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Mortgage Lending, Banking Crises and Financial Stability in Asia

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Abstract

We estimated the effect of the share of mortgage lending by individual banks (together with some control variables) on two measures of financial stability—the bank Z-score and the non-performing loan ratio—for a sample of 1,889 banks in 65 advanced and emerging economies for the period 1987–2014 from the Bankscope database. We find evidence that an increased share of mortgage lending is positive for financial stability, specifically by lowering the probability of default by financial institutions and reducing the non-performing loan ratio, at least in non-crisis periods, for levels of mortgage shares up to 49%–68%. For higher levels of mortgage lending shares, the impact on financial stability turns negative. Also, the occurrence of a banking crisis reduces the diversification benefits associated with mortgage lending. Asian banks show greater financial stability during non-crisis periods, but are more negatively affected by a higher mortgage ratio during crisis periods. Finally, a higher level of regulatory quality improves both financial stability measures, but the effects of macroprudential measures are mixed.

This finding most likely reflects the effect of a higher share of mortgage lending in diversifying the mix of banks' assets and thereby reducing overall risk. However, if the share of mortgage lending is too high, of if there is a banking crisis, then the diversification effect diminishes. Therefore, the challenge is to balance the expected improvement in financial stability due to asset diversification against negative impacts that might result from easier lending standards or too rapid increases in mortgage lending that could trigger a bubble in the housing market. This highlights the need for prudent monetary policy and macroprudential policy measures to forestall the development of such bubbles.

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1. INTRODUCTION

Domestic banking crises often originate in the real estate sector, as shown by Reinhart and Rogoff (2009), Bordo and Jeanne (2012) and others. Therefore, one might conclude that mortgage lending is negative for financial stability. However, in normal (non-crisis) periods, mortgage lending may actually contribute to financial stability. This is because mortgage loans have different risk properties from other bank assets, e.g., commercial loans, so having some share of mortgage loans in a bank's portfolio tends to diversify the risk of that portfolio. Also, because individual mortgage loans are small, they do not contribute much to systemic risk, except in periods of real estate bubbles (International Monetary Fund (IMF) 2006). For example, Morgan and Pontines (2014) found some evidence from a cross-country panel data set that an increased share of lending to small and medium-sized enterprises (SMEs) can be positive for some measures of financial stability. An increased share of lending for mortgages may operate in a similar way. Thus, mortgage lending could be an important mechanism for increasing financial development, financial stability and financial inclusion in emerging economies at the same time, providing that the development of housing price bubbles and banking crises can be avoided or at least controlled.

In this paper, we estimate the effect of the share of mortgage lending in total loans by individual banks (together with some control variables) on two measures of financial stability—the bank Z-score and the non-performing loan (NPL) ratio. Our sample comprises 1,889 banks in 65 advanced and emerging economies. We focus on mortgage lending for two reasons: its importance in overall household credit (averaging about 54% of total household credit in major Asian emerging economies according to IMF (2011)); and the fact that it is the only variable in the Bankscope database on banks that is related to financial inclusion. We find some evidence that an increased share of mortgage lending aids financial stability, mainly by lowering the probability of default by financial institutions and reducing the NPL ratio, at least for mortgage lending shares up to 49%–68% of the total. The main contribution of our paper is that few studies have examined the relationship between the mortgage lending share and financial stability, despite the importance of real estate lending in many financial systems. Even fewer studies have examined this relationship at the bank level, or looked at the interaction effects between the mortgage share and the occurrence of a banking crisis.

Section 2 of this paper provides definitions of financial inclusion and financial stability, and describes possible channels for interactions between mortgage lending and financial stability. Section 3 surveys the previous literature in this area. Section 4 describes the data on financial stability and mortgage lending that are used in this study. Section 5 describes the econometric model that is used in this paper, followed by the empirical results. Section 6 explains some robustness checks on the results obtained. Section 7 concludes.

2. FINANCIAL INCLUSION, FINANCIAL STABILITY AND MORTGAGE LENDING

This section provides some definitions of financial inclusion and financial stability and discusses the channels by which increases in mortgage lending might affect financial stability.

2.1 Definition of Financial Inclusion

Financial inclusion broadly refers to the degree of access of households and firms, especially poorer households and small and medium-sized firms, to financial services. However, it generally is not taken to mean any kind of access, but access at appropriate risk-adjusted costs with appropriate degrees of consumer protection, consumer information and consumer education. One definition is provided by Atkinson and Messy (2013: 11):

"the process of promoting affordable, timely and adequate access to a wide range of regulated financial products and services and broadening their use by all segments of society through the implementation of tailored existing and innovative approaches including financial awareness and education with a view to promote financial well-being as well as economic and social inclusion."

Studies of financial inclusion have generally focused on measures such as the percentage of adults with access to credit or deposits with a formal financial institution, or the share of total lending to small and medium-sized enterprises (SMEs). We argue that the share of mortgage loans in total lending can also be considered as a measure of financial inclusion. Basically, this is because mortgage loans are relatively small, so an increase in the share of mortgage lending implies an increase in the total number of borrowers.

