

## ***Internet Appendix***

# **When Banks Grow Too Big for their National Economies: Tail Risks, Risk Channels, and Government Guarantees**

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This appendix contains information and tabulated results of additional tests on the relationship between bank relative size and tail risk.

A1	Estimation of the Market Value of Bank Assets and Bank Debts
A2	Additional Summary Statistics
A3	Additional Empirical Tests
	<ul style="list-style-type: none"><li>• Subsample analysis</li><li>• Excluding relative size <math>\geq 100\%</math> (<math>\geq 50\%</math>)</li><li>• Alternative measures of tail risk</li><li>• Alternative measures of relative size</li><li>• Controlling for IFRS distortions</li></ul>

## A1: Estimation of the Market Value of Bank Assets and Bank Debts

We infer the market value of bank assets from the Merton (1974) credit risk model. In this model, a firm's equity is seen as a call option on the market value of bank assets. The value of this option corresponds to the value of a European call option with a strike price equal to the face value of the firm's debts and a maturity equal to the maturity of debts. Under this setting, the market value of assets ( $V_{A,t}$ ) and the asset return volatility ( $\sigma_{A,t}$ ) are obtained by simultaneously solving two equations derived from the Black and Scholes (1973) option valuation model: 1) the European call option equation; 2) the optimal hedge equation.

More formally, the market value of a firm's equity ( $V_{E,t}$ ) is expressed as a function of the asset value by solving the following system of nonlinear equations:

$$V_{E,t} = V_{A,t}N(d_{1,t}) - X_t e^{-r_f T} N(d_{2,t}) \quad (1A)$$

$$\sigma_{E,t} = \left( \frac{V_{A,t}}{V_{E,t}} \right) N(d_{1,t}) \sigma_{A,t} \quad (2A)$$

Equation (1A) defines  $V_{E,t}$  as a call option on the market value of a bank's total assets,

with  $d_{1,t} = \frac{\ln(V_{A,t} / L_t) + (r_{f_t} + 0.5\sigma_{A,t}^2)T}{\sigma_{A,t}\sqrt{T}}$  and  $d_{2,t} = d_{1,t} - \sigma_{A,t}\sqrt{T}$ . Equation (2A) is the optimal

hedge equation that relates the standard deviation of a bank's equity value to the standard deviation of a bank's total asset value (both on an annualized basis).

This system of equations is solved employing as starting values for  $\sigma_{A,t}$  the historical volatility of equity (computed on a yearly basis using daily data) multiplied by the ratio of the

market value of equity to the sum of the market value of equity and the book value of total liabilities, namely,  $\sigma_{A,t} = \sigma_{E,t} V_{E,t} / (V_{E,t} + L_t)$ .

As in Vassalou and Xing (2004), a Newton search algorithm then identifies the values for  $V_{A,t}$  and  $\sigma_{A,t}$ . Finally, the market value of bank debt in a given year is computed as the difference between  $V_{A,t}$  and  $V_{E,t}$ .

## A2: Additional Summary Statistics

**Table A1:** Descriptive Statistics for Additional Variables

		N	Mean	Median	St.Dev.
<b><u>Other Dependent Variables</u></b>					
DEBT VALUE GROWTH	Log growth in the market value of debt over a one-year period.	7,533	10.849	7.935	14.786
EQUITY VALUE GROWTH	Log growth of the market value of equity.	7,534	7.677	7.560	43.192
<b><u>Additional Controls</u></b>					
LOCAL CRISIS	A dummy equal to 1 if a country has suffered from a systemic banking crisis in the period before the global turmoil.	8,438	0.050	0.000	0.218
DEBT CRISIS	A dummy equal to 1 when a country has suffered from a sovereign bond default.	8,438	0.008	0.000	0.091
SOVEREIGN TAIL RISK	The expected shortfall of sovereign bond returns computed yearly as the average of the daily returns below the 5 <sup>th</sup> percentile.	7,038	0.008	0.006	0.008
SOVEREIGN BETA	A proxy of a bank's sovereign bond holding based on yearly regressions of bank daily stock returns on domestic market returns (based on Datastream domestic market indexes) and domestic sovereign bond returns. Similar to Gennaioli et al. (2016) for developed countries, we use J.P. Morgan's Global Bond Index (GBI) file to compute sovereign returns. We compute bond returns for emerging countries from J.P. Morgan's Emerging Market Global Bond Index file (EMBI GLOBAL).	7,038	0.073	0.049	0.592

### **A3: Additional Empirical Tests**

#### **1. Subsample Analyses**

We start by excluding U.S. banks from our sample. Despite our attempt to reduce the overrepresentation of U.S. banks, they still represent a large share of the sample. The removal of U.S. banks does not lead to material changes in our findings. Specifically, we still find our result that relative size shapes a bank's tail risk remains unchanged. Furthermore, the exclusion of US banks does not alter our findings as regards the determinants of bank tail risk, except in relation to the coefficient on the Basel II dummy. Across the whole sample, banks that have adopted Basel II appear less risky in the majority of the specifications. However, when excluding U.S. banks, Basel II banks are riskier *ceteris paribus*. This is in line with Blum (2008) and Vallascas and Hagendorff (2013), who argue that because Basel II offers banks the ability to underreport the true economic risks of their asset portfolios, it makes banks riskier by undermining their ability to withstand adverse shocks. Next, in addition to U.S. banks, we remove Japanese banks as they represent the second largest group of banks in our sample. We then repeat the analysis by removing developing countries from the sample. While these tests reduce the sample size, they all confirm a positive relationship between relative size and tail risk.

Finally, we evaluate whether our results are driven by a few extremely large banks. We sequentially remove sample banks with relative size  $\geq 100\%$  and  $\geq 50\%$  of GDP. In both cases, our finding that an increase in relative size is associated with higher tail risk remains unchanged.

**Table A2: Subsample Analyses**

The table shows the regression results of the impact of the ratio LIABILITIES/GDP on bank tail risk for subsamples of banks. The models are estimated using the within estimator or a pooled OLS specification. Standard errors (in round brackets) have been corrected for heteroscedasticity and clustered at the bank level or at the country level. SIZE is the log of total assets measured in thousands of US dollars; LOANS is the ratio between net loans and total assets; DEPOSITS is equal to customer deposits divided by total assets; LEVERAGE is the ratio between total liabilities and total assets; ROA is the ratio between net income and total assets; BOOK-TO-MARKET is the ratio between the book value of equity and the market value of equity; CREDIT RISK is the ratio between loan loss provisions and total loans; NONINTEREST INCOME is the ratio between noninterest income and total operating income; DEVELOPMENT is the log of GDP per capita; REALGDP GROWTH is the yearly growth rate in real GDP; GDP VOLATILITY is the volatility of the domestic GDP in a four-year period; PRIVATE CREDIT is the ratio between credit to the private sector and country GDP; FINANCIAL FREEDOM is the index of financial freedom from the Heritage Foundation; BASEL II is a dummy equal to 1 if a country has adopted Basel II; GLOBAL CRISIS is a dummy equal to 1 from 2007 to 2009; FISCAL CAPACITY is the difference between tax revenues and public spending divided by country GDP. Bank characteristics are winsorized at the 1% level. \*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	No United States		No United States and No Japan		No Developing Countries	
LIABILITIES/GDP	<b>0.025***</b> (0.007)	<b>0.014***</b> (0.003)	<b>0.018**</b> (0.008)	<b>0.014***</b> (0.003)	<b>0.020***</b> (0.006)	<b>0.015***</b> (0.003)
SIZE	-0.000 (0.002)	-0.002*** (0.000)	-0.001 (0.002)	-0.002*** (0.000)	-0.001 (0.001)	-0.002*** (0.000)
LOANS	0.003 (0.005)	0.000 (0.004)	-0.002 (0.005)	-0.008** (0.004)	0.010** (0.005)	0.004 (0.003)
DEPOSITS	-0.018*** (0.004)	-0.017*** (0.003)	-0.016*** (0.004)	-0.013*** (0.003)	-0.020*** (0.005)	-0.019*** (0.004)
LEVERAGE	0.013 (0.020)	0.009 (0.014)	0.022 (0.020)	0.014 (0.015)	0.023 (0.022)	0.013 (0.014)
ROA	-0.127** (0.059)	-0.216*** (0.050)	-0.086 (0.059)	-0.197*** (0.051)	-0.361*** (0.088)	-0.422*** (0.080)
BOOK-TO-MARKET	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.002*** (0.001)	0.007*** (0.001)	0.005*** (0.001)
CREDIT RISK	0.121*** (0.037)	0.157*** (0.033)	0.114*** (0.038)	0.129*** (0.034)	0.195*** (0.065)	0.303*** (0.065)
NONINTEREST INCOME	-0.006* (0.004)	0.006** (0.003)	-0.007* (0.004)	0.002 (0.003)	0.001 (0.004)	0.009*** (0.003)
DEVELOPMENT	-0.025*** (0.007)	-0.027*** (0.007)	-0.026*** (0.008)	-0.029*** (0.007)	-0.048*** (0.010)	-0.050*** (0.009)
REALGDP GROWTH	-0.074*** (0.016)	-0.083*** (0.016)	-0.068*** (0.016)	-0.075*** (0.017)	-0.101*** (0.024)	-0.103*** (0.025)
GDP VOLATILITY	0.069* (0.038)	0.071* (0.037)	0.111*** (0.039)	0.118*** (0.039)	-0.105* (0.064)	-0.076 (0.061)
PRIVATE CREDIT	0.010*** (0.002)	0.012*** (0.001)	0.018*** (0.003)	0.019*** (0.003)	0.004*** (0.001)	0.006*** (0.001)
FINANCIAL FREEDOM	-0.004 (0.004)	-0.005 (0.004)	0.004 (0.005)	0.003 (0.005)	-0.006 (0.004)	-0.007 (0.005)
BASEL II	0.005*** (0.001)	0.004*** (0.001)	0.005*** (0.002)	0.004*** (0.002)	-0.010*** (0.002)	-0.010*** (0.002)
GLOBAL CRISIS	0.010*** (0.001)	0.009*** (0.001)	0.012*** (0.001)	0.011*** (0.001)	0.020*** (0.002)	0.021*** (0.002)
FISCAL CAPACITY	0.056*** (0.017)	0.062*** (0.017)	0.050*** (0.018)	0.057*** (0.018)	0.051*** (0.019)	0.054*** (0.019)
Constant	0.107*** (0.026)	0.149*** (0.018)	0.120*** (0.028)	0.157*** (0.020)	0.246*** (0.037)	0.285*** (0.038)
Observations	5,863	5,863	3,790	3,790	2,073	2,073
Adjusted R-squared	0.456	0.513	0.464	0.529	0.588	0.590
Bank Fixed Effects	Yes	No	Yes	No	Yes	No
Country Fixed Effect	No	Yes	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

