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Is the leverage of European banks procyclical?

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Abstract Detecting whether banks' leverage is indeed procyclical is relevant to support the view that booms and crises may be reinforced by some sort of supply side financial accelerator, whilst finding a plausible explanation of banks' behaviour is crucial to trace the road for a sensible reform of financial regulation and managers' incentives. By analyzing a large sample of European banks, we show that procyclical leverage appears to be well entrenched in the behaviour of those banks for which investment banking prevails over the traditional commercial banking activity.

Keywords Banks · Procyclicality · Financial regulation · Leverage

JEL Classification G21 · E3

1 Introduction

In traditional models of the financial accelerator (Bernanke and Gertler 1989; Kiyotaki and Moore 1997) procyclical asset prices increase (decrease) the value of borrowers' collateral and thus increase (decrease) the value of loans they are able to obtain. The ensuing credit expansion (contraction) fuels cyclical upturns (downturns). This is a demand-side (of credit) channel through which the financial system may have an amplification effect on the business cycle. On the other hand, the pioneering " lending view" model (Bernanke and Blinder 1988) relies on a supply-side (of credit) effect, working through the effect of monetary policy on banks' balance sheets. As in this model banks' net worth is ignored, no amplification mechanism is at work.

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However, it is a shared view that a supply side amplification mechanism had a role in the growth of the financial bubble (2002–2007) and in the great recession (2007–2009) triggered by the burst of the bubble. Most observers point at banks' leverage as the propagating factor. The mechanism may be shortly described as follows. During upturns, asset prices rise and—for a given value of debt—leverage goes down. When asset prices go up, banks targeting their leverage will increase their debt in order to purchase more assets and restore the initial leverage. Such a mechanism also works, in the reverse, when there is a negative shock to asset prices. The dynamics of banks' balance sheets may reinforce cyclical upturns and downturns, under neutral or even mildly stabilizing monetary policy.

The propagation mechanism becomes self-reinforcing if banks do not try to keep a constant leverage but let it be procyclical. Following an increase in the price of securities, banks would increase leverage and demand for *more* securities than needed to restore the initial leverage. An upward pressure on asset prices follows, which in turn feeds back in higher leverage, generating a vicious spiral. Any negative shock to banks' balance sheets would trigger a downward spiral of leverage and asset prices. Several explanations have been put forward for the procyclical management of banks' leverage (see Angelini et al. 2009, for an extensive survey).

There is a burgeoning literature aimed at capturing the impact of financial intermediaries' balance sheets over the business cycle. Contributions range from the reconsideration of the role of financial intermediaries in monetary economics (Adrian and Shin 2010a) to the general equilibrium approach of Geanakoplos (2009; with a comment by Shin 2009) to more macro-oriented DSGE models either in the flex-price version (Mimir 2010) or in the New Keynesian version with price rigidities (Gertler and Karadi 2009; Gertler and Kiyotaki 2010; Meh and Moran). Mimir (2010) presents evidence (based on Flow of Funds Accounts) according to which the leverage ratio of the US financial sector as a whole (i.e. comprising insurance companies, finance companies and bank holding companies) tends downwards in the time period 1984–2009. He also shows that " the financial leverage ratio is mildly procyclical" (p. 10).

Adrian and Shin (2010b) show that an active management of leverage introduces a procyclicality into the behaviour of financial institutions, even when such a policy aims at keeping leverage constant: if this is the case, intermediaries respond to an increase of their asset value by increasing the size of their balance sheets, namely by issuing more debt and buying more assets (doing the opposite in case of a reduction of asset value). If an intermediary pursues a procyclical leverage policy, this adds a further component to its behaviour, strengthening the procyclicality of its trading behaviour. Adrian and Shin show that a procyclical leverage characterises the major five US investment banks between 1997 and 2008, whilst US commercial banks' leverage, in the same period, was roughly constant. Their argument is based on two ingredients. First, a bank is supposed to target its capital to a fixed proportion of its VaR; this may be justified by considering the solvency regulation (1996 Market Risk Amendment to the Basel Accord). Second, market value accounting makes the value of bank assets strongly depend on the price changes of assets traded in financial markets.

In the present paper we build on Adrian and Shin's analysis, by investigating a sample of 77 European major banks over 2000–2009. As among large European banks the "universal bank" model is widespread, we shall search for active leverage management of those banks in our sample for which investment banking prevails over the traditional commercial banking activity. We shall find that European banks belonging to this subset show the same pattern of US investment banks. Given the universal bank nature of European banks we may infer that procyclical leverage is even more entrenched in the European banking system than in the US one. A financial accelerator mechanism may have been at work on the eastern side of the Atlantic as well as (or even more than) on the western side.

Some recent studies are strictly related to ours. The overall evidence emerging from them is mixed, so we can say that the procyclicality of leverage deserves further empirical investigation. Damar et al. (2010) find a positive link between total assets value and leverage for Canadian banks; they also find that wholesale funding plays a relevant role in strengthening this link. To the contrary, Piffer (2010) finds no significant cyclical pattern of leverage, with a large sample of banks located in several countries.[1] Gropp and Heider (2010) use a large sample of US and European banks between 1991 and 2004, focussing on the behaviour of bank leverage through time; they find that banks' target leverage is time-invariant and bank specific. Memmel and Raupach (2010) analyze how German banks manage the regulatory capital requirement, finding that those banks more engaged in proprietary trading are more active in adjusting their assets so as to meet the regulatory ratio. Kalemli-Ozcan et al. (2011) find that leverage is procyclical for large (more than a billion dollars worth of assets) banks in the US and to a lesser extent in Europe. However, the regressions run by Kalemli-Ozcan et al. (2011) only take into account size, but do not distinguish between commercial and investment banks or between mainly commercial and mainly investment banks.

The paper is organised as follows. Section 2 presents the data set, our empirical research strategy, and our results. The next section provides some concluding remarks. Appendix A reviews the analytics of leverage procyclicality and VaR. Appendix B provides a synthetic description of our sample and correlations among variables.

2 Leverage procyclicality: evidence from a panel of European banks

Our empirical analysis seeks to build on the existing literature in several respects. First, it extends the scope of the established literature by examining at a cross-country level the experience of European banking industries and procyclical leverage before and during the acute phase of the recent financial crisis. We use bank-level data on the 77 constituents of a major market index over the period 2000–2009. As the prevailing European business model is universal banking—where investment banking and commercial banking co-exist although in different proportions—we are able to investigate whether and how different proportions of investment versus commercial banking affect leverage procyclicality.[2]

[1] It should be noticed, however, that Piffer's research question is slightly different from the one pursued by Adrian and Shin and in the present paper. Piffer searches for " a statistically significant positive comovement between leverage ratios and the business cycle" (p. 4). Accordingly, the aggregate output gap replaces the increase in total assets as the main independent variable in his empirical analysis.

[2] Such an investigation would not be possible by using aggregate flow of funds data.

2.1 Our sample

The sample refers to European listed banks composing the Stoxx600 Banks index over the period January 2000–December 2009. The choice of this index is motivated by the fact that it represents the largest European companies in the banking sector as defined by the Industry Classification Benchmark, therefore their activity is expected to have a systemic impact on financial markets. Moreover this removes any arbitrary choice in the selection of the sample. The construction of the dataset required the aggregation of two sources: Datastream for market data on the constituents of the Stoxx600 Bank index in each year under observation and Bloomberg for the semi-annual financial statements of the European banks in the sample. To take into account the effect of the change in the accounting systems (i.e. the switch from the national accounting standards whose balances approaches relied much on at—cost-valuation—to international accounting standards based on the fair-value approach) we exclude in our regression the first semester 2005. This leaves us with 1,099 observations.

The sample consists of 77 listed banks operating in 18 European countries (continental Europe, Switzerland and the UK) for a total of 1,169 observations, as shown in detail in Appendix B. Descriptive statistics for the variables used in the analysis are provided in Table (1) (where assets and loans are in millions euros). Our sample is made up by some banks where the traditional commercial banking activity is prevalent, and by other financial institutions which are more focused on investment banking. To identify a clear procyclicality of leverage, we disentangle the commercial lending from the investment banking components in our data set. In the base regression model, commercial banks are defined as those having a ratio between interest income and net revenues above the median ratio of the whole sample. As a robustness check, we will also run a regression where the distinction between mainly commercial and mainly investment banks relies on the ratio between commercial loans and total assets. A bank is allowed to switch from one group to another through time, but these changes do not have any relevant impact on our results, since the number of switches is limited.