2.2 Definition of Financial Stability

The global financial crisis of 2007-2009 heightened awareness of financial stability and the need for a macroprudential dimension to financial surveillance and regulation. Nonetheless, there is no generally agreed definition of financial stability, because financial systems are complex with multiple dimensions, institutions, products, and markets. Indeed, it is easier to describe financial instability than stability. The European Central Bank (ECB) defines financial stability as:

"… a condition in which the financial system—comprising of financial intermediaries, markets and market infrastructures—is capable of withstanding shocks, thereby reducing the likelihood of disruptions in the financial intermediation process which are severe enough to significantly impair the allocation of savings to profitable investment opportunities." (ECB 2012)

Further, the ECB defines three particular conditions associated with financial stability:

1. The financial system should be able to efficiently and smoothly transfer resources from savers to investors.
2. Financial risks should be assessed and priced reasonably accurately and should also be relatively well managed.
3. The financial system should be in such a condition that it can comfortably absorb financial and real economic surprises and shocks. (ECB 2012)

Perhaps the third condition is the most important, because the inability to absorb shocks can lead to a downward spiral whereby they are propagated through the system and become self-reinforcing, leading to a general financial crisis and broadly disrupting the financial intermediation mechanism. In this study, we focus on two measures of bank-level stability—the bank Z-score and the non-performing loan (NPL) ratio. As is described in more detail below, both of these measures provide information on the potential resilience of banks in the face of a financial crisis or other shock.

2.3 Interactions between Mortgage Lending and Financial Stability

We focus on the train of causality from mortgage lending to financial stability. In other words, does an increase in the mortgage loan ratio tend to enhance financial stability? Alternatively, one could ask if an increase in financial stability leads to an increase in the mortgage loan ratio. It is unlikely that an increase in financial stability would lead to a decrease in mortgage lending. However, as discussed below, it is possible that a bank's degree of financial stability could influence its asset allocation toward mortgage lending. Therefore, our estimation strategy attempts to isolate the effect going from the mortgage share to the financial stability measure.

Evidence from the advanced economies suggests that household loans have lower default rates compared with larger corporate loans. Also, relative to losses from corporate loans, those incurred from household loans tend to be smaller and more predictable. Thus, the risk that individual household loans pose to financial stability is less compared with that of corporate loans. Moreover, a balanced portfolio of household and corporate loans would increase the risk diversification of bank portfolios (IMF 2006). Of course, housing booms (and subsequent busts), and the associated movements in house prices, can lead to financial crises and economic downturns. In such periods, the risk of individual mortgage loans become highly correlated, and, hence, entails much greater risk for financial stability.

3. LITERATURE REVIEW

Research on the impacts of housing prices and mortgage lending growth on financial stability has been extensive. Reinhart and Rogoff (2009) show that the six major historical episodes of banking crises in advanced economies since the mid-1970s were all associated with housing price busts. Bordo and Jeanne (2002) find that financial crises are generally triggered when house prices have peaked, or just after they have started falling. Claessens, Kose and Terrones (2008) find evidence that recessions associated with credit crunches and house price busts tend to be deeper and longer than other recessions, although their paper used total credit to the private sector, rather than mortgage credit, in their analysis. Calabria (2013) argues that the uniquely high levels of “dual” leverage in the US mortgage finance system were the primary drivers of the high levels of losses to both households and financial institutions. Gerlach (2012) notes that a sharp fall in property prices can lead to financial instability in many ways, including: economic weakness as housing construction slows, triggering financial strains and defaults among property developers, construction companies and real estate firms; rising unemployment leading to non-performing loans and defaults among households; and overall weakness leading to a sharp worsening of banks’ balance sheets.

The experience of the subprime crisis in the US in 2007–2009 shows the perils to financial stability of increasing financial inclusion by relaxing lending standards and lending terms at the same time. Dell’Ariccia, Igan and Laeven (2008) find evidence that lending standards in the US declined more where credit booms were larger, and that there was a mutually reinforcing interaction between housing prices, lending standards and credit growth. Mian and Sufi (2009) find that the increase in mortgage defaults in 2007 in the US was disproportionately large in districts with a relatively large share of subprime borrowers, and those districts experienced an unprecedented relative growth in mortgage credit.

IMF (2011) analyzes the relationship between housing finance and financial stability using a panel-data set of 36 advanced and emerging economies from 2004 through 2009. They estimate a two-equation model of inflation-adjusted home price changes and the change in the proportion of NPLs. They find that a one percentage point increase in the ratio of mortgage credit to GDP in 2004–2007 was associated with a 0.15 percentage point increase in NPLs during the global financial crisis period of 2007–2009. However, the overall effect of the change in the mortgage loan ratio on NPLs during 2004–2009 was negative and insignificant. These results suggest that mortgage loans have a negative impact on financial stability during a financial crisis, but the impact for the period as a whole is ambiguous, and highlights the importance of distinguishing the effects of mortgage lending in crisis and non-crisis periods. In contrast to our paper, IMF (2011) used macro-level data.

However, research on the impacts of the share of mortgage finance in total lending is much scarcer and less conclusive. Cacnio (2014) describes a research project by the SEACEN Centre based on 13 country case studies in South Asia and Southeast Asia. Most of the results show that the level of mortgage loans does not pose a risk to financial stability of banks in this region. For example, the study of India (Kumar 2014) uses micro-level data from Indian banks to estimate a regression model of determinants of NPLs as a measure of financial stability. He finds that the change in the share of housing loans in total credit is negatively related with changes in NPLs. The study of Taipei,China (Hsu and Yu 2014) estimated a vector error-correction model of the mortgage NPL ratio using quarterly macro-level data, with independent variables including real GDP, real mortgage loan growth, real housing price and real interest rate. In the long-term cointegration equation, the coefficient of mortgage loans was positive, but not significant. In the short-run error-correction model, the coefficient for mortgage loan growth was negative and significant, implying that a short-term increase in mortgage loan growth was positive for financial stability.