**Table A3:** Excluding Relative Size  $\geq 100\%$  ( $\geq 50\%$ )

The table shows the regression results of the impact of the ratio LIABILITIES/GDP on bank tail risk for subsamples of banks. The models are estimated using the within estimator or a pooled OLS specification. Standard errors (in round brackets) have been corrected for heteroscedasticity and clustered at the bank level or at the country level. SIZE is the log of total assets measured in thousands of U.S. dollars; LOANS is the ratio between net loans and total assets; DEPOSITS is equal to customer deposits divided by total assets; LEVERAGE is the ratio between total liabilities and total assets; ROA is the ratio between net income and total assets; BOOK-TO-MARKET is the ratio between the book value of equity and the market value of equity; CREDIT RISK is the ratio between loan loss provisions and total loans; NONINTEREST INCOME is the ratio between noninterest income and total operating income; DEVELOPMENT is the log of GDP per capita; REALGDP GROWTH is the yearly growth rate in real GDP; GDP VOLATILITY is the volatility of the domestic GDP in a four-year period; PRIVATE CREDIT is the ratio between credit to the private sector and country GDP; FINANCIAL FREEDOM is the index of financial freedom from the Heritage Foundation; BASEL II is a dummy equal to 1 if a country has adopted Basel II; GLOBAL CRISIS is a dummy equal to 1 from 2007 to 2009; FISCAL CAPACITY is the difference between tax revenues and public spending divided by country GDP. Bank characteristics are winsorized at the 1% level. \*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	No Banks with LIABILITIES/GDP $\geq 100\%$		No Banks with LIABILITIES/GDP $\geq 50\%$	
LIABILITIES/GDP	0.025*** (0.008)	0.020*** (0.004)	0.029** (0.013)	0.023*** (0.006)
SIZE	-0.001 (0.001)	-0.002*** (0.000)	-0.001 (0.001)	-0.003*** (0.000)
LOANS	0.007 (0.004)	0.005 (0.003)	0.003 (0.005)	0.000 (0.003)
DEPOSITS	-0.021*** (0.004)	-0.020*** (0.003)	-0.018*** (0.004)	-0.017*** (0.003)
LEVERAGE	-0.010 (0.020)	0.008 (0.012)	0.008 (0.021)	0.015 (0.013)
ROA	-0.289*** (0.058)	-0.332*** (0.049)	-0.254*** (0.057)	-0.304*** (0.050)
BOOK-TO-MARKET	0.005*** (0.001)	0.004*** (0.001)	0.005*** (0.001)	0.004*** (0.001)
CREDIT RISK	0.146*** (0.038)	0.204*** (0.034)	0.116*** (0.039)	0.175*** (0.035)
NONINTEREST INCOME	-0.001 (0.004)	0.007*** (0.003)	0.001 (0.004)	0.006** (0.003)
DEVELOPMENT	-0.034*** (0.006)	-0.034*** (0.006)	-0.036*** (0.006)	-0.036*** (0.006)
REALGDP GROWTH	-0.090*** (0.016)	-0.102*** (0.016)	-0.085*** (0.018)	-0.094*** (0.018)
GDP VOLATILITY	0.036 (0.040)	0.048 (0.039)	0.121*** (0.043)	0.137*** (0.042)
PRIVATE CREDIT	0.007*** (0.002)	0.008*** (0.001)	0.013*** (0.003)	0.013*** (0.002)
FINANCIAL FREEDOM	-0.012*** (0.004)	-0.010*** (0.004)	-0.003 (0.004)	-0.001 (0.004)
BASEL II	-0.007*** (0.001)	-0.008*** (0.001)	-0.010*** (0.002)	-0.011*** (0.002)
GLOBAL CRISIS	0.015*** (0.002)	0.015*** (0.002)	0.018*** (0.002)	0.017*** (0.002)
FISCAL CAPACITY	0.044*** (0.014)	0.050*** (0.013)	0.051*** (0.014)	0.057*** (0.013)
CONSTANT	0.171*** (0.022)	0.182*** (0.016)	0.180*** (0.023)	0.183*** (0.017)
Observations	7,008	7,008	5,713	5,713
Adjusted R-squared	0.497	0.534	0.513	0.552
Bank Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

