, the house price increase along with bank stability by using house price index as house price determinant.

Model (B) shows that during FDI change is above 16.48% the NPL decreases, which mean that the bank stability is higher during this net capital flows (when HPD increases by 1% NPL decreases by 0.059%). If the FDI change is below 16.48% the NPL will increase which means that banks tend to have low stability. The result is consistent with deviation hypothesis during high capital outflows. Banks are likely to have higher non-performing loan ratio, which can cause the high banks' instability. The risky borrowers have lower ability to pay back the loans and debt. However, the impact is opposite when net capital flow is above the threshold. Therefore, the result is consistent of my third hypothesis argued that the collateral value hypothesis should hold during high net capital flows and the deviation hypothesis should hold during low net capital flows. To provide another new evidence to support the third hypothesis, I also investigate the portfolio investment.

In addition, compare to the previous results of FDI threshold effects excluding China, the coefficients of house price deviation and non-performing loans slightly increase. It means that by adding the real interest rate to house price deviation lead the stronger impact to the relationship of bank stability and house price deviation.

Table 32
Tests for threshold effects (HP and HPD interact with PI)

	Model A	**Model B**
Single threshold		
p-value	0.018	0.017
Double threshold		
p-value	0.227	0.168
Triple threshold		
p-value	0.666	0.766

Note: Model A is the threshold that HP interact with PI. Model B is the threshold that HPD interact with FDI.

Table 32 shows model (A) and model (B) are significant at the 5%. For double and triple threshold, both model (A) and model (B) are not significant. Therefore, there are one threshold in the regression of model (A) and model (B).

Table 33
Threshold estimates

	Model A		**Model B**	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Single Threshold	42.5800	[42.2020, 42.9700]	52.6010	[52.2100, 52.8160]

Note: Model A is the threshold that HP interact with portfolio investment changes. Model B is the threshold that HPD interact with portfolio investment changes.

Table 33 shows the threshold estimates. For model (A), the point estimates of single threshold is 42.58% and model (B) is 52.6% when HP and HPD interact with the threshold variable. The asymptotic 95% confidence intervals are consistent in both models.

Table 34
Regression estimates (HP and HPD interact with PI)

Dependent variable: NPL (Non-performing loans)	**Model A**	**Model B**
	Coefficient estimate	Coefficient estimate
Macro variables		
GDP per capita growth (%)	-0.0276 (0.410)	-0.0208 (0.563)
FDI changes (%)	0.0001 (0.902)	0.0007 (0.490)
Portfolio investment changes (%)	-0.0007** (0.054)	-0.0003 (0.488)
Real interest rate	-0.6456*** (0.001)	-0.4942** (0.013)
Unemployment rate	0.5733** (0.014)	0.6659*** (0.008)
Bank-specific variables		
Bank efficiency ratio	1.1587*** (0.000)	1.5332*** (0.000)
Capital to asset ratio	0.2830*** (0.000)	0.3339*** (0.000)
Return on assets	1.2611*** (0.000)	0.9116** (0.013)
Liquidity	-0.8451** (0.017)	-1.1106*** (0.003)
House price index changes (%) (PI $\leq$ Th1)	-0.0329*** (0.000)	-
House price index changes (%) (PI $>$ Th1)	-0.0233*** (0.000)	-
House price deviation (PI $\leq$ Th1)	-	0.4164** (0.017)
House price deviation (PI $>$ Th1)	-	-0.1707** (0.046)
Statistics		
F-stat p-value	0.000	0.000
R-squared	0.5982	0.5477
Obs	204	204

Note: Model A is the threshold that HP interact with portfolio investment changes. Model B is the threshold that HPD interact with portfolio investment changes. * Significance at 10% level, ** Significance at 5% level, *** Significance at 1% level. The number in parenthesis is p-value of coefficients.

Table 34 shows the estimates for the single threshold model of both model (A) and (B) which are HP and HPD interact with portfolio investment changes. The coefficient in model (A) equals -0.0233 when portfolio investment changes is below 42.58% and -0.0329 when portfolio investment changes is above threshold effects. This result is consistent with the collateral value hypothesis using house price index as house price indicator. During the high or low net capital flows of portfolio investment, the house price increase along with bank stability. House price appreciation improves bank stability by increasing the value of collaterals hold by banks. It also supports the previous FDI result.