As mentioned above, the risk characteristics of housing loans may be similar to those of SMEs (at least in non-crisis periods), because both are small-scale. In a study of Chilean banks, Adasme, Majnoni and Uribe (2006) find that the NPLs of small firms have quasi-normal loss distributions, whereas those of large firms have fat-tailed distributions. They note that the quasi-normality of small loans' loss curves means that the occurrence of large and infrequent losses is not a major concern, and therefore that lending processes to this class can be greatly simplified. This implies that the systemic risk of the former group is less than that of the latter, so that increased loans to SMEs (or mortgage loans) should reduce the overall riskiness of banks' lending portfolios. It seems likely that the same would be true of mortgage loans.

4. DATA

Our data set covers 65 advanced and emerging economies, including 10 Asian economies (see Appendix for list), and 1,889 individual banks. The variable of interest in the analysis is the share of mortgage loans in total outstanding loans (*mtgr*). The two measures of financial stability used as dependent variables are the bank Z-score (*z*) and the ratio of non-performing loans to total loans (*npl*). The data are annual, and the unbalanced panel sample covers the period 1987–2014. Bank-level data were obtained from the Bankscope database[1].

The first measure, bank Z-score, is a widely used indicator of financial stability (e.g., World Bank 2013). It is defined as:

(1) $z = (ROA + equity/assets)/sd(ROA)$,

where ROA is the average annual return on end-year assets, assets are total end-year assets, and sd(ROA) is the standard deviation of ROA (World Bank 2013:23). The numerator of the Z-score is the total available equity in a given period, i.e., the equity already on the balance sheet plus the current year's profits. The Z-score indicates the number of standard deviations that a bank's rate of return on assets can fall in one period before it becomes insolvent, i.e., the size of an annual loss that would be needed to wipe out all existing equity (Roy 1952). Therefore, a higher Z-score signals a lower probability of bank insolvency, because the loss would have to be a higher number of standard deviations to trigger insolvency, and hence implies greater financial stability. We calculated this measure for each bank in our sample set using data obtained from the Bankscope database. The second measure, *npl*, represents future potential capital losses, so a

[1] Bureau van Dijk, Bankscope database
https://bankscope.bvdinfo.com/version-2015325/home.serv?product=scope2006

higher value of *npl* implies potentially lower financial stability. Bank NPLs also come from the Bankscope database.[2]

Bank-level control variables include:

- ratio of liquidity to the total deposits (*liq*);
- logarithm of total assets (*lgast*);
- ratio of debt to total assets (*la*);
- ratio of operating cost to total income (*ci*); and
- income diversity (*ind*).

The data are taken from the Bankscope database. Income diversity (*ind*) was calculated as one minus the absolute value of the ratio of interest income to total operating income. Interest income and total operating income were also from Bankscope. These variables are commonly used in analyses of the financial stability of banks.

Country-level control variables include:

- year-on-year percent change of real GDP (*gdpgr*);
- year-on-year percent change of the consumer price index (*inflation*); and
- dummy variable for banking crisis period (*crisis*).

The GDP and inflation data were from the World Bank's World Development Indicators database.[3] Crisis periods were taken from Reinhart and Rogoff (2010). In the sensitivity analysis, we also included an index of the use of lender-related macroprudential policies (*mpib*) from Cerutti, Claesens and Leaven (2015); and the index of regulatory quality[4] from the World Bank (*rq*).

Table 1 reports the descriptive statistics for all the variables used in the empirical analysis, respectively. As a benchmark, the normal distribution is characterized by a skewness of zero (symmetry) and kurtosis of three (not very fat tails). Against these criteria, *z, npl, liq, la, ci, ind, gdpgr and inflation* all show significant signs of both skewness and kurtosis, which suggests that the presence of outliers could be a significant issue in our sample. In these circumstances, the traditional ordinary least-squares (OLS) estimator could be biased and inefficient. The correlations among the right-hand side variables are quite low, which suggests that multicollinearity is not likely to be an issue in our empirical analysis.

The following rules were used to reduce outliers in the data:

- Mortgage loan ratio: Dropping lowest 1% and those with ratio >85%
- Z-score: Dropping highest 1% and lowest 1%
- NPLs: Dropping highest 1% and lowest 1%. These rules were also followed in the regression estimates described in Section 5.
- Liability-asset ratio: Dropping observations greater than 1.

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[2] Bankscope defines NPLs as "impaired loans." However, they do not provide information about the extent to which the definition of NPLs is standardized across countries or banks.

[3] World Bank World Development Indicators

http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators

[4] World Bank World Governance Indicators http://data.worldbank.org/data-catalog/worldwide-governance-indicators

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
z	9,965	26.33	23.56	0.68	136.37
npl	9,965	3.76	4.48	0.01	32.26
mtgr	3,921	0.4	0.25	0	1
liq	9,965	26.77	23.35	1.35	128.07
lgast	9,965	15.08	2.19	7.83	21.63
lgloans	9,965	14.57	2.2	7.54	21.03
la	9,965	0.63	0.17	0.09	0.96
ci	9,965	63.58	16.27	16.56	117.01
ind	9,615	0.17	0.22	0	1
gdpgr	9,965	2.89	3.05	-10.89	15.24
inflation	9,965	3.63	3.73	-1.31	26.67
mpib	9,965	0.21	0.54	0	2
rq	9,965	0.76	0.72	-1.29	2.12

Source: Authors' calculations.

Note: Number of observations is different for some variables because of different numbers of missing data.