## **2. Alternative Measures of Tail Risk**

We use two alternative measures of tail risk. The first is the 5% Value at Risk (VaR). VaR is the value of the daily bank return corresponding to the 5th percentile of the yearly distribution. More formally, given a probability level  $\alpha$ , VaR is the maximum loss that a bank can suffer on  $100(1 - \alpha)\%$  of trading days:

$$\text{VaR}_{i,t}^{1-\alpha}(R_{i,t}) = -\sup\{z \mid \Pr[R_{i,t}] < \alpha\} \quad (3A)$$

where  $\text{VaR}_{i,t}^{1-\alpha}(R_{i,t})$  is (minus) the return of firm  $i$  at time  $t$ , and  $z$  identifies the percentile of the yearly distribution of daily returns that is equal to the chosen  $\alpha$  parameter. As in Van Bakkum (2016), we calculate tail risk ex post. As a result, it is possible to obtain  $100(1 - \alpha)\%$  daily VaR by selecting the lowest  $100\alpha\%$  of daily observations for each bank and year. Under the assumption that the underlying data-generating process is accurately described by realized returns, VaR is equal to the higher value of the lowest  $100\alpha\%$  daily observations. Realized VaR is a measure of a bank's willingness to absorb extreme losses, and higher VaR values are, therefore, consistent with banks engaging in riskier business policies.<sup>1</sup>

The second measure is the maximum drawdown (MDD). MDD measures the maximum decline from the historical peak in the daily value of bank equity in a given calendar year. More formally, if  $X$  is the value of bank equity, MDD can be expressed as follows:

$$\text{MDD}_{i,t} = \max_{\tau \in (0,T)} \left[ \left( \max_{t \in (0,\tau)} X(t) - X(\tau) \right) / \max_{t \in (0,\tau)} X(t) \right] \quad (4A)$$

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<sup>1</sup> It is worth noting that recent studies demonstrate that this straightforward nonparametric approach to computing VaR leads to results that are very similar to those based on more sophisticated methodologies (Bali, Dermitas, and Levy, 2009).



Essentially, MDD captures the maximum loss that an equity investor can suffer from a given maximum in the valuation of bank equity and it thus signals an extreme deterioration due to cumulative losses in the value of bank shares.

When using the above two alternative measures of tail risk, we still observe that an increase in relative size is associated with an increase in the exposure of banks to extreme losses.