The banks in the sample are the largest in Europe (median size equal to 201,441.1 millions euros in terms of total assets). The median ratio between interest income and net revenues is 56 %, which confirms the prevalence of the universal banking business model. The median level of leverage, measured as total assets over equity (Lev1), is equal to 19.16; this ratio is crucial in assessing its procyclicality (i.e. higher levels would amplify the effects of the propagation factor). Alternative measures of leverage will be used in the robustness checks: risk weighted assets over regulatory capital (Lev2) and total assets over tangible common equity (Lev3).

The sample comprises banks that have been taken over by other banks and banks that have grown through mergers and acquisitions. One may therefore infer that, if mergers and acquisitions are somehow procyclical, they may add to the procyclicality of leverage. However, it may be plausibly argued that if such an effect exists it must be negligible, if not counter-cyclical. Suppose there are two merging banks (1,2), whose pre-merger leverages are $L_1 = \frac{A_1}{E_1}$ and $L_2 = \frac{A_2}{E_2}$, respectively. Suppose also that $A_1 = \alpha A_2$ and $E_1 = \beta E_2$, with $\alpha > \beta$, which implies that bank 1 is more

Table 1 Sample descriptive statistics

	Median	5th percentile	95th percentile
Assets (euro mln)	201,441.10	13,735.79	2,157,357.20
Loans (euro mln)	100,486.70	8,151.20	987,061.00
Commercial1 = interest income/revenues	0.56	0.19	0.88
Commercial2 = loans/assets	0.60	0.17	0.82
Lev1 = total assets/equity	19.16	9.53	40.37
Lev2 = risk weighted assets/total regulatory capital	9	7	11
Lev3 = assets/tangible common equity	26	13	86
Δ % Leverage1	0.24	24.65	22.49
Δ % Leverage2	0	−0.2	0.17
Δ % Leverage3	0.01	−0.45	0.43
Δ % Assets	4.41	−7.68	21.98

leveraged than bank 2: $L_1 = \frac{\alpha}{\beta} L_2$. The resulting bank's leverage will be $L_M = \frac{1+\alpha}{1+\beta} L_2$. As $\frac{1+\alpha}{1+\beta} < \frac{\alpha}{\beta}$, one has $L_1 > L_M > L_2$; that is the resulting bank's leverage will be a weighted average of the two merging banks' leverages, which means that L_M gets closer to L_1 the higher are α and β, i.e. the bigger is bank 1 relative to bank 2. When the acquiring bank (surviving in the sample) is the less leveraged one will observe an increase in its leverage, the size of such an increase depending on the relative size of the acquiring and the acquired bank. The reverse will happen when the acquiring bank is the more leveraged one. However, as noted, such changes in leverage ratios will be the smaller the bigger is the surviving bank. Hence the effects of mergers and acquisitions on our sample depend the likelihood of big banks being acquirers and likelihood of highly leveraged banks being acquirers. The empirical literature on the subject supports our view that these effects are indeed small if not running against procyclicality, as larger, more leveraged banks are proven to be more likely acquirers (Focarelli et al. 2002; Beccalli and Frantz 2012; Pasiouras et al. 2011).

2.2 The regression model

We have run the following panel data regression model, where the percentage change (on a semester basis) of leverage is regressed over the percentage change of total assets' value:

$$\begin{aligned}\Delta \text{Leverage}_{i,t} = {} & \beta_0 + \beta_1 \Delta \text{assets}_{i,t} + \beta_2 \text{Commercial}_{i,t} \times \Delta \text{Assets}_{i,t} \\ & + \beta_3 \text{Commercial}_{i,t} + \beta_4 \text{Leverage}_{i,t-1} + \epsilon_{i,t}, \end{aligned} \tag{1}$$

where $\Delta \text{Leverage}_{i,t}$ is the log-differenced leverage of bank i at time t, $\Delta \text{assets}_{i,t}$ is the log-differenced total assets' value of bank i at time t, Commercial is a dummy variable taking value 1 for commercial banks and zero otherwise, and

$$\epsilon_{i,t} = \alpha_i + \alpha_t + \eta_{i,t}.$$

The regression includes time and bank fixed effects (α_t and α_i) to account for unobserved heterogeneity at the bank level and across time that may be correlated with the explanatory variables. $\eta_{i,t}$ is the usual error term. Time dummies are included to account for patterns of leverage through time, which turn out to be significant, and they are defined as dummies taking value one in one semester and zero otherwise. We also run a regression where the time dummies are included only for the time span 2008–2009, to account for any specific impact of the financial crisis. Following the information provided by the Hausman test, all our regressions are based on the fixed-effects model.[3]

In the base model (regression (a)), commercial banks are defined as those where the ratio between interest income and net revenues is above the median ratio of the whole sample. As a robustness test, in regression (b), we define Commercial as a dummy variable referred to the ratio between commercial loans and total assets.

Since the dummy variable *Commercial* identifies those banks which can be classified as " commercial", β_1 has to be interpreted as the slope of the regression line for the base group of " investment" banks, while ($\beta_1 + \beta_2$) gives the slope for the group of observations labelled as " commercial" banks. The expected sign of β_1 is positive, reflecting the procyclical pattern of investment banks' leverage. The expected sign of β_2 is negative: since we do not expect a procyclical leverage for commercial banks, the sum ($\beta_1 + \beta_2$) should be close to zero. The dummy Commercial is also included in the regression model to follow the proper methodology (see Brambor et al. 2006), but we do not expect its coefficient (β_3) to be significantly different from zero. Finally, *Leverage* is the (log) leverage lagged by one semester, which is included to capture banks' reaction to the leverage level in the previous period; the expected sign of β_4 is negative, possibly reflecting a behaviour of banks trying to correct deviations from some target levels.

2.3 Empirical results

We first provide correlations to get some preliminary evidence on the relations among the variables for the overall sample: both commercial and investment banks. Correlation results are provided in Appendix B. The correlation coefficients for Δassets and Δleverage are positive and statistically significant at 1 % level, providing preliminary evidence of the procyclicality of leverage: this is true for Lev1 and Lev3. To the contrary, it is not true for Lev2: not surprisingly, the regulatory leverage is much less flexible and cannot be managed as the other two definitions of leverage.

We then move to multivariate analysis as specified in Eq. 1. Regression results are reported in Table 2.

[3] The null hypothesis of the Hausman test is that the effects α_i are uncorrelated with the explanatory variables. A rejection indicates that the random effects estimator is inconsistent, while the fixed effects estimator is consistent and efficient. See Johnston and DiNardo (1997, pp. 403–404).

Table 2 Regression results

Dep. variable: Δleverage	(a)	(b)	(c)
Constant	0.718***	0.686**	0.852***
	(0.117)	(0.329)	(0.115)
ΔAssets	0.315***	0.237**	0.338***
	(0.099)	(0.096)	(0.086)
Commercial × Δassets	−0.364*	−0.27*	−0.375*
	(0.201)	(0.137)	(0.199)
Commercial	−0.014	−0.022	−0.008
	(0.021)	(0.024)	(0.022)
$Leverage_{t-1}$	−0.269***	−0.252**	−0.290***
	(0.04)	(0.107)	(0.040)
2008_FQ2			0.069***
			(0.020)
2008_FQ4			0.095**
			(0.042)
2009_FQ2			−0.068***
			(0.026)
2009_FQ4			−0.073***
			(0.016)
Time dummies	Yes	Yes	No
Adj. R^2	0.231	0.156	0.202
N. obs.	714	1,023	714

*** and ** denote 1 and 5 % significance levels, respectively, based on HAC standard errors (in parenthesis)

We focus first on the base model (a). The estimated β_1 is positive and highly significant. This finding points to a clear procyclicality of leverage, as far as the group of (mainly) investment banks is concerned: they seem to respond to a change in their asset value by changing their leverage in the same direction. To the contrary, the estimated slope coefficient for commercial banks ($\beta_1 + \beta_2$) turns out to be slightly negative, implying the absence of any procyclicality for such banks: we can conclude that either they target their leverage to some constant level or they even do not follow any active leverage management.

As expected, the estimated β_3 is not statistically different from zero. Finally, the estimated value of β_4 is negative and significant, confirming that banks do react to the previous period leverage by correcting values that deviate from some target level.[4]

2.4 Robustness tests

Column (b) in Table 2 confirms that our results are robust to a different definition of the dummy Commercial, which here takes value one for those banks where the ratio

4 Results are qualitatively unchanged when removing this variable from the regression.

Table 3 Different leverage specifications

Dep. variable:	Δleverage[=RWA/TRC]	Δ leverage[=assets/TCE]
Constant	0.415***	0.038
	(0.058)	(0.041)
ΔAssets	0.032	0.432**
	(0.044)	(0.199)
Commercial × Δassets	−0.169	−0.634**
	(0.105)	(0.291)
Commercial	−0.007	−0.003
	(0.011)	(0.031)
Leverage [=RWA/TRC]$_{t-1}$	−5.358***	–
	(0.651)	
Leverage [=Assets/TCE]$_{t-1}$	–	−0.439***
		(0.087)
Time dummies	Yes	Yes
Adj. R^2	0.266	0.208
N. obs.	543	491

*** and ** denote 1 and 5 % significance levels, respectively, based on HAC standard errors (in parenthesis)

between commercial loans and total assets is above the median of the whole sample, and zero otherwise. It can be seen that the procyclicality of leverage is still significant for investment banks, while it is absent for commercial banks.[5]

Column (c) in Table 2 provides another specification of the model, where the impact of the financial crisis is tested. It turns out that banks have generally increased their leverage in 2008, while doing the opposite in 2009: the latter finding accounts for the well-known deleveraging process taking place in the aftermath of the crisis peak, following the collapse of Lehman Brothers.

Finally, Table 3 reports the estimates of Eq. 1, where leverage is defined in two alternative ways: risk weighted assets over regulatory capital (Lev2), and total assets over tangible common equity (Lev3).[6] While the latter specification points to an even stronger procyclicality of leverage than in the above results, the regulatory definition of leverage does not show a significant procyclical component: as we have already observed, this finding is not surprising, given the rigidity of the regulatory leverage.

[5] We have also tried a different specification of the dummy " commercial" , to account for the role of wholesale funding (following Damar et al. 2010). In particular, commercial banks have been defined as those having a ratio of short term interbank borrowing plus repos to total assets below the median of the whole sample. The estimated coefficients have the correct sign, but they lack statistical significance, so we have not included them in Table 2 (they are available upon request).

[6] The dummy Commercial is still defined with reference to the ratio between interest income and net revenues.

3 Concluding remarks

Adrian and Shin (2010b) showed that, in the last decade, US investment banks had a marked procyclical leverage and argued that such a pattern for leverage may have contributed to a supply-side financial accelerator of the business cycle. A burgeoning literature sprung from Adrian and Shin's seminal paper. We analyzed a sample of 77 listed banks from 18 European countries in order to check whether some procyclical behaviour was at work on the East side of the Atlantic as well as on the West side. The prevailing banking model (especially among large banks) in Europe is the so-called "universal bank" , wherein both commercial and investment banking activities are carried out by the same bank. We have identified as (mainly) " commercial" banks those having a ratio between interest income and net revenues above the median ratio of the whole sample, whilst the other ones are labelled as (mainly) "investment" banks. By doing so we are able to show that the leverage of mainly investment European banks is clearly procyclical whilst that of mainly commercial European banks is not, thus confirming Adrian and Shin's results. Our analysis also shows that some correction mechanism is present in banks' behaviour, as banks do react to deviations of leverage from a target level. These findings are robust to different specifications of leverage and of the dummy "commercial".

Some policy implications can be drawn from our analysis. The procyclical pattern of bank leverage has negative consequences on the macroeconomy and on the stability of the financial sector. It contributes to amplify business fluctuations, and it can lead some intermediaries to accumulate an extremely high leverage, thus making their balance sheets more fragile and increasing their risk of default. In our view, the authorities' response to this issue cannot rely only on monetary policy; it has to include also some prudential measures, namely a regulatory limit to leverage.[7] Under this regard, the steps recently taken by the Basel Committee on Banking Supervision (see Basel Committee 2010a,b) and by the EU Commission with the "CRD IV package" (Capital Requirements Directive and Regulation, July 2011) are welcomed. However, the approach taken by the Basel Committee seems to be insufficient for at least two reasons. First, the implementation of the leverage ratio is delayed until 2018. Second, and more importantly, the Committee's proposal is a minimum 3 % ratio between capital and total (un-weighted) assets, equivalent to a 33.3 leverage ratio defined as assets (off-balance sheets included) over equity (Tier 1). Although our definition of leverage does not entirely overlap with that employed by the Basel Committee, our findings may suggest that such a regulatory limit might not be binding for many institutions. This suggests that a lower limit to leverage should be set by the authorities.

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[7] The advantages of introducing the leverage ratio as an additional prudential tool are discussed in D'Hulster (2009), together with a presentation of recent regulatory experiences in Canada, Switzerland and the US.

Appendix A

In this Appendix we review the Adrian and Shin's argument by distinguishing three different cases, relative to the leverage policy followed by a financial institution: (i) passive leverage policy, (ii) active leverage policy with a constant target, (iii) active leverage policy with a target defined on VaR. We start by considering a bank with the following balance sheet at time $t = 0$:

$$A_0 = D_0 + E_0 \tag{2}$$

where A_0 is the market value of bank assets, D_0 is the amount of bank debt and E_0 is its equity capital. The leverage of the bank at this date is defined as

$$L_0 = \frac{A_0}{A_0 - D_0} = \frac{A_0}{E_0} \tag{3}$$

Now, suppose that at $t = 1$ the value of its assets is hit by a positive shock: $\Delta A > 0$. The new balance sheet is

$$A_1 = D_0 + E_1 \tag{4}$$

where $A_1 = A_0 + \Delta A$ and $E_1 = E_0 + \Delta A$.

Case 1: **passive leverage policy**. If the bank takes no action, its leverage becomes:

$$L_1 = \frac{A_1}{A_1 - D_0} = \frac{A_1}{E_1} \tag{5}$$

It is easy to see that $L_1 < L_0$. Thus, absent any active policy of leverage management, an increase of A leads to a lower L: bank leverage is *anti-cyclical*.

Case 2: active leverage policy with a constant target. Now suppose that the bank wants to keep its leverage unchanged. To do so, she can buy new assets by issuing more debt. We call ΔD this change on both sides of its balance sheet, which becomes:

$$A_1 + \Delta D = D_0 + E_1 + \Delta D \tag{6}$$

The leverage is now defined by:

$$L_1 = \frac{A_1 + \Delta D}{A_1 + \Delta D - (D_0 + \Delta D)} = \frac{A_1 + \Delta D}{E_1} \tag{7}$$

We can compute the size of the balance sheet increase (ΔD^*) necessary to keep the leverage constant. By inserting the definitions (3) and (7) into the condition $L_1 = L_0$ and solving for ΔD, we get:

$$\Delta D^* = \Delta A(L_0 - 1) \tag{8}$$

Equation 8 shows that, following an initial shock ΔA, a constant leverage target induces the bank to expand its balance sheet by a multiple of such shock. Consider that the median leverage of the European banks included in our sample is above 19 (see Table 1), so that the multiplier is around 18.

Case 3: active leverage policy with a target defined on VaR. The Value-at-Risk may be defined as the maximum loss of asset value, over a specified time horizon and with given probability. Formally:

$$\Pr(A < A_0 - \mathrm{VaR}_0) = 1 - c \tag{9}$$

where A_0 is the initial asset value and c is the confidence level, say 99 %. If $E_0 = \mathrm{VaR}_0$, the bank is solvent—over a given time horizon—with probability c. Let us assume that our representative bank follows the policy of targeting its capital to VaR. Then we can start from the initial condition $E_0 = \mathrm{VaR}_0$, implying that

$$L_0 = \frac{A_0}{\mathrm{VaR}_0} = \frac{1}{V_0} \tag{10}$$

where V_0 is the "unit VaR": the value-at-risk per unit of assets. In other words, the leverage turns out to be targeted at a level which is the inverse of the unit VaR.

Now we introduce a shock $\Delta A > 0$, say an increase of the market value of assets, taking place at $t = 1$. Condition (10) becomes

$$\overline{L_1} = \frac{A_1}{\mathrm{VaR}_1} = \frac{1}{V_1} \tag{11}$$

which defines the new target for leverage: $\overline{L_1}$. Adrian and Shin (2010b) argue that the unit VaR is counter-cyclical, and this in turn originates the procyclicality of leverage. Formally: $V_1 < V_0$ hence $\overline{L_1} > L_0$. Adrian and Shin (2010a) note that the immediate impact of the shock is that the bank has some " spare capacity" on its balance sheet, since $E_1 > \mathrm{VaR}_1$, implying that L_1 (defined in (5)) is lower than $\overline{L_1}$. The bank makes use of this spare capacity by issuing more debt and buying new assets until its VaR is again in line with its equity: $E_1 = \mathrm{VaR}_1$ and $L_1 = \overline{L_1}$.

The bottom line of this argument is: if a bank targets its capital to its VaR, L turns out to be *increasing* in A. More generally, if a bank targets its capital to a fixed proportion of VaR (say λ), so that $E = \lambda \cdot \mathrm{VaR}$, its leverage turns out to be:

$$L = \frac{A}{\lambda \mathrm{VaR}} = \frac{1}{\lambda}\frac{1}{V} \tag{12}$$

and the procyclicality of L follows from the counter-cyclicality of V.

Appendix B

See Tables 4 and 5.

Table 4 Our sample—No. of observations by country/semester

Country	Year/quarter										
	2000_FQ4	2001_FQ2	2001_FQ4	2000_FQ2	2002_FQ2	2002_FQ4	2003_FQ2	2003_FQ4	2004_FQ2	2004_FQ4	2005_FQ2
Austria	1	1	1		1	1	1	2	2	2	2
Belgium			1		2	2	3	3	3	3	3
Denmark	3	3	3		3	3	3	3	3	3	3
Finland								1	1	1	1
France	2	2	2		2	2	3	3	3	3	3
Germany	3	3	3		4	3	3	4	4	5	5
Greece			5		5	5	5	5	5	5	5
Ireland		1	1	1	1	1	1	2	2	2	2
Island						1	1	2	2	2	2
Italy	13	12	14		14	14	15	16	17	18	18
The Netherlands	1	1		1	1	1	1	1	1	1	
Norway	2	2	2		2	2	2	1	1	1	1
Portugal	2	2	2		2	2	2	2	2	2	2
Spain	4	5	7		7	7	7	7	7	7	7
Sweden	4	4	4		4	4	4	4	4	4	4
Switzerland	1	1	2		2	2	2	2	2	2	2
United Kingdom	7	9	9		9	9	9	9	9	9	9
Panel	42	46	57	1	59	59	62	67	68	70	70

Table 4 Continued

Country	Year/quarter									
	2005_FQ4	2006_FQ2	2006_FQ4	2007_FQ2	2007_FQ4	2008_FQ2	2008_FQ4	2009_FQ2	2009_FQ4	Panel
Austria	3	3	3	3	3	3	3	2	2	39
Belgium	3	3	3	3	3	3	2	2	2	44
Denmark	3	3	3	3	3	3	3	3	2	56
Finland	1	1	1	1	1	1	1	1	1	13
France	3	3	3	3	3	3	3	3	3	52
Germany	5	5	4	5	5	5	5	5	4	80
Greece	5	5	5	5	5	5	5	5	5	85
Ireland	2	2	2	2	2	1	1	1		27
Island	2	2	2	2	2	2				22
Italy	16	16	14	12	12	12	12	12	9	266
The Netherlands	1	1	1	1	1	1	1	1		17
Norway	1	1	1	1	1	1	1	1	1	25
Portugal	2	2	2	2	2	2	2	2	2	38
Spain	7	7	7	7	7	7	7	7	7	128
Sweden	4	4	4	4	4	4	4	4	4	76
Switzerland	2	2	2	2	2	2	2	2	2	36
United Kingdom	9	9	9	9	9	9	9	8	6	165
Panel	69	69	66	65	65	64	61	59	50	1,169

Table 5 Correlations

	ΔLeverage1	ΔLeverage2	ΔLeverage3	$Lev1t_1$	$Lev2t_1$	$Lev3t_1$	Commercial 1 × Δ Assets	Commercial 1	Commercial 2 × Δ Assets	Commercial 2	ΔAssets
ΔLeverage1	1	0.280**	0.755**	−0.070	−0.314**	−0.141**	−0.027	−0.015	0.011	−0.015	0.174**
		0.000	0.000	0.095	0.000	0.000	0.378	0.619	0.757	0.686	0.000
	1,099	561	507	574	545	1,023	1,099	1,099	768	768	1,099
ΔLeverage2	280**	1	0.321**	−0.335**	−0.089	−0.108*	−0.014	−0.029	−0.068	−0.091*	0.051
	0.000		0.000	0.000	0.059	0.011	0.749	0.490	0.107	0.031	0.225
	561	561	429	547	456	548	561	561	557	557	561
ΔLeverage3	0.755**	0.321**	1	−0.074	−0.357**	−0.171**	−0.003	−0.097*	−0.003	−0.029	0.174**
	0.000	0.000		0.121	0.000	0.000	0.946	0.030	0.946	0.514	0.000
	507	429	507	437	496	496	507	507	502	502	507
Lev1t_1	−0.070	−0.335**	−0.074	1	−0.081	−0.025	0.056	0.252**	0.061	0.189**	0.021
	0.095	0.000	0.121		0.061	0.547	0.176	0.000	0.147	0.000	0.604
	574	547	437	628	529	589	589	589	564	564	628
Lev2t_1	−0.314**	−0.089	−0.357**	−0.081	1	0.674**	−0.175**	−0.299**	−0.121**	−0.124**	−0.176**
	0.000	0.059	0.000	0.061		0.000	0.000	0.000	0.005	0.004	0.000
	545	456	496	529	603	561	561	561	537	537	603
Lev3t_1	−0.141**	−0.108**	−0.171**	−0.025	0.674**	1	−0.091**	−0.201**	−0.110**	−0.175**	−0.143**
	0.000	0.011	0.000	0.547	0.000		0.003	0.000	0.003	0.000	0.000
	1,023	548	496	589	561	1,050	1,050	1,050	714	714	1,050
Commercial 1 × ΔAssets	−0.027	−0.014	−0.003	0.056	−0.175**	−0.091**	1	0.494**	0.497**	0.067	0.467**
	0.378	0.749	0.946	0.176	0.000	0.003		0.000	0.000	0.062	0.000
	1,099	561	507	589	561	1,050	1,368	1,368	768	768	1,368

Table 5 continued

	ΔLeverage1	ΔLeverage2	ΔLeverage3	Lev1t_1	Lev2t_1	Lev3t_1	Commercial 1 × Δ Assets	Commercial 1	Commercial 2 × Δ Assets	Commercial 2	ΔAssets
Commercial 1	−0.015	−0.029	−0.097*	0.252**	−0.299**	−0.201**	0.494**	1	0.127**	0.294**	0.136**
	0.619	0.490	0.030	0.000	0.000	0.000	0.000		0.000	0.000	0.000
	1,099	561	507	589	561	1,050	1,368	1,368	768	768	1,368
Commercial 2 × ΔAssets	0.011	−0.068	−0.003	0.061	−0.121**	−0.110**	0.497**	0.127**	1	287**	0.570**
	0.757	0.107	0.946	0.147	0.005	0.003	0.000	0.000		0.000	0.000
	768	557	502	564	537	714	768	768	768	768	768
Commercial 2	−0.015	−0.091*	−0.029	0.189**	−0.124**	−0.175**	0.067	0.294**	0.287**	1	−0.007
	0.686	0.031	0.514	0.000	0.004	0.000	0.062	0.000	0.000		0.846
	768	557	502	564	537	714	768	768	768	768	768
ΔAssets	0.174**	0.051	0.174**	0.021	−0.176**	−0.143**	0.467**	0.136**	0.570**	−0.007	1
	0.000	225	0.000	0.604	0.000	0.000	0.000	0.000	0.000	0.846	
	1,099	561	507	628	603	1,050	1,368	1,368	768	768	1,444

** and * denote 1 and 5 % significance levels

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