To test the time-series properties of the main variables in our model, we conducted unit-root tests on our three main variables. There are six types of unit-root tests often used in panel data analysis literature, namely Levin-Lin-Chu test (Levin, Lin and Chu 2002), Harris-Tzavalis test (Harris and Tzavalis 1999), Breitung test (Breitung 2000), Hadri LM stationarity test (Hadri 2000), Im-Pesaran-Shin test (Im, Pesaran and Shin 2003), and Fisher-type tests (Maddala and Wu 1999). However, the first four types of test require the data to be strongly balanced and the Im-Pesaran-Shin test requires strongly balanced data or a time dimension of longer than nine periods. However, our dataset is not balanced and only spans seven years at most. Therefore, we test for unit roots using two kinds of Fisher-type methods, which are based on the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test based on Dickey and Fuller (1979) and Phillips and Perron (1988), respectively. The null hypotheses for the Fisher tests are that the time-series data follow a unit root process. All the tests for our main variables strongly reject the null hypothesis that there are unit roots in these data.[5]

5. MODEL AND RESULTS

5.1 Regression model

To verify the relationship between financial stability and financial inclusion, we estimate the following model with our panel data:

$$finstab_{i,j,t} = \alpha + \beta mtgr_{i,j,t} + \gamma mtgr_{i,j,t}^2 + \theta X_{i,j,t} + \lambda C_{j,t} + \eta_t + \nu_i + \varepsilon_{i,j,t}. \qquad (2)$$

where *finstab* is the measure of financial stability and *mtgr* is the share of mortgage loans to total loans of each bank. We also include a quadratic term of the mortgage loan share to test its potential non-linear relationship with financial stability. Based on previous research on the effects of other bank-related variables on financial stability (Hesse and Cihak, 2007; Cihak and Hesse, 2008), we include a group of control variables for both bank-level and macro-level

[5] The 1% criteria follows Hesse and Cihak (2007)

factors that may affect financial stability. The vector, X, contains bank-specific control variables, including:

- ratio of liquidity to the total deposits (*liq*);
- logarithm of total assets (*lgast*);
- ratio of liabilities to total assets (*la*);
- ratio of operating cost to total income (*ci*); and
- income diversity (*ind*).

The vector, C, contains macroeconomic control variables, including:

- year-on-year percent change of real GDP (*gdpgr*);
- year-on-year percent change of the Consumer Price Index (*inflation*);
- dummy variable for crisis period (*crisis*); and
- dummy variable for Asian economies (*asia*).

Further, η_t and v_i, are vectors of time-dummy and bank-dummy variables, respectively. Finally, we include some interaction terms between *crisis*, *asia*, *mtgr* and *lgast*. The error terms, $\varepsilon_{i,j,t}$, where i = 1,…, N represents the bank; j = 1, …, M represents the country; and t = 1, …, T represents year of observation, are assumed to be normally and independently distributed. Finally, β and γ are the coefficients of interest that measure the effects of the mortgage ratio on financial stability, θis the vector of coefficients of the bank-specific variables, and λ is the vector of coefficients of the country-specific variables. Finally, in the sensitivity analysis, we also include an index of the use of lender-related macroprudential policies (*mpib*); and an index of regulatory quality (*rq*).

5.2 Regression methods

We estimate the parameters of equation (2) using the system-generalized method of moments (GMM) dynamic panel. Two aspects of equation (2) are worth noting. First, the financial stability of each bank may depend on its historical trend and may be slow to adjust substantially in the short run. Second, there is a potential endogeneity problem of regressing financial stability measures on mortgage loans in the same year, because the bank's financial stability measure may also affect its choice of the mortgage loans ratio. If we use contemporaneous regressors, the possible mutual causality might lead to bias in our estimates.[6]

The system-GMM method includes the lagged dependent variable in the regression model. System-GMM is based on a system composed of first-differences instrumented on lagged levels, and of levels instrumented on lagged first-differences (Arellano and Bond, 1991). In addition to providing a rigorous remedy for endogeneity bias, dynamic-panel GMM estimation holds two further attractions. First, it is more robust to measurement error than cross-section regressions. Second, dynamic-panel GMM estimates remain consistent even if the explanatory variables are endogenous in the sense that $E[X_t\varepsilon_s] \neq 0$ for $s \leq t$, if the instrumental variables are sufficiently lagged. Therefore, the system-GMM estimation method is suitable to alleviate the endogeneity bias and explore the dynamic structure of financial stability. We also consider longer lags of *mtgr* in the section on robustness checks.

[6] We do not believe that endogeneity of *mtgr* is a major problem. The average standard deviation of *mtgr* for individual banks in the sample is 0.05, which is relatively small compared with the sample mean of 0.38. This shows significant momentum for the mortgage shares of each bank, and suggests they are not overly influenced by other variables, including financial stability measures.

5.3 Results

Table 2 presents the results of the GMM regressions for *lnz*. (The natural log of the Z-score is used to reduce skewness.) Equation (1) shows the basic equation and equations (2)-(3) show the results of introducing interaction terms between the crisis dummy and the mortgage ratio and asset size. In Equations (1), (2) and (3), the mortgage loan share ($mtgr_{-1}$) enters positively and is significant at the 1% level. More interestingly, the quadratic term of the mortgage loan share ($mtgr^2_{-1}$) is negative and significant at the 1% level. The estimates are very similar for the three equations.

The positive coefficient of the linear term and the negative coefficient of the quadratic term imply an inverse U-shape relationship between mortgage loans and financial stability. That is, when the mortgage ratio is lower than a critical level, a higher share of mortgage lending leads to a higher Z-score (lower probability of insolvency); and, when the mortgage ratio exceeds that point, a higher mortgage loan share leads to a lower Z-score (higher probability of insolvency). Based on the estimated coefficients, one can calculate the critical point of the mortgage loan share where the Z-score reaches its highest estimated value. For the coefficient estimates in equations (1) and (4)-(6), Table 2, the critical value of the mortgage ratio lies in the range of 58%-68%.[7]

[7] In equations (2) and (3), the critical value is over 100%, which implies there is no limit to the diversification benefit. This is improbable, and seems to be related to the introduction of the interaction term of *mtgr* and *crisis.* However, this result does not occur when the *asia* dummy is also included. Also, this does not occur for the coefficient estimates from the robustness check in Table 4.

Table 2: GMM estimation results for Z-score

Variable	(1) lnz	(2) lnz	(3) lnz	(4) lnz	(5) lnz	(6) lnz
L.lnz	0.95***	0.95***	0.95***	0.94***	0.93***	0.93***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.mtgr	0.07***	0.08***	0.09***	0.34***	0.38***	0.38***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$L.mtgr^2$	-0.06***	-0.02***	-0.03***	-0.25***	-0.29***	-0.29***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.lgast	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.liq	-0.00007***	0.00019***	0.00029***	0.00011***	0.00007***	0.00007***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.la	-0.15***	-0.11***	-0.10***	-0.13***	-0.13***	-0.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.ci	0.00186***	0.00180***	0.00180***	0.00085***	0.00086***	0.00086***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.ind	-0.06***	-0.05***	-0.05***	-0.18***	-0.18***	-0.18***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.gdpgr	-0.00060***	-0.00068***	-0.00061***	-0.00044***	-0.00052***	-0.00052***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.inflation	0.00117***	0.00111***	0.00079***	-0.00006**	-0.00015***	-0.00015***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
L.crisis	0.03***	0.07***	0.16***	0.13***	0.13***	0.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.mtgr*L.crisis		-0.10***	-0.09***	-0.06***	-0.08***	-0.08***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.lgast*L.crisis			-0.01***	-0.01***	-0.00449***	-0.00449***
			(0.00)	(0.00)	(0.00)	(0.00)
asia				0.04***	0.04***	0.04***
				(0.00)	(0.00)	(0.00)
asia*L.crisis					-0.82***	
					(0.00)	
L.mtgr*asia*L.crisis						-6.85***
						(0.00)
Constant	0	0.04***	-0.03***	0	0	0
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	4915	4915	4915	4915	4915	4915
no of instruments	728	810	809	1093	1092	1092
AB test of R2 (p-value)	0.537	0.575	0.584	0.672	0.678	0.678
Hansen test (p-value)	1.000	1.000	1.000	1.000	1.000	1.000

Notes: "L" denotes one-year lag. Estimated system-GMM results are based on two-step standard errors based on Windmeijer (2005) finite sample correction. Standard errors are reported in parentheses. 'AB test AR2': p-value of the Arellano-Bond test that average auto covariance in residuals of order 2 is 0. Robust standard errors are reported in parentheses. * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. The coefficients of the year dummies are not reported.

Source: Authors' calculations.

Regarding the control variables, Table 2 shows that bank total assets tend to be positively correlated with financial stability, which suggests that the size of total assets could be an indicator showing the financial strength of a bank.[8] The liquidity ratio has a positive effect on financial stability in all except one equation, i.e., the Z-score tends to be higher, which is in line with expectations. The ratio of liabilities to assets has a consistent and significant negative effect on financial stability, which is in line with expectations. The cost-to-income ratio is found to be positive for *lnz*, which is not expected. Higher income diversity and GDP growth negatively affect *lnz*, which is not expected, while the effects of inflation are mixed.

In equation (2) the interaction term between *crisis* and *mtgr* (*mtgr*crisis*) is negative and significant, suggesting that mortgage lending reduces financial stability in crisis periods, as expected. Equation (3) shows that asset size interaction dummy (*lgast*crisis*) also tends to reduce financial stability in crisis periods, perhaps reflecting greater risk taking by large banks. The implied reduction in the critical point for *mtgr* ranges between 12-14 percentage points compared with non-crisis periods.

Equations (4)-(6) include a dummy variable for Asian economies (*asia*), together with interaction effects with *crisis* and *mtgr (asia*crisis* and *mtgr*asia*crisis*, respectively*)*. The coefficients of *asia* are positive and significant, suggesting greater financial stability in Asian economies during non-crisis periods. However, the coefficients of the interaction terms are negative and significant, suggesting that banks in Asian economies are less stable in crisis periods, and this effect increases in line with *mtgr*. The reasons for this need further study.

Equations (7)-(12) in Table 3 show the corresponding GMM regression results for *npl*. The results are broadly similar. In all six equations, the coefficient of ($mtgr_{-1}$) is significantly negative and the coefficient of the quadratic term ($mtgr^2_{-1}$) is significantly positive. This implies a U-shape relationship with regards to *npl*. Based on the coefficient estimates, this implies that *npl* is minimized for mortgage ratios in the range of 49%-61%. In other words, up to the critical point, a higher share of mortgage lending leads to a lower level of *npl*, which is positive for bank stability, and *npl* increases when mortgage ratio is higher than this critical value, which is negative for bank stability. However, during crisis periods, the coefficient for *mtgr*crisis* implies that the critical point for *mtgr* ranges between 15-23 percentage points lower compared with non-crisis periods. Therefore, results from both of our financial stability measures imply that, up to a certain point, increasing the share of mortgage loans of a bank increases its financial stability, which highlights the role of mortgage loans as a means of asset diversification. However, if a bank's share of mortgage loans rises above the critical point, the diversification effect turns negative, and financial stability decreases.

The standard diagnostic tests of the 12 regressions presented in Tables 2 and 3 suggest no misspecification problems. The AR2 test fails to reject the null hypothesis of no second-order residual autocorrelation.

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[8] Some studies have found a negative relationship between asset size and financial stability measures, presumably because of the "too-big-to-fail" effect, e.g., Hesse and Cihak (2007), Laeven and Levine (2009), Beltratti and Stulz (2012) and Bhaghat, Bolton and Lu (2015). However, in our study the effect turns negative in crisis periods.

Table 3: GMM estimation results for NPLs

Variable	(7) npl	(8) npl	(9) npl	(10) npl	(11) npl	(12) npl
L.npl	0.70***	0.68***	0.68***	0.70***	0.70***	0.70***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.mtgr	-3.27***	-2.98***	-3.08***	-4.90***	-5.23***	-5.23***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.mtgr^2	3.34***	2.46***	2.53***	4.12***	4.53***	4.53***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.lgast	0.04***	0.01***	0.00***	-0.07***	-0.07***	-0.07***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.liq	0.02***	0.02***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.la	2.45***	2.58***	2.49***	0.81***	0.78***	0.78***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.ci	0.02***	0.01***	0.01***	0.00011	0.00001	0.00001
	(0.00)	(0.00)	(0.00)	(0.06)	(0.90)	(0.90)
L.ind	1.63***	1.80***	1.77***	1.65***	1.62***	1.62***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.gdpgr	-0.04***	-0.04***	-0.04***	-0.08***	-0.08***	-0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.inflation	0.14***	0.15***	0.15***	0.13***	0.14***	0.14***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.crisis	0.58***	0.16***	-0.89***	-1.60***	-1.59***	-1.59***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.mtgr*L.crisis		1.12***	1.05***	1.18***	1.33***	1.33***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.lgast*L.crisis			0.07***	0.10***	0.09***	0.09***
			(0.00)	(0.00)	(0.00)	(0.00)
asia				-0.53***	-0.52***	-0.52***
				(0.00)	(0.00)	(0.00)
asia*L.crisis					7.14***	
					(0.00)	
L.mtgr*asia*L.crisis						59.97***
						(0.00)
Constant	0	-1.69***	0	0	2.37***	2.37***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	4915	4915	4915	4915	4915	4915
no of instruments	805	810	809	1093	1092	1092
AB test of R2 (p-value)	0.869	0.844	0.824	0.931	0.933	0.933
Hansen test (p-value)	1.000	1.000	1.000	1.000	1.000	1.000

Notes: "L" denotes one-year lag. Estimated system-GMM results are based on two-step standard errors based on Windmeijer (2005) finite sample correction. Standard errors are reported in parentheses. 'AB test AR2': *p*-value of the Arellano-Bond test that average auto covariance in residuals of order 2 is 0. * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. The coefficients of the year dummies are not reported.

Source: Authors' calculations.

On the whole, the results for the control variables are similar to those for *lnz*. Unlike the findings in Table 2, equations (7)-(9) in Table 3 shows that banks with higher assets tend to have higher *npl*, but this effect is reversed in equations (10)-(12). Higher liquidity and higher liability-to-asset ratios tend to increase *npl*, similar to the results for *lnz*; again the former is unexpected and the latter is expected. A higher cost-to-income ratio also tends to increase *npl*, as expected, although the effect is not significant in equations (10)-(12). Income diversity is associated with higher *npl*, consistent with the results for *lnz*, but also against expectations. GDP growth is negative for *npl*, which is expected, while higher inflation tends to increase *npl*.

The coefficients of *crisis* are significant, but the sign is not consistent across the regressions. As in the case of *lnz*, the interaction terms between *crisis*, *mtgr* and *lgast* all tend to raise *npl*, i.e., reduce financial stability. Also, *asia* tends to reduce *npl*, but the interaction terms with *crisis* and *mtgr* tend to raise *npl*, which is consistent with the results for lnz. In other words, Asian banks tend to be more stable in non-crisis periods, but less stable in crisis periods.

Lastly, we investigated the effects of the use of bank-related macroprudential measures (*mpib*) and the level of regulatory quality (*rq*) on the dependent variables. The results are given in Table 4 in equations (13)-(15) for *lnz* and (16)-(18) for *npl*. Regulatory quality is significant and has the expected signs on both *lnz* and *npl* (positive and negative, respectively). However, the results for macroprudential measures are significant but inconsistent, with negative signs for both *lnz* and *npl*, which is expected for the latter but unexpected for the former. This may be a result of reverse causality, i.e., lower *lnz* would tend to induce the use of macroprudential measures, although it is not obvious why this is not the case for *npl* as well.

Table 4: Effects of macroprudential measures and regulatory quality

Variable	(13) lnz	(14) lnz	(15) lnz	(16) npl	(17) npl	(18) npl
L.lnz	0.97***	0.98***	0.96***			
	(0.0)	(0.0)	(0.0)			
L.npl				0.73***	0.73***	0.73***
				(0.0)	(0.0)	(0.0)
L.mtgr	0.41***	0.44***	0.67***	-3.78***	-3.22***	-3.65***
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
L.mtgr2	-0.57***	-0.62***	-0.79***	4.44***	4.29***	4.43***
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
L.lgast	0.01**	-0.00*	0.01***	0.09***	0.08***	0.10***
	(0.0)	(0.04)	(0.0)	(0.0)	(0.0)	(0.0)
L.liq	0	0	0	0.01***	0.01***	0.01***
	(0.19)	(0.15)	(0.08)	(0.0)	(0.0)	(0.0)
L.la	0.01	-0.08***	-0.14***	2.93***	2.84***	3.02***
	(0.83)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
L.ci	0.00***	0	0	0.04***	0.04***	0.04***
	(0.0)	(0.11)	(0.11)	(0.0)	(0.0)	(0.0)
L.ind	-0.14***	-0.06**	-0.13***	-0.78***	-0.49***	-0.76***
	(0.0)	(0.01)	(0.0)	(0.0)	(0.0)	(0.0)
L.gdpgr	0.00***	0.00***	0.00***	-0.02***	-0.03***	-0.02***

	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
L.inflation	-0.01***	-0.00***	0.00***	0.00**	0.02***	0
	(0.0)	(0.0)	(0.0)	-0.01	(0.0)	(0.77)
L.crisis	0.03***	0.03***	0	-0.09***	0	-0.09***
	(0.0)	(0.0)	(0.85)	(0.0)	(0.92)	(0.0)
L.asia	-0.03***	0.0	-0.02***	0.05**	0.03*	0.0
	(0.0)	(0.45)	(0.0)	(0.01)	(0.03)	(0.82)
L.mpib	-0.04***		-0.01***	-0.33***		-0.33***
	(0.0)		(0.0)	(0.0)		(0.0)
L.rq		0.04***	0.01***		-0.09***	-0.10***
		(0.0)	(0.0)		(0.0)	(0.0)
N	2144	2144	2144	2144	2144	2144
No. of instruments	207	207	333	333	333	333
AB test of R2 (p-value)	0.644	0.644	0.551	0.812	0.78	0.807
Hansen test (p-value)	0.174	0.174	0.347	0.392	0.488	0.402

Notes: "L" denotes one-year lag. Estimated system-GMM results are based on two-step standard errors based on Windmeijer (2005) finite sample correction. Standard errors are reported in parentheses. 'AB test AR2': *p*-value of the Arellano-Bond test that average auto covariance in residuals of order 2 is 0. * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. The coefficients of the year dummies are not reported.

Source: Authors' calculations.

6. ROBUSTNESS CHECKS

In our main analysis, we employ a one-year lag of the mortgage loan ratio to control for potential endogeneity. As a robustness check, we tried avoid potential endogeneity even further by using a two-year lag of *mtgr* as our explanatory variable of interest. The results are for *lnz* are summarized in Table 5 and those for *npl* are summarized in Table 6. There is very little difference from the results in Tables 2 and 3, respectively. In particular, the signs of the linear and quadratic terms of *mtgr* for both *lnz* and *npl* remain unchanged, and are still significant at the 1% level. Since the relationship holds even with a two-year lag, this should further ease any concerns about endogeneity of *mtgr*. The coefficients of the control variables and the interaction terms are also virtually the same.

Table 5: Robustness check regression estimation results for Z-score

	(19)	(20)	(21)	(22)	(23)	(24)
	lnz	lnz	lnz	lnz	lnz	lnz
L.lnz	0.95***	0.95***	0.94***	0.94***	0.94***	0.94***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.mtgr	0.17***	0.20***	0.22***	0.32***	0.36***	0.36***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.mtgr^2	-0.11***	-0.13***	-0.15***	-0.20***	-0.25***	-0.25***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.lgast	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.liq	-0.00018***	0.00001	0.00015***	0.00018***	0.00011***	0.00011***
	(0.00)	(0.32)	(0.00)	(0.00)	(0.00)	(0.00)
L.la	-0.15***	-0.13***	-0.12***	-0.13***	-0.13***	-0.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.ci	0.00235***	0.00189***	0.00192***	0.00115***	0.00117***	0.00117***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.ind	-0.09***	-0.07***	-0.07***	-0.16***	-0.16***	-0.16***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.gdpgr	-0.00105***	-0.00161***	-0.00156***	-0.00107***	-0.00109***	-0.00109***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.inflation	0.00260***	0.00205***	0.00158***	0.00174***	0.00160***	0.00160***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.crisis	0.03***	0.07***	0.21***	0.18***	0.18***	0.18***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.mtgr*L.crisis		-0.12***	-0.11***	-0.07***	-0.10***	-0.10***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.lgast*L.crisis			-0.01***	-0.01***	-0.01***	-0.01***
			(0.00)	(0.00)	(0.00)	(0.00)
asia				0.03***	0.03***	0.03***
				(0.00)	(0.00)	(0.00)
asia*L.crisis					-0.99***	
					(0.00)	
L2.mtgr*asia*L.crisis						-7.97***
						(0.00)
Constant	0.05***	0.06***	0	0	-0.04***	-0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	4047	3923	3923	3923	3923	3923
no of instruments	722	797	796	1045	1044	1044
AB test of R2 (p-value)	0.38	0.404	0.409	0.343	0.331	0.331
Hansen test (p-value)	1.000	1.000	1.000	1.000	1.000	1.000

Notes: "L" denotes one-year lag, "L2" denotes two-year lag. Estimated system-GMM results are based on two-step standard errors based on Windmeijer (2005) finite sample correction. Standard errors are reported in parentheses. 'AB test AR2': *p*-value of the Arellano-Bond test that average auto covariance in residuals of order 2 is 0. * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. The coefficients of the year dummies are not reported..

Source: Authors' calculations.

Table 6: Robustness check regression estimation results for NPL ratio

	(25)	(26)	(27)	(28)	(29)	(30)
	npl	npl	npl	npl	npl	npl
L.npl	0.69***	0.66***	0.65***	0.72***	0.72***	0.72***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.mtgr	-2.01***	-2.84***	-3.08***	-4.62***	-4.77***	-4.77***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.mtgr^2	1.87***	2.09***	2.26***	4.05***	4.23***	4.23***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.lgast	0.05***	0.01***	-0.01***	-0.10***	-0.10***	-0.10***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.liq	0.02***	0.01***	0.01***	0.00288***	0.00311***	0.00311***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.la	2.40***	2.05***	1.81***	0.80***	0.78***	0.78***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.ci	0.02***	0.01***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.ind	1.99***	1.81***	1.75***	1.63***	1.62***	1.62***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.gdpgr	-0.04***	-0.05***	-0.05***	-0.08***	-0.08***	-0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.inflation	0.11***	0.16***	0.17***	0.14***	0.14***	0.14***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.crisis	0.69***	0.05***	-2.34***	-2.34***	-2.35***	-2.35***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.mtgr*L.crisis		1.14***	1.07***	0.72***	0.82***	0.82***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L2.lgast*L.crisis			0.16***	0.17***	0.17***	0.17***
			(0.00)	(0.00)	(0.00)	(0.00)
asia				-0.27***	-0.26***	-0.26***
				(0.00)	(0.00)	(0.00)
asia*L.crisis					3.81**	
					(0.00)	
L2.mtgr*asia*L.crisis						30.58**
						(0.00)
Constant	-3.61***	-2.25***	0	2.44***	0	2.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	4047	3923	3923	3923	3923	3923

no of instruments	781	797	796	1045	1044	1044
AB test of R2 (p-value)	0.222	0.191	0.189	0.216	0.214	0.214
Hansen test (p-value)	1.000	1.000	1.000	1.000	1.000	1.000

Notes: "L" denotes one-year lag, "L2" denotes two-year lag. Estimated system-GMM results are based on two-step standard errors based on Windmeijer (2005) finite sample correction. Standard errors are reported in parentheses. 'AB test AR2': *p*-value of the Arellano-Bond test that average auto covariance in residuals of order 2 is 0. * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. The coefficients of the year dummies are not reported..

Source: Authors' calculations.

7. CONCLUSIONS

The main contribution of our paper is to find a relationship between the share of mortgage lending in total bank loans and measures of financial stability, an area which has been little studied. Most related studies have looked instead at the effects of mortgage lending growth and general credit growth on the risk of financial crises. Even fewer studies have examined this relationship using bank-level data.

We estimated the effect of the share of mortgage lending by individual banks (together with some control variables) on two measures of financial stability—bank Z-score and NPL ratio. We find evidence that an increased share of mortgage lending tends to be positive for a bank's financial stability, specifically by lowering the probability of default by financial institutions and reducing the ratio of non-performing loans. This result is significant for all specifications. However, if the mortgage share exceeds a critical level of 49%-68% of total loans, the incremental impact on financial stability becomes negative. This result is consistent with the notion that asset diversification increases financial stability, whereas asset concentration is negative for financial stability.

We also found significant differences in the behavior of the bank financial stability measures between crisis and non-crisis periods. Following crisis periods, bank financial stability is negatively affected by both larger asset size and a higher mortgage share. In other words, the diversification benefits of mortgage shares are reduced, a result which is not surprising. In particular, the presence of crises is estimated to lower the stability-maximizing level of the mortgage ratio by about 12-23 percentage points.

Further, we found some evidence of a difference in the financial stability performance of Asia banks relative to that of the whole sample. Specifically, Asian banks tend to have better than average financial stability during non-crisis periods, but are more vulnerable than average in crisis periods. In particular, increases in the mortgage ratio are more negative for Asian banks than for the sample as a whole. It is not clear why this would be, and this finding needs further investigation. Finally, a higher level of regulatory quality is found to improve both financial stability measures, but the effects of macroprudential measures are mixed.

These results are supported by the robustness checks. This suggests that mortgage lending can make a positive contribution to financial stability up to a certain point, although this point is lower during crisis periods. This diversification effect is similar to that found for SME lending described in Morgan and Pontines (2014).[9] Therefore, the challenge is to balance the expected improvement in financial stability due to asset diversification against any negative impacts that might result from easier lending standards leading to a rapid increase in mortgage lending that

[9] In Morgan and Pontines (2014) the sample was too small to identify possible nonlinear effects.

could trigger a price bubble in the housing market. This highlights the need for prudent monetary policy and macroprudential policy measures such as loan-to-value ratios to forestall the development of such bubbles.[10] Further work in this area is needed.

Future work could also consider the effects of the mortgage ratio on other measures of financial stability, such as the volatility of GDP growth, bank loans and bank deposits, or the presence of financial crises. The effect of usage of macroprudential regulatory instruments such as loan-to-value ratios could also be investigated.

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Appendix

Table A: List of Countries

ANGOLA	DOMINICAN REPUBLIC	INDIA	NIGERIA	SPAIN
ARGENTINA	ECUADOR	INDONESIA	NORWAY	SRI LANKA
AUSTRALIA	EGYPT	IRELAND	PANAMA	SWEDEN
AUSTRIA	EL SALVADOR	ITALY	PARAGUAY	SWITZERLAND
BELGIUM	FINLAND	JAPAN	PERU	THAILAND
BOLIVIA	FRANCE	KENYA	PHILIPPINES	TUNISIA
BRAZIL	GERMANY	MALAYSIA	POLAND	TURKEY
CANADA	GHANA	MAURITIUS	PORTUGAL	UNITED KINGDOM
CHILE	GREECE	MEXICO	REPUBLIC OF KOREA	UNITED STATES
CHINA	GUATEMALA	MOROCCO	ROMANIA	URUGUAY
COLOMBIA	HONDURAS	NETHERLANDS	RUSSIAN FEDERATION	VENEZUELA
COSTA RICA	HUNGARY	NEW ZEALAND	SINGAPORE	ZAMBIA
DENMARK	ICELAND	NICARAGUA	SOUTH AFRICA	ZIMBABWE

Source: Authors.