Model (B) shows that during portfolio investment changes is above 52.6% the NPL decreases, which mean that the bank stability is higher during this portfolio investment changes. If the portfolio investment changes is below 52.6%, the NPL will increase which means that banks tend to be default. The result is consistent with deviation hypothesis during high outflows. Banks are likely to have high non-performing loan ratio. This result is also consistent with collateral value hypothesis during high net capital flow of portfolio investment with less impact to bank stability. These two results are consistent with the third hypothesis and support the previous result of FDI. In addition to compare with previous results excluding China. The coefficients between non-performing loans and bank stability are increase slightly. By adding the real interest rate to the factor that drive house price deviation, the impact of house price deviation on bank stability are greater than the previous results.

To conclude the results, they show the house price changes and house price deviation have the impact on bank stability varies in overall from emerging countries: Indonesia, Malaysia, China, Taiwan, and Thailand, with different GDP per capita growth, foreign direct investment changes and portfolio investment changes. When house price changes interact with GDP per capita growth, there is single threshold effect is suggested and the result and support the collateral value hypothesis. During high GDP per capita growth, the house prices increase and bank stability increases (low NPLs). Thus, the results support my second hypothesis which states that during high economic changes, the house prices increase along with bank stability – collateral value hypothesis holds. During low GDP per capita growth, house price deviations increase but bank stability decreases (high NPLs). This results also support my second hypothesis which states that during low economic changes, the house price deviations increase but bank stability decrease since the banks hold aggregate risky assets as collaterals from borrowers – deviation hypothesis holds. Furthermore, the results imply that only house price determinant is not reflect the true value of house price when the prices are bubble. To be more accurate in estimation the impact of house price on bank stability, using house price deviation as house price determinant reflect the fundamental value of real estates over period of time.

To provide more evidences of relationship between house prices and bank stability in condition of capital flows, I also test the thresholds of two macro variables which are foreign direct investments and portfolio investments as capital flows. When house price changes interact with foreign direct investment changes, there is single effect is suggested and the result is consistent with my expectation that the collateral hypothesis hold during high and low capital flows as house price changes is the indicator. For house price deviations as house price indicator, there is single threshold effect is suggested. During high outflows, house price deviations increase but bank stability decreases (high NPLs). This results support my third hypothesis which states that during high outflows, the house price deviations increase and bank stability decrease since the banks hold aggregated risky assets as collaterals from borrowers who have low ability to pay back the debts – deviation hypothesis holds. On the other hand, during inflows, the house prices deviations increase and bank stability increases (low NPLs). Thus, the results support my third hypothesis which states that during inflows, the house prices increase along with bank stability – collateral value hypothesis holds.

Furthermore, portfolio investments are applied as economic change indicators. The results show that when house price changes interact with portfolio investments changes, there is single threshold effect is suggested and the result and support the collateral value hypothesis. During high or low capital flows, the house prices increase and bank stability increases. Thus, the results support my third hypothesis which states that high net capital flows, the house prices increase along with bank stability – collateral value hypothesis holds. When house price deviations interact with portfolio investments changes, during high outflows, house price deviations increase but bank stability decreases. This results also support my third hypothesis which states that during outflows, the house price deviations increase but bank stability decrease since the banks hold and exposed to risky assets as collaterals and from risky borrowers who have low ability to pay back the debts – deviation hypothesis holds.

By applying threshold model, the result of threshold values look odds since the data obtained from China is biased and limited to the true value of banks and economic. To provide the reliable results, I estimate the impact of house prices on bank stability without China in new dataset. The results are reported from Table 13 to Table 23 with new threshold value, which are reasonable and reliable to explain the relationship. Moreover, bank-specific variables are more significant and explainable such as the significantly negative relationship of liquidity of banks and non-performing loans. To consider real interest as the factor that drives house prices to be deviated from fundamental value, I provide evidence to investigate the dataset excluding China with real interest rate as driven factors to house price deviation. The results are reported from Table 24 to Table 34. With real interest rate including in the dataset without China, we can observe the changes in the same direction when applying the threshold estimations with different of capital flow levels (Foreign direct investments and portfolio investments) reported in Table 31 and Table 34. By considering the real interest rate as driven factor house price deviation, the results show the slightly stronger impact to the relationship of bank stability and house price deviation.

5. Conclusion

This study aims to provide empirical evidence whether the real estate price affects bank stability in emerging countries under the different levels of economic growth (GDP per capita) and capital inflows (foreign direct investment and portfolio investment). The two competing hypotheses which are collateral value hypothesis and deviation hypothesis are used in attempt to explain these relationships. The threshold model is applied and the results show that during recession and capital outflows (below threshold effects), only deviation hypothesis holds, the house prices highly deviate from their fundamental value and cause the lower bank stability. While in the period of expanding economy (above threshold effects), collateral value hypothesis hold but deviation hypothesis do not hold. However, capital inflows has a positive effect on bank stability.

To test the threshold effects, threshold model is applied to examine the relationship and threshold effects between house price and bank stability. Moreover, the threshold model is applied to test two competing hypotheses which are collateral value hypothesis and deviation hypothesis by using house prices and bank specific variables in Asian countries from 2002Q1 to 2014Q4 with three different threshold variables (GDP per capita growth, foreign direct investment changes and portfolio investment changes). Following Pan and Wang (2013), I use non-performing loans as bank stability proxy. Following Koetter and Poghosyan (2010), the pooled mean group estimators are applied to estimate the house price deviation from long-run fundamental values.

The results have significant evidences to support deviation hypothesis from three threshold variables with house price deviation as house price indicator. During high GDP per capita and high net capital flows, the house price deviations have less impact on bank stability. On the other hand, when GDP per capita growth, foreign direct investment changes and portfolio investment changes below some points of threshold, the house price deviation do harm to the bank stability. For collateral hypothesis, there are two evidences support the hypothesis by two threshold variables - GDP per capita and portfolio investment changes with house price changes as house price indicator.

This study provides empirical evidence to passive and risk-averse investors. For bank-linked companies and institutional investors, our findings support that real estate market has strong impact on bank stability by deviation from fundamental value especially during the recession of economic changes and low net capital flows. Banks should reduce the amount of lending to the borrowers during the recessions and low net capital flows or outflows since the collateral values hold by banks have higher deviations which can cause the mispriced assets and banks' default by holding large numbers of non-performing loans. Banks should improve lending standards and requirements to reduce the chances of default to prevent the bubble in house prices and financial crisis. Furthermore, this study also provides the empirical evidence on the relationship of house price changes and deviation on bank stability in emerging market: Indonesia, Malaysia, Taiwan, and Thailand with different economic conditions.

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APPENDIX

Appendix A: List of banks in samples

Country	Name of Banks	Number of observations (before converting to ratio)
Malaysia	HONG LEONG BANK BERHAD	318
	AFFIN BANK BERHAD	318
	BIMB BANK BERHAD	318
	ALLIANCE BANK	318
	AMMB BANK	318
	CIMB GROUP BANK	318
	MALAYAN BANKING BERHAD	318
	PUBLIC BANK BERHAD	318
	RHB BANK BERHAD	318
Taiwan	SINOPAC BANK	318
	CTBC BANK	318
	BANK OF KAOHSIUNG	318
	CHANG HWA BANK	318
	FIRST FINAN BANK	318
	HUA NAN BANK	318
	KING'S TOWN BANK	318
	TAIWAN BUSINESS BANK	318
	MEGA BANK	318
	TAISHIN BANK	318
	UNION BANK OF TAIWAN	318
	FAR EASTERN INT'L BANK	318
	ENTIE COMMERCIAL BANK	318
	TA CHONG BANK	318
Thailand	KRUNG THAI BANK	318
	BANK OF AYUDHYA	318
	THANACHART BANK	318
	TISCO BANK	318
	TMB BANK	318
	KIATNAKIN BANK	318
	CIMB THAI BANK	318
	SIAM COMMERCIAL BANK	318
	KASIKORN BANK	318
	BANGKOK BANK	318
Indonesia	BANK OCBC NISP	318
	BANK PUNDI INDONESIA	318
	PT BANK	318
	BANK MNC INTL	318
	BANK QNB INDONESIA	318
	BANK MANDIRI	318
	BANK RAKYAT INDO	318

	BANK MEGA TERBUKA	318
	BANK CENTRAL ASIA	318
	BANK DANAMON INDO	318
	BANK INTL INDONESIA	318
	BANK CIMB NIAGA TBK	318
	BANK PERMATA TBK	318
	BANK ARTHA GR	318
	BANK VICTORIA	318
	BANK PAN INDONESIA	318
	BANK NEGARA	318
	BANK MAYAPADA	318
China	PING AN BANK	318
	CHINA MERCHANTS BANK	318
	CHINA MINSHENG BANK	318
	HUA XIA BANK	318
	SHANGHAI PUDONG BANK	318

VITA