Capital Regulations and Credit Line Management during Crisis Times*

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October 15, 2019

Abstract

Credit line drawdowns by firms reduce a bank's regulatory capital ratio. Using the Austrian Credit Register, we provide novel evidence that during the 2008-09 financial crisis, capital-constrained banks managed this concern by substantially cutting little-used credit lines. Controlling for a bank's capital position, we also find that greater liquidity problems induced banks to considerably cut little-used credit lines over 2008-09. These results suggest that banks actively manage both capital and liquidity risk caused by undrawn credit lines in periods of financial distress, but thereby reduce liquidity provision to firms exactly when they need it most.

1 Introduction

Most firms in Europe are bank-dependent, and a significant fraction of bank lending is done via credit lines. A corporate credit line commits a bank to lend to a firm up to an agreed amount for an agreed period of time, unless the firm violates a covenant. This makes credit lines a particularly flexible and reliable source of debt financing (Sufi, 2009). Having a credit line that is not fully

*We thank members of the Economic Analysis and Research Department of the Oesterreichische Nationalbank (OeNB), the research department of De Nederlandsche Bank (DNB), Franklin Allen, Hans Degryse, Tim Eisert, Aysil Emirmahmutoglu, Pirmin Fessler, Glenn Schepens, Jakob de Haan, Franz Hahn, Steven Poelhekke, Doris Ritzberger-Grünwald, Gunseli Tumer-Alkan and seminar participants at the OeNB, DNB, Tinbergen Institute, VU Amsterdam, University of Amsterdam, Norwegian School of Economics (NHH), WU Vienna, Carlos III Madrid and the European Bank for Reconstruction and Development (EBRD) as well as conference participants at the CESifo Workshop on Banking and Institutions in Munich, the C.r.e.d.i.t. 2018 in Venice, the 6th WU-WAETRIX Workshop in Vienna, the 35th International Symposium of Money, Credit and Banking in Aix-en-Provence, the TI Jamboree 2018 in Amsterdam, the NOeG Annual Meeting 2018 in Vienna, the 5th Research Workshop of the MPC Task Force on Banking Analysis for Monetary Policy in Brussels, the 1st NOeG Winter Workshop in Vienna and IFABS 2017 in Oxford for helpful comments and suggestions. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the OeNB or DNB.

used provides liquidity insurance and also sends a positive signal on the quality of the firm to other financial market participants (Mosebach, 1999). From the bank's perspective, commitment fees charged on the unused portion of the line make up a considerable fraction of revenues from credit lines (Sufi, 2009; Loukoianova et al., 2006). These earnings come at relatively low cost for the bank as long as the line remains unused. The reason is that from a regulatory perspective, the undrawn portion of a credit line is largely off-balance sheet and must therefore be backed by only little capital in the Basel framework. The flip-side is that additional drawdowns result in a direct and possibly unexpected increase in the size of the bank's balance sheet and thus decrease in its regulatory capital ratio. This reduces a bank's buffer towards its minimum capital requirement, which limits the bank's potential to absorb future losses and also harms its stock market performance (Demirguc-Kunt et al., 2013). Exposure to unused credit lines may therefore put a bank's capital buffer at risk. This source of risk has received virtually no attention in the academic literature. At the same time, it is far from negligible: if the usage of all credit lines that we observe increased to match their committed volume in early 2008, the average bank in our sample would have had to increase its capital stock by up to six percent to keep its capital ratio and thus capital buffer constant. Without raising extra capital, the bank would have suffered a decrease in its capital buffer by up to 15 percent. Since we do not observe relatively small credit lines, the total impact is still somewhat higher.

The described risk of capital buffer reductions is particularly relevant in periods of financial distress. The reason is that the capital position of banks is then typically weakened, raising capital is more expensive and credit line drawdowns are more likely. This raises the question whether and to what extent banks actively manage capital concerns that come with exposure to undrawn credit lines in crisis times, and what consequences this has on lending to the corporate sector. To the best of our knowledge, we are the first to study this question. In theory, banks can adjust their credit line portfolio after covenant violations by firms, after expiring maturities or, for "revocable" credit lines, by using the right to cut or abandon the line unilaterally. We find that during the 2008-09 financial crisis, banks whose capital position was hit relatively hard and whose initial capital buffer was comparatively small made use of these options. In particular, they reduced the risk of capital buffer reductions by substantially cutting the volume of credit lines that were used relatively little in relation to their granted amount at the onset of the crisis. This result sheds light on a novel yet important link between capital regulations and bank lending to the real economy.

As a second contribution, we show that conditional on a bank's capital position, relatively large

exposure to the liquidity dry-up during the crisis affected a bank's credit line supply as well. In particular, such liquidity problems also induced banks to cut little-used credit lines over 2008-09 considerably and more than other banks, thereby limiting the scope of additional credit line drawdowns and the resulting costs. Our findings are conditional on changes in firm-specific credit demand and creditworthiness as well as bank-specific unobservables during the crisis. We therefore provide causal evidence that banks actively manage both capital and liquidity risk caused by exposure to undrawn credit lines in periods of financial distress. From the perspective of banking system stability, this is good news. However, the implication is that banks reduce liquidity provision to firms exactly at a time in which they need it most and when alternatives to bank financing tend to be scarce, especially in bank-dependent financial systems. Our evidence thereby indicates a transfer of liquidity risk from banks to firms. This phenomenon has received little attention so far, partly because limited data availability has often prevented a comprehensive analysis of credit commitment volumes as opposed to actual levels of credit usage.

Our primary data source is the Austrian credit register, which is ideally suited to pursue our research goals. The register provides information on credit commitments over time at the bank-firm level and thus allows us to convincingly account for selection effects and to control for bank unobservables. What's more, the register provides information on how much a firm makes use of a credit commitment in a given month, which allows to measure the risk of additional drawdowns for each individual credit relationship we observe. Data are available for the universe of banks and firms operating in Austria, as long as the bank-firm-specific credit commitment or usage exceeds €350,000. This results in a coverage of around 90 percent of total credit commitments in Austria. Not only due to the quality of data, but also from a conceptual perspective Austria is an ideal setting to study our research questions. This is in part because Austrian banks have traditionally had relatively small capital buffers compared to banks in other countries (Fonseca and González, 2010). Furthermore, for many Austrian banks it has been particularly difficult to raise external capital due to their ownership structure, as we explain in section 3. Austrian banks have therefore been exceptionally sensitive to capital buffer reductions and thus additional credit line drawdowns.

Our identification strategy is to exploit the 2008-09 financial crisis as a shock of varying degree to the capital and liquidity position of banks operating in Austria. The Austrian economy is relatively small and did not experience a domestic housing market bubble burst before or during 2008-09.

Therefore, the outbreak of the crisis was clearly exogenous and unexpected to the Austrian banking sector. We expect that the more a bank's capital position was hit by the crisis and the smaller the bank's initial capital buffer, the more vulnerable the bank was to a capital ratio reduction and therefore additional credit line drawdowns during the crisis. As an exogenous proxy for the effect of the crisis on a bank's capital position, we use the bank's pre-crisis exposure to US asset markets. Using confidential data at the individual bank level, we show that banks with higher US asset exposure at the onset of the crisis experienced larger US-related and also total asset value losses in 2008-09. Since such losses have to be marked to market, they directly affected a bank's capital buffer. Our proxy is in the tradition of the literature to use ex-ante asset holdings to capture ex-post losses during crisis times (see e.g. Popov and Van Horen, 2015; De Marco, 2018; Ongena et al., 2018). Furthermore, the proxy is in the spirit of Peek and Rosengren (1997), Puri et al. (2011) and Ongena et al. (2018) since it exploits an exogenous shock occurring in a distant country. Besides capital concerns, we also expect that the more a bank depended on wholesale funding before the crisis, the more sensitive it was to additional credit line drawdowns in 2008-09. This is because it faced a larger shock to its cost of liquidity and thus the cost of meeting additional credit demand from its firms. To proxy for this type of crisis exposure, we follow Ongena et al. (2015) and use a bank's pre-crisis dependence on international interbank funding.

Controlling for firm-specific changes in credit demand and creditworthiness (Khwaja and Mian, 2008), we find that banks with a one standard deviation larger US asset exposure significantly cut little-used credit lines by 12 percent and more than other banks between January 2008 and December 2009. What's more, we show that US-exposed banks that had a relatively small capital buffer at the onset of the crisis cut little-used credit lines more than US-exposed banks with a relatively large buffer. Our interpretation of these results is that capital-constrained banks cut little-used lines mostly as a precautionary move to limit further capital problems. This conclusion is supported by our finding that among little-used lines, those that had a larger commitment volume and therefore posed larger risk to a bank's capital buffer were cut significantly more.[1]

Our results also indicate that capital-constrained banks did not cut credit lines that were *highly* used in relation to their granted volume. We conclude that this is because they posed a smaller risk of additional drawdowns, cutting highly-used lines was potentially less feasible and/or because

[1] In addition to reducing the risk of drawdowns, banks may have also cut little-used credit lines to free capital directly. However, this motive appears less relevant since the effect is limited, given the low capital charge on the unused portion of most credit line types (see Section 3).

banks wanted to avoid imposing credit constraints on their firms. The latter was arguably a good strategy to limit payment defaults of firms and to prevent firms from switching to other banks in the short, medium or long run, especially given the importance of relationship lending in Austria. The mentioned concerns were clearly smaller when banks cut little-used lines, while at the same time it enabled them to reduce the risk of a sudden capital buffer reduction in times in which capital was scarce and expensive.

Regarding liquidity concerns, we find that a one standard deviation increase in pre-crisis dependence on international interbank funding lead to a substantial reduction of little-used credit lines by up to 18.5 percent over 2008-09, controlling for a bank's US asset exposure and initial capital buffer. Again, the impact was larger than for other banks, and highly-used lines were not significantly cut. Similar to our results on the "capital channel", this shows that banks actively reduced the risks caused by undrawn credit lines, but thereby transferred liquidity risk to the corporate sector.

Our main set of results provides an additional rationale for the policymaker's quest to strengthen bank capital buffers. What's more, our findings may reflect that the regulatory framework prior to the crisis induced banks to excessively grant credit line volumes that could not be sustained in crisis times, when both the risk and the consequences of additional drawdowns are larger. In this light, the measure of Basel III to increase the capital charge on the unused portion of most credit line types compared to Basel II may smoothen credit line supply over the business cycle in the future. This would limit the impact of runs on undrawn credit lines on banks and may also benefit firms. Similarly, the introduction of the Liquidity Coverage Ratio (LCR) in Basel III, which requires banks to hold an adequate stock of unencumbered high-quality liquid assets, may better prepare banks for liquidity problems and a rise in credit line demand.

2 Contribution to the literature

We empirically establish a link between bank capital requirements and credit supply in light of the regulatory treatment of unused credit commitments. Conceptually, this contribution relates to a small literature on asset-backed commercial paper (ABCP) conduits (often called "shadow banks"). Assets held by ABCP conduits are similar to undrawn credit lines in the sense that they fully come on the balance sheet of the bank that set up the conduit only if liquidity guarantees on these assets

are used, which then decreases the bank's capital ratio. Acharya et al. (2013) and Acharya and Schnabl (2010) describe the motivation and risks behind ABCP conduits, while Covitz et al. (2013) document a run on ABCP programs at the onset of the Great Recession. More generally, our results confirm that bank capital is an important determinant of bank lending behavior (Gambacorta and Mistrulli, 2004; Berrospide and Edge, 2010; Gambacorta and Shin, 2016). We also corroborate the finding that banks actively adjust their credit supply as a response to changes in net worth due to exposure to certain assets and asset markets (Santos, 2010; De Haas and Van Horen, 2012; Popov and Van Horen, 2015; De Marco, 2018; Ongena et al., 2018; Acharya et al., 2018). Regarding capital regulations, we relate to Gropp et al. (2018) who find that banks respond to an increase in their minimum capital requirement by reducing their risk-weighted assets – including lending to the real sector – rather than raising their levels of capital. Our results further confirm the results of the literature on macro-financial feedback loops, which suggest that well-capitalized banks cut back assets and loans less than poorly-capitalized banks as a response to adverse capital shocks (Brunnermeier and Sannikov, 2014; Brunnermeier et al., 2016; Farhi and Tirole, 2017). Our study also builds on Chodorow-Reich and Falato (2017), who show that banks in worse health during the 2008-09 crisis were more likely to force a loan commitment reduction in response to a covenant violation of a non-financial firm. This result and the fact that more than one-third of loans in the US data of Chodorow-Reich and Falato breach a covenant over 2008-09 may suggest that besides expiring maturities and the right to cut revocable lines, covenant violations provided a noteworthy opportunity for capital- or liquidity-constrained banks to cut little-used credit lines in Austria during the crisis.

The results of our study also contribute to a growing literature that deals with liquidity risk caused by unused credit commitments. Several studies have shown that deposit funding can help to mitigate this risk (Kashyap et al., 2002), especially during periods of tight liquidity (Gatev et al., 2009; Gatev and Strahan, 2006). Acharya and Mora (2015) highlight that in the US, banks were only able to honor credit line drawdowns during 2007-2009 because of explicit and large support from the government and government-sponsored agencies. Ippolito et al. (2016) find that the likelihood of Italian firms to draw down previously unused credit lines during the interbank market freeze in the summer of 2007 increased with the dependence on interbank funding of their banks. However, exposed banks did not significantly reduce credit line volumes, despite higher funding costs. This is arguably due to the fact that unless the borrower violated a covenant, most credit lines could not

be adjusted downwards over a period of only two months even if the bank had wanted to. Given our horizon of almost two years, this is different in our setting. Ippolito et al. (2016) also show that banks that were more exposed to liquidity shocks actively managed this risk *ex ante* by granting fewer credit lines to firms that were expected to draw down unused credit lines more extensively during crisis times. We confirm this result by showing that firms that held little-used credit lines had a significantly lower probability of default before the crisis (see section 5.5). Ivashina and Scharfstein (2010) document a run on credit lines in the US after the Lehman default and find that banks responded to this drain on liquidity and higher funding costs by reducing new lending. Cornett et al. (2011) find that banks with higher levels of unused credit commitments managed the resulting liquidity risk by increasing their liquid asset holdings and by reducing new credit origination during 2007-2009. We mainly contribute to this liquidity-oriented literature by showing that banks not only take action outside of their credit line portfolio conditional on liquidity risk due to unused credit lines, but also actively limit this risk itself by reducing their exposure to undrawn credit commitments.

In a broader sense, our study relates to the literature that studies the effect of liquidity shocks on credit supply to firms without explicitly focusing on heterogeneity in credit usage levels and the resulting risks from little-used credit commitments (Khwaja and Mian, 2008; Schnabl, 2012; Iyