

Supplementary Appendix

The Risk Sensitivity of Capital Requirements: Evidence from an International Sample of Large Banks

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This appendix contains information and tabulated results of additional tests on the relationship between capital requirements and the market assessment of bank portfolio risk.

- Appendix A Additional tests on the relationship between capital requirements and the market assessment of bank portfolio risk.
- Appendix B Table reporting the results of additional tests on the impact of the market assessment of bank portfolio risk on RWATA.
- Appendix C Shadow banking systems, capital requirements and the market assessment of bank portfolio risk.
- Appendix D Table reporting the results of shadow banking systems, capital requirements and the market assessment of bank portfolio risk.

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A. Additional Tests on the Relationship between Capital Requirements and the Market Assessment of Bank Portfolio Risk

We test whether the positive but economically weak link between RWATA and asset volatility is robust to various model modifications. We report the results of these tests in Appendix B

First, we assess the sensitivity of our results to an alternative econometric specification which does not rely on a dynamic GMM estimator. In Column 1, we estimate a static two-stage least squares instrumental variable (2SLS-IV) model. We estimate this model to address concerns that the dynamic nature or the number of instruments used in the GMM estimations may have caused the coefficient on asset volatility to be biased downward. When using the 2SLS-IV method, we only treat asset volatility as endogenous and exploit two macro variables as instruments for asset volatility: (i) the volatility of the annualized daily yield on one-year government bonds, computed during the preceding quarter, and (ii) the yearly volatility of the domestic stock market (based on local Datastream market indices).¹ Using this relatively simple and static specification, the results in Column 1 show that, while the coefficient on asset volatility is somewhat higher, it remains economically weak and therefore in line with the previous results we report. A five-percentage point increase in asset volatility leads to additional capital requirements of 0.33 percent per unit of assets (assuming a regulatory capital ratio of 8 percent).

Next, the recent financial crisis may have distorted the relationship between asset volatility and RWATA we report above, for instance because the risk sensitivity of capital requirements may be more attuned to normal market conditions and could be particularly out of sync with the market risks of bank assets during periods of extreme market volatility. In Column 2 of Appendix B, we re-estimate the model for the period from 2000 to 2007 (as

¹ We verify that the two instruments are valid instruments using a Sargan test of over-identifying restrictions and correlations between the instruments and asset volatility and RWATA respectively. Furthermore, the partial R-squared of the two excluded instruments in the first stage regression is equal to 0.155, showing that these instruments explain cross-bank differences in asset volatility.

previously, we require sample banks to have at least five years of data before the crisis). The regression results, based on a smaller sample of 1,386 observations, confirm that asset volatility exerts a positive impact on RWATA. While the estimated coefficient on asset volatility is higher compared to the full sample period (which confirms that the Basel Framework is indeed better aligned to portfolio risk under normal market conditions), the magnitude of the coefficient remains so small that increases in asset volatility will only have minor effects in terms of increases in bank capital requirements.

Furthermore, a number of banks have received government aid in the form of capital support during the financial crisis. In Column 3 we test whether the inclusion of these banks in our sample impacts upon our main results by re-estimating the model after excluding banks with government-funded recapitalizations from the sample. In spite of the substantial decline in sample size which ensues when we exclude ‘bailed out’ institutions, we continue to observe a positive and economically weak relationship between RWATA and asset volatility.

In Column 4 we add two additional macro controls. First, we add the yearly average of the three-month interbank rate. Our expectation is that, because banks face incentives to take on additional risk in a low interest rate environment (Delis and Kouretas, 2011), banks are more likely to engage in capital arbitrage when interest rates are low. Second, we add the ratio of domestic bank credit to GDP to measure the degree of competition and banking sector development. We expect that banks operating in bank-based economies have more incentives to engage in capital arbitrage to improve their market position. While the estimation results offer evidence only in favor of the conjecture that RWATA are lower in bank-based environments, the results still confirm our main finding of a positive but economically limited relationship between asset volatility and RWATA.

The sample period includes RWATA based on both Basel I and II. While the baseline specification includes indicator variables to control for which capital adequacy regime is in operation at each bank, the impact of several control variables on RWATA may still vary across capital regimes and these differences may affect the reported magnitude of the link

between RWATA and asset volatility. We rule out this possibility in the first column of Appendix B where we provide model estimations only for banks that report RWATA under Basel I (as previously, with at least five consecutive years of RWATA data). The results do not suggest any material changes in the relationship between RWATA and asset volatility when we exclude Basel II data from the analysis.

In Column 5, we replace asset volatility with equity volatility as an alternative measure of the market assessment of bank portfolio risk. We follow Flannery and Rangan (2008) and define equity volatility as the unlevered bank equity volatility (equity volatility multiplied by the ratio of the market value of equity to the quasi-market value of bank total assets [book value of liabilities + market value of equity]). The results confirm our main finding of a positive but economically weak link between RWATA and asset volatility while also confirming that the results we report in this paper do not rely on us employing a specific measure of portfolio risk.

A final set of robustness tests refers to the country composition of our sample. First, while the baseline model controls for regulatory characteristics, differences in the implementation of capital rules may affect the link between RWATA and asset volatility in ways that are not fully captured by our regulatory variables. Therefore, we re-estimate the model after replacing these variables with country dummies. To avoid multicollinearity issues with the bank fixed effects, the country dummies are included only for countries with at least three banks. Column 6 shows that we continue to observe a positive link between RWATA and asset volatility after including country fixed effects (in fact, the coefficient on asset volatility is smaller once we control for unobservable country characteristic). Second, due to our focus on large and listed banks, our sample features a high share of U.S. banks. Column 8 shows that our main conclusions remain unaffected if we exclude U.S. banks from the sample. Finally, the sample includes several developing countries and/or countries with only a limited number of banks. Column 9 reports the estimation results after excluding developing countries (as identified by the World Bank), U.S. banks and countries with only a single bank

in the sample. Again, we do not observe any material changes to our results compared with the results reported in the previous section.

B. Table Reporting the Results of Additional Tests on the relationship between the Market Assessment of Bank Portfolio Risk and RWATA

This table shows additional regression results for the dynamic panel data model on the ratio of risk-based assets to total assets (RWATA), asset volatility is the value of asset volatility estimated via option pricing theory, Size is the log of total assets, ROA is the ratio of net income to total assets, Buffer is the percent difference between the regulatory capital ratio and the required capital ratio, Deposits is customer deposits over total liabilities, Loans is the ratio of net loans to total assets and Non-interest income is the ratio of non-interest income to total operating income, Basel II is a dummy which equals 1 if a bank complies with the Basel II capital standards in a given year, IRB is a dummy which equals 1 if a bank adopts the internal rating-based approach to compute RWATA, Standardized is a dummy which equals 1 if a bank has adopted the standardized approach, Shadow banking is the ratio of outstanding securitized assets to GDP, Regulatory strength is an index of general regulatory strength, Capital regulation is an index of the regulatory approach to assessing and verifying the degree of capital at risk in a bank, GDP growth is the real GDP growth rate (measured in U.S. \$), Domestic credit is the ratio of domestic credit from the banking sector to GDP, Interbank rate is the annual average of the three-month interbank rate. The columns run models (in the following order) which are based on 2SLS, exclude 2008–10, exclude banks with recapitalization which was at least in part financed via government purchases of participation capital, control for additional macro variables, use unlevered equity volatility as an alternative risk measure, exclude bank-years where RWATA are reported according to Basel II, include country fixed effects, exclude U.S. banks developing countries and countries with a single bank in the sample. For (2) – (9), standard errors are adjusted via the finite sample correction derived by Windemeijer (2005). Robust Z statistics (t statistics for the 2SLS estimates) are reported in round brackets. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	2SLS IV	Excl. 2008–2010	Excl. Bailouts	Additional Macro	Alternat. Risk	Excl. Basel II	Country Dummies	Excl. US Banks	Developed countries, excl. US
Lagged RWATA		0.801*** (15.90)	0.768*** (17.00)	0.756*** (21.39)	0.803*** (24.35)	0.789*** (20.18)	0.739*** (21.26)	0.780*** (19.13)	0.861*** (28.66)
Asset volatility	0.813*** (2.70)	0.695*** (5.23)	0.463*** (3.46)	0.424*** (3.85)		0.457*** (3.96)	0.245** (2.35)	0.495*** (3.28)	0.670*** (4.07)
Equity volatility					0.503*** (4.06)				
Size	-0.005** (2.20)	0.004 (1.09)	-0.006 (1.48)	0.000 (0.14)	-0.001 (0.30)	0.001 (0.45)	0.003 (0.84)	-0.008* (1.87)	-0.009** (2.27)
ROA	3.038*** (5.36)	-0.397 (0.70)	0.430 (0.91)	0.575 (1.63)	0.456 (1.20)	0.597** (2.17)	0.171 (0.54)	1.242 (1.61)	0.132 (0.16)
Buffer	-1.472*** (11.99)	-0.401*** (3.16)	-0.534*** (3.18)	-0.630*** (4.42)	-0.549*** (4.25)	-0.449*** (3.70)	-0.515*** (3.92)	-0.852*** (3.23)	-0.852*** (2.77)
Deposits	0.211*** (12.37)	0.095*** (3.02)	0.058** (2.29)	0.096*** (3.91)	0.057** (2.35)	0.085*** (3.23)	0.070** (2.57)	0.075*** (2.61)	0.032 (1.29)
Loans	0.457*** (17.31)	0.093** (2.03)	0.070 (1.63)	0.070* (1.77)	0.066* (1.89)	0.122*** (3.23)	0.120*** (2.75)	0.023 (0.41)	-0.030 (0.56)
Non-interest income	0.149*** (7.18)	0.028 (0.86)	0.055* (1.76)	0.013 (0.60)	0.014 (0.52)	0.003 (0.15)	0.058** (2.08)	0.043 (1.05)	0.052 (1.42)
IRB	-0.080*** (6.03)	-0.034*** (3.61)	-0.020** (2.21)	-0.004 (0.53)	-0.014** (2.04)			-0.026*** (2.90)	-0.023** (2.40)
Standardized	-0.020 (1.38)	-0.009 (1.23)	0.001 (0.07)	0.010 (1.30)	0.006 (0.83)			-0.014* (1.73)	-0.014 (1.56)
Shadow banking	0.072*** (7.89)	0.030*** (2.69)	-0.001 (0.08)	0.037*** (4.01)	0.015** (2.25)	0.011 (1.32)		0.012 (0.60)	0.010 (0.66)
Capital regulation	0.013*** (6.55)	0.005*** (2.63)	0.005*** (3.12)	0.005*** (3.45)	0.004*** (3.29)	0.003** (2.24)		0.003** (2.16)	0.003** (2.16)
Regulatory strength	0.010*** (4.35)	0.001 (0.74)	0.004** (2.06)	0.004** (2.13)	0.003* (1.84)	0.004** (1.99)		0.003 (1.47)	0.001 (0.52)
GDP growth	0.565*** (3.75)	0.277** (2.16)	0.150 (1.46)	0.045 (0.49)	0.169* (1.89)	0.220** (2.35)		0.057 (0.55)	0.099 (0.92)
Interbank rate				0.025 (0.20)					
Domestic credit				-0.019*** (3.76)					
Constant	0.120** (2.23)	-0.117 (1.52)	0.102 (1.00)	-0.000 (0.00)	0.005 (0.06)	-0.086 (1.20)	-0.017 (0.20)	0.203* (1.78)	0.238** (2.41)
Bank fixed effects	NO	YES							
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country fixed effects	NO	NO	NO	NO	NO	NO	YES	NO	NO
Observations	2,256	1,386	1,297	1,963	1,996	1,580	2,015	1,168	981
Number of banks	246	220	166	241	246	225	246	140	114
m2 Statistic (p-value)	-	0.283	0.557	0.158	0.154	0.100	0.186	0.383	0.270
Hansen J statistic (p-value)	-	0.484	1.000	0.651	0.454	0.744	0.762	0.959	1.000

C. Shadow Banking Systems, Capital Requirements and the Market Assessment of Bank Portfolio Risk

We have previously demonstrated that the risk sensitivity of capital requirements is low for the entire sample and under different capital regimes. In this appendix, we test whether the risk sensitivity of capital requirements varies across countries. The implementation of the Basel Framework varies across countries, in particular with respect to regulatory tolerance of shadow banking when banks use securitization to take on credit risk without being subjected to capital requirements.

We examine whether the size of the shadow banking sector affects the relationship between asset volatility and RWATA. If securitization lowers capital requirements without a commensurate transfer in asset risk, a larger shadow banking sector will widen discrepancies between the regulatory and market indicators of portfolio risk. This will be particularly true if securitization increases inter-bank linkages and gives rise to new types of systemic risk which are not captured by capital adequacy rules. We expect a larger shadow banking sector to undermine the regulatory oversight of bank capital requirements and to weaken the link between RWATA and asset volatility.

To test this expectation, we mean-center asset volatility and the shadow banking variable and add an interaction term based on the multiplication of the two mean-centered variables to the baseline specification. A negative coefficient on this interaction term indicates that in countries where the use of securitization is more pronounced, increases in asset volatility will have a lower impact on RWATA and, thus, on capital requirements.²

The regression results reported in Panel A of Appendix D show that the interaction terms between securitization and asset volatility enter the regression models with the expected negative coefficients (significant below the 5 percent level). This result is robust to changes in

² In additional tests, we employ two alternative proxies of the size of the shadow banking system. First, we construct a dummy which is equal to 1 if the size of the shadow banking sector is above the sample median (and 0 otherwise). Second, we measure a country's market share in securitized assets as the yearly ratio of securitized assets to the total volume of outstanding securitized assets. When we employ these two alternative measures our main findings remain unchanged.

the model specification. Thus, the larger the size of the shadow banking system in a country, the lower the sensitivity of capital requirements with respect to portfolio risk.

Panel B of Appendix D provides estimations of the impact of securitization on the relationship between asset volatility and RWATA by computing the coefficient on asset volatility for low and high values of shadow banking. We define countries as having low (high) levels of shadow banking when the volume of securitization is in the lowest (highest) quartile of the sample distribution. The results show that the impact of asset volatility on RWATA declines when banks operate in financial systems characterized by a larger shadow banking system. For instance, Column 1 shows that as the volume of securitized assets over GDP increases from the lowest to the highest quartile, the coefficient on asset volatility declines from 0.59 to 0.269 (both significant at the 1 percent level). Evidently, high levels of securitization and a larger shadow banking sector cause risk sensitivity of capital adequacy rules to further deteriorate.

D. Table Reporting the Results of Shadow Banking Systems and the Relationship between the Market Assessment of Bank Portfolio Risk and RWATA

Panel A shows the regression results for the dynamic panel data model presented in section 4.1. The models are estimated via the two-step GMM estimator proposed by Blundell and Bond (1998). RWATA is the ratio between the risk-weighted assets and total assets, asset volatility is the risk value of asset volatility estimated via option pricing as discussed in Section 4, Size is the log of total assets, ROA is the ratio of net income to total assets, Buffer is the difference between the bank regulatory capital ratio and the required capital ratio in the country the bank is chartered in, Deposits is computed as customer deposits over total liabilities, Loans is the ratio of net loans to total assets, Non-interest income is the ratio of non-interest income to total operating income, Basel II is a dummy equal to 1 if a bank complies with the Basel II capital standards in a given year, IRB is a dummy which is equal to 1 if a bank adopts the Internal Rating-Based Approach to compute RWATA, Standardized is a dummy which is equal to 1 if a bank adopts the Standardized Approach, Shadow banking is the ratio of outstanding securitized assets to GDP, Capital regulation is an index of the regulatory approach to assessing and verifying the degree of capital at risk in a bank, Regulatory strength is an index that assesses the general regulatory strength at the country level, GDP growth is the real GDP growth rate (measured in U.S. \$). Standard errors are adjusted via the finite sample correction derived by Windemeijer (2005); robust z-statistics are reported in round brackets. All specifications control for time dummies. Panel B reports the impact of asset volatility on RWATA by levels of securitization. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

Panel A: Regression Analysis						
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged RWATA	0.804*** (23.03)	0.796*** (23.81)	0.794*** (23.27)	0.807*** (24.48)	0.796*** (24.47)	0.786*** (24.04)
Asset volatility	0.440*** (4.81)	0.462*** (4.64)	0.467*** (4.85)	0.502*** (5.15)	0.459*** (4.82)	0.479*** (4.62)
Size	-0.004 (1.16)	-0.003 (0.89)	-0.002 (0.82)	-0.003 (0.94)	-0.002 (0.72)	-0.001 (0.51)
ROA	0.442 (1.31)	0.505 (1.53)	0.493 (1.52)	0.327 (1.01)	0.547 (1.61)	0.532 (1.55)
Buffer	-0.538*** (4.31)	-0.543*** (4.19)	-0.559*** (4.28)	-0.550*** (4.11)	-0.553*** (4.28)	-0.556*** (4.07)
Deposits	0.055*** (2.80)	0.063*** (3.12)	0.056*** (2.74)	0.063*** (3.02)	0.058*** (2.89)	0.062*** (2.95)
Loans	0.077** (2.06)	0.082** (2.21)	0.076** (2.08)	0.065* (1.88)	0.072** (1.98)	0.079** (2.13)
Non-interest income	0.052** (2.09)	0.046* (1.75)	0.045* (1.83)	0.049** (2.03)	0.042* (1.78)	0.036 (1.47)
Basel II	-0.008 (1.47)	-0.006 (0.96)				
IRB			-0.017*** (2.68)		-0.019*** (2.75)	-0.018** (2.46)
Standardized				0.009 (1.36)	0.001 (0.08)	0.004 (0.58)
Shadow banking	0.008 (1.36)	0.012** (2.08)	0.012** (2.01)	0.013** (1.98)	0.012* (1.91)	0.016** (2.40)
Shadow banking*asset volatility	-0.433** (2.38)	-0.427** (2.15)	-0.459** (2.44)	-0.348* (1.89)	-0.443** (2.40)	-0.443** (2.16)
Capital regulation	0.003** (2.45)	0.004*** (3.02)	0.004*** (2.83)	0.004*** (2.85)	0.004*** (2.94)	0.004*** (3.04)
Regulatory strength	0.004** (2.44)	0.003** (2.18)	0.004** (2.24)	0.003** (2.16)	0.004** (2.18)	0.003* (1.87)
GDP growth		0.155 (1.56)				0.133 (1.37)
Constant	0.066 (0.84)	0.045 (0.57)	0.053 (0.75)	0.046 (0.67)	0.048 (0.66)	0.036 (0.48)
Observations	2,015	1,996	2,015	2,015	2,015	1,996
Time fixed effects	YES	YES	YES	YES	YES	YES
Number of banks	246	246	246	246	246	246
Bank fixed effects	YES	YES	YES	YES	YES	YES
m2 Statistic (p-value)	0.193	0.190	0.192	0.175	0.189	0.189
Hansen J Statistic (p-value)	0.878	0.895	0.824	0.839	0.876	0.846
Panel B: Coefficient on (Asset Volatility +Shadow Banking*Asset Volatility), by Size of the Shadow Banking Sector						
Low shadow banking	0.590*** (4.92)	0.610*** (4.50)	0.626*** (5.11)	0.622*** (5.05)	0.612*** (4.89)	0.632*** (4.56)
High shadow banking	0.269*** (2.54)	0.293*** (2.69)	0.286*** (2.49)	0.364*** (3.21)	0.284*** (2.65)	0.304*** (2.62)