**Table A4:** Alternative Measures of Tail Risk: Value at Risk (VaR)

The table shows the regression results of the impact of the ratio LIABILITIES/GDP on bank tail risk measured as Value at Risk (VaR). The models are estimated using the within estimator or a pooled OLS specification. Standard errors (in round brackets) have been corrected for heteroscedasticity and clustered at the bank level or at the country level. SIZE is the log of total assets measured in thousands of U.S. dollars; LOANS is the ratio between net loans and total assets; DEPOSITS is equal to customer deposits divided by total assets; LEVERAGE is the ratio between total liabilities and total assets; ROA is the ratio between net income and total assets; BOOK-TO-MARKET is the ratio between the book value of equity and the market value of equity; CREDIT RISK is the ratio between loan loss provisions and total loans; NONINTEREST INCOME is the ratio between noninterest income and total operating income; DEVELOPMENT is the log of GDP per capita; REALGDP GROWTH is the yearly growth rate in real GDP; GDP VOLATILITY is the volatility of the domestic GDP in a four-year period; PRIVATE CREDIT is the ratio between credit to the private sector and country GDP; FINANCIAL FREEDOM is the index of financial freedom from the Heritage Foundation; BASEL II is a dummy equal to 1 if a country has adopted Basel II; GLOBAL CRISIS is a dummy equal to 1 from 2007 to 2009; FISCAL CAPACITY is the difference between tax revenues and public spending divided by country GDP. Bank characteristics are winsorized at the 1% level. \*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
<b>LIABILITIES/GDP</b>	<b>0.019***</b> <b>(0.004)</b>	<b>0.013***</b> <b>(0.003)</b>	<b>0.013***</b> <b>(0.003)</b>	<b>0.013***</b> <b>(0.004)</b>	<b>0.013**</b> <b>(0.005)</b>	<b>0.011***</b> <b>(0.002)</b>
SIZE			-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)	-0.001*** (0.000)
LOANS		0.005* (0.003)	0.006** (0.003)	0.006* (0.003)	0.006 (0.004)	0.003 (0.002)
DEPOSITS		-0.014*** (0.002)	-0.014*** (0.002)	-0.014*** (0.003)	-0.014*** (0.003)	-0.013*** (0.002)
LEVERAGE		-0.017 (0.013)	-0.010 (0.014)	-0.014 (0.014)	-0.014 (0.019)	-0.002 (0.009)
ROA		-0.252*** (0.031)	-0.182*** (0.038)	-0.198*** (0.039)	-0.198*** (0.065)	-0.235*** (0.035)
BOOK-TO-MARKET		0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)
CREDIT RISK			0.079*** (0.025)	0.087*** (0.027)	0.087** (0.035)	0.126*** (0.024)
NONINTEREST INCOME			-0.000 (0.002)	-0.000 (0.002)	-0.000 (0.003)	0.006*** (0.002)
DEVELOPMENT	-0.032*** (0.004)	-0.022*** (0.004)	-0.020*** (0.004)	-0.022*** (0.004)	-0.022*** (0.008)	-0.022*** (0.004)
REALGDP GROWTH	-0.081*** (0.011)	-0.052*** (0.010)	-0.049*** (0.010)	-0.055*** (0.010)	-0.055*** (0.020)	-0.063*** (0.010)
GDP VOLATILITY	0.087*** (0.026)	0.047* (0.026)	0.038 (0.027)	0.035 (0.028)	0.035 (0.060)	0.050* (0.027)
PRIVATE CREDIT	0.005*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.005*** (0.001)	0.005** (0.002)	0.006*** (0.001)
FINANCIAL FREEDOM	-0.007*** (0.002)	-0.007*** (0.002)	-0.007*** (0.002)	-0.008*** (0.002)	-0.008 (0.006)	-0.007*** (0.002)
BASEL II	-0.005*** (0.001)	-0.004*** (0.001)	-0.003*** (0.001)	-0.004*** (0.001)	-0.004 (0.004)	-0.005*** (0.001)
GLOBAL CRISIS	0.009*** (0.001)	0.011*** (0.001)	0.012*** (0.001)	0.012*** (0.001)	0.012*** (0.004)	0.011*** (0.001)
FISCAL CAPACITY				0.025** (0.012)	0.025 (0.026)	0.029*** (0.011)
Constant	0.132*** (0.013)	0.105*** (0.013)	0.102*** (0.016)	0.107*** (0.016)	0.107*** (0.033)	0.113*** (0.011)
Observations	7,534	7,502	7,373	7,140	7,140	7,140
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	No	Yes
Clustered SE	Bank	Bank	Bank	Bank	Country	Bank
Adjusted R-squared	0.462	0.504	0.507	0.509	0.509	0.539

**Table A5: Alternative Measures of Tail Risk: Maximum Drawdown**

The table shows the regression results of the impact of the ratio LIABILITIES/GDP on bank tail risk measured as maximum drawdown. The models are estimated using the within estimator or a pooled OLS specification. Standard errors (in round brackets) have been corrected for heteroscedasticity and clustered at the bank level or at the country level. SIZE is the log of total assets measured in thousands of U.S. dollars; LOANS is the ratio between net loans and total assets; DEPOSITS is equal to customer deposits divided by total assets; LEVERAGE is the ratio between total liabilities and total assets; ROA is the ratio between net income and total assets; BOOK-TO-MARKET is the ratio between the book value of equity and the market value of equity; CREDIT RISK is the ratio between loan loss provisions and total loans; NONINTEREST INCOME is the ratio between noninterest income and total operating income; DEVELOPMENT is the log of GDP per capita; REALGDP GROWTH is the yearly growth rate in real GDP; GDP VOLATILITY is the volatility of the domestic GDP in a four-year period; PRIVATE CREDIT is the ratio between credit to the private sector and country GDP; FINANCIAL FREEDOM is the index of financial freedom from the Heritage Foundation; BASEL II is a dummy equal to 1 if a country has adopted Basel II; GLOBAL CRISIS is a dummy equal to 1 from 2007 to 2009; FISCAL CAPACITY is the difference between tax revenues and public spending divided by country GDP. Bank characteristics are winsorized at the 1% level. \*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
<b>LIABILITIES/GDP</b>	<b>0.147***</b> <b>(0.041)</b>	<b>0.119***</b> <b>(0.037)</b>	<b>0.092**</b> <b>(0.038)</b>	<b>0.093**</b> <b>(0.039)</b>	<b>0.093*</b> <b>(0.054)</b>	<b>0.068***</b> <b>(0.020)</b>
SIZE			0.022*** (0.008)	0.022*** (0.008)	0.022** (0.010)	-0.007*** (0.002)
LOANS		0.113*** (0.032)	0.126*** (0.032)	0.122*** (0.032)	0.122** (0.047)	0.070*** (0.021)
DEPOSITS		-0.245*** (0.028)	-0.227*** (0.029)	-0.220*** (0.029)	-0.220*** (0.034)	-0.171*** (0.021)
LEVERAGE		-0.570*** (0.147)	-0.475*** (0.146)	-0.484*** (0.150)	-0.484*** (0.180)	-0.082 (0.089)
ROA		-2.832*** (0.321)	-1.840*** (0.415)	-1.952*** (0.436)	-1.952*** (0.602)	-2.454*** (0.361)
BOOK-TO-MARKET		-0.007 (0.005)	-0.005 (0.005)	-0.005 (0.005)	-0.005 (0.009)	0.007* (0.004)
CREDIT RISK			1.096*** (0.272)	1.161*** (0.283)	1.161*** (0.400)	1.417*** (0.246)
NONINTEREST INCOME			0.024 (0.027)	0.026 (0.029)	0.026 (0.033)	0.080*** (0.018)
DEVELOPMENT	-0.352*** (0.042)	-0.328*** (0.039)	-0.348*** (0.041)	-0.352*** (0.046)	-0.352*** (0.081)	-0.258*** (0.036)
REALGDP GROWTH	-0.446*** (0.110)	-0.282** (0.109)	-0.247** (0.109)	-0.271** (0.110)	-0.271 (0.217)	-0.363*** (0.104)
GDP VOLATILITY	0.605** (0.286)	0.436 (0.283)	0.329 (0.287)	0.387 (0.303)	0.387 (0.532)	0.439 (0.272)
PRIVATE CREDIT	0.064*** (0.014)	0.045*** (0.013)	0.039*** (0.013)	0.044*** (0.013)	0.044 (0.038)	0.062*** (0.011)
FINANCIAL FREEDOM	-0.006 (0.029)	-0.046* (0.027)	-0.052** (0.026)	-0.064** (0.027)	-0.064 (0.054)	-0.036 (0.026)
BASEL II	-0.003 (0.009)	0.008 (0.008)	0.015* (0.008)	0.012 (0.009)	0.012 (0.029)	0.004 (0.009)
GLOBAL CRISIS	0.072*** (0.011)	0.081*** (0.011)	0.091*** (0.011)	0.095*** (0.011)	0.095*** (0.034)	0.093*** (0.011)
FISCAL CAPACITY				0.186 (0.127)	0.186 (0.273)	0.264** (0.115)
Constant	1.289*** (0.130)	1.342*** (0.126)	1.007*** (0.154)	1.035*** (0.157)	1.035*** (0.260)	1.080*** (0.093)
Observations	7,534	7,502	7,373	7,140	7,140	7,140
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	No	Yes
Clustered SE	Bank	Bank	Bank	Bank	Country	Bank
Adjusted R-squared	0.422	0.445	0.447	0.448	0.448	0.473

### **3. Alternative Measures of Relative Size**

Our measure of relative size may not accurately capture incentives for banks to shift risk if a sizable share of bank liabilities are held outside the domestic economy. We, therefore, conduct additional tests where we define relative size as national liabilities (total liabilities minus international liabilities) to national GDP. We estimate the volume of international liabilities on the basis of the ratio between international assets and total assets provided by Worldscope. Specifically, we assume that the share of international liabilities over total liabilities is equal to the share of international assets in total assets. While, due to missing values, we are only able to construct this alternative relative size measure for a much smaller sample of banks, we still observe higher tail risks for relatively larger banks in all specifications.

Finally, another possible concern related to the ratio between total liabilities and GDP is the omission of off-balance-sheet items from bank liabilities which may well lead us to underestimate relative bank size. As an alternative measure, we employ the ratio between on- and off-balance-sheet assets scaled by national GDP. Again we find that an increase in relative size produces an increase in tail risk.

**Table A6: Alternative Measures of Relative Size**

The table shows the regression results of the impact of the alternative measures of relative size on bank tail risk. DOMESTIC LIABILITIES are bank liabilities net of international liabilities, estimated via the value of international assets. ON AND OFF BALANCE SHEET ASSETS is the sum of the book value of bank assets and the value of off-balance-sheet items. The models are estimated using the within estimator or a pooled OLS specification. Standard errors (in round brackets) have been corrected for heteroscedasticity and clustered at the bank level or at the country level. SIZE is the log of total assets measured in thousands of U.S. dollars; LOANS is the ratio between net loans and total assets; DEPOSITS is equal to customer deposits divided by total assets; LEVERAGE is the ratio between total liabilities and total assets; ROA is the ratio between net income and total assets; BOOK-TO-MARKET is the ratio between the book value of equity and the market value of equity; CREDIT RISK is the ratio between loan loss provisions and total loans; NONINTEREST INCOME is the ratio between noninterest income and total operating income; DEVELOPMENT is the log of GDP per capita; REALGDP GROWTH is the yearly growth rate in real GDP; GDP VOLATILITY is the volatility of the domestic GDP in a four-year period; PRIVATE CREDIT is the ratio between credit to the private sector and country GDP; FINANCIAL FREEDOM is the index of financial freedom from the Heritage Foundation; BASEL II is a dummy equal to 1 if a country has adopted Basel II; GLOBAL CRISIS is a dummy equal to 1 from 2007 to 2009; FISCAL CAPACITY is the difference between tax revenues and public spending divided by country GDP. Bank characteristics are winsorized at the 1% level. \*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
<b>DOMESTIC LIABILITIES/GDP</b>	<b>0.021*</b> <b>(0.011)</b>	<b>0.025***</b> <b>(0.006)</b>		
<b>ON AND OFF BALANCE SHEET ASSETS/GDP</b>			<b>0.008**</b> <b>(0.004)</b>	<b>0.010***</b> <b>(0.002)</b>
SIZE	-0.001 (0.001)	-0.002*** (0.000)	0.001 (0.001)	-0.002*** (0.000)
LOANS	0.008 (0.005)	0.006 (0.004)	0.008 (0.005)	0.003 (0.003)
DEPOSITS	-0.025*** (0.006)	-0.018*** (0.004)	-0.024*** (0.004)	-0.022*** (0.003)
LEVERAGE	0.026 (0.025)	0.025 (0.017)	-0.009 (0.023)	0.004 (0.014)
ROA	-0.450*** (0.093)	-0.413*** (0.075)	-0.238*** (0.061)	-0.318*** (0.055)
BOOK-TO-MARKET	0.005*** (0.001)	0.005*** (0.001)	0.005*** (0.001)	0.004*** (0.001)
CREDIT RISK	0.150** (0.069)	0.250*** (0.056)	0.160*** (0.041)	0.208*** (0.037)
NONINTEREST INCOME	-0.002 (0.004)	0.007** (0.003)	-0.002 (0.004)	0.006** (0.003)
DEVELOPMENT	-0.028*** (0.008)	-0.032*** (0.008)	-0.031*** (0.006)	-0.031*** (0.006)
REALGDP GROWTH	-0.121*** (0.023)	-0.143*** (0.024)	-0.091*** (0.018)	-0.109*** (0.018)
GDP VOLATILITY	-0.056 (0.055)	-0.035 (0.055)	0.034 (0.043)	0.038 (0.043)
PRIVATE CREDIT	0.004** (0.002)	0.004** (0.002)	0.007*** (0.002)	0.008*** (0.001)
FINANCIAL FREEDOM	-0.015*** (0.005)	-0.013** (0.005)	-0.014*** (0.004)	-0.009** (0.004)
BASEL II	-0.008*** (0.002)	-0.009*** (0.002)	-0.003** (0.002)	-0.006*** (0.002)
GLOBAL CRISIS	0.016*** (0.002)	0.016*** (0.002)	0.015*** (0.002)	0.014*** (0.002)
FISCAL CAPACITY	-0.001 (0.029)	0.006 (0.027)	0.030* (0.017)	0.031* (0.016)
Constant	0.188*** (0.028)	0.218*** (0.034)	0.133*** (0.024)	0.174*** (0.018)
Observations	4,801	4,801	6,043	6,043
Adjusted R-squared	0.579	0.588	0.479	0.530
Bank Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

#### **4. Potential Distortions due to International Financial Reporting Standards (IFRS)**

Some banks have adopted IFRS during the sample period. IFRS adoption may have distorted the evolution of the value of relative size over time. We conduct two tests to show that the potential distortion does not affect our results. First, we add to the model a dummy variable that is equal to 1 if a bank has adopted IFRS during the sample period. Second, based on Acharya, Engle, and Pierret (2014), we assume that IFRS inflate the book value of total liabilities by up to 30% compared to previous accounting standards and discount the value of liabilities by 30% for IFRS adopters. For non-U.S. banks, this is a conservative assumption as IFRS mainly has an impact on the value of derivatives that are moved on-balance sheet; this is not a major item for non-U.S. banks. These two additional tests confirm that an increase in relative size is linked to higher tail risks.

**Table A7: Controlling for IFRS Distortions**

The table shows the regression results of the impact of the ratio LIABILITIES/GDP on bank tail risk controlling for IFRS distortions. The models are estimated using the within estimator or a pooled OLS specification. Standard errors (in round brackets) have been corrected for heteroscedasticity and clustered at the bank level or at the country level. SIZE is the log of total assets measured in thousands of U.S. dollars; LOANS is the ratio between net loans and total assets; DEPOSITS is equal to customer deposits divided by total assets; LEVERAGE is the ratio between total liabilities and total assets; ROA is the ratio between net income and total assets; BOOK-TO-MARKET is the ratio between the book value of equity and the market value of equity; CREDIT RISK is the ratio between loan loss provisions and total loans; NONINTEREST INCOME is the ratio between noninterest income and total operating income; DEVELOPMENT is the log of GDP per capita; REALGDP GROWTH is the yearly growth rate in real GDP; GDP VOLATILITY is the volatility of the domestic GDP in a four-year period; PRIVATE CREDIT is the ratio between credit to the private sector and country GDP; FINANCIAL FREEDOM is the index of financial freedom from the Heritage Foundation; BASEL II is a dummy equal to 1 if a country has adopted Basel II; GLOBAL CRISIS is a dummy equal to 1 from 2007 to 2009; FISCAL CAPACITY is the difference between tax revenues and public spending divided by country GDP. Bank characteristics are winsorized at the 1% level. \*, \*\*, and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	IFRS Dummy		30% Adjustments for IFRS Banks	
<b>LIABILITIES/GDP</b>	<b>0.019***</b> <b>(0.006)</b>	<b>0.015***</b> <b>(0.003)</b>	<b>0.015**</b> <b>(0.007)</b>	<b>0.016***</b> <b>(0.004)</b>
SIZE	-0.001 (0.001)	-0.002*** (0.000)	-0.000 (0.001)	-0.002*** (0.000)
LOANS	0.007* (0.004)	0.003 (0.003)	0.006 (0.004)	0.003 (0.003)
DEPOSITS	-0.022*** (0.004)	-0.019*** (0.003)	-0.023*** (0.004)	-0.020*** (0.003)
LEVERAGE	-0.007 (0.020)	0.010 (0.012)	-0.006 (0.020)	0.010 (0.012)
ROA	-0.282*** (0.058)	-0.329*** (0.050)	-0.281*** (0.058)	-0.329*** (0.050)
BOOK-TO-MARKET	0.005*** (0.001)	0.004*** (0.001)	0.005*** (0.001)	0.004*** (0.001)
CREDIT RISK	-0.002 (0.003)	0.007*** (0.002)	0.147*** (0.038)	0.203*** (0.034)
NONINTEREST INCOME	0.146*** (0.038)	0.203*** (0.034)	-0.002 (0.003)	0.007*** (0.002)
DEVELOPMENT	-0.032*** (0.006)	-0.034*** (0.006)	-0.032*** (0.006)	-0.034*** (0.006)
REALGDP GROWTH	-0.093*** (0.016)	-0.104*** (0.016)	-0.091*** (0.016)	-0.104*** (0.016)
GDP VOLATILITY	0.037 (0.040)	0.049 (0.040)	0.037 (0.040)	0.049 (0.040)
PRIVATE CREDIT	0.007*** (0.002)	0.008*** (0.001)	0.008*** (0.002)	0.009*** (0.001)
FINANCIAL FREEDOM	-0.012*** (0.004)	-0.010*** (0.004)	-0.013*** (0.004)	-0.010*** (0.004)
BASEL II	-0.006*** (0.001)	-0.007*** (0.001)	-0.006*** (0.001)	-0.007*** (0.001)
GLOBAL CRISIS	0.015*** (0.001)	0.015*** (0.002)	0.016*** (0.001)	0.015*** (0.002)
FISCAL CAPACITY	0.035** (0.016)	0.041*** (0.016)	0.035** (0.016)	0.041** (0.016)
IFRS DUMMY	0.000 (0.001)	-0.000 (0.001)		
Constant	0.019*** (0.006)	0.015*** (0.003)	0.167*** (0.022)	0.179*** (0.016)
Observations	7,140	7,140	7,140	7,140
Adjusted R-squared	0.503	0.535	0.501	0.534
Bank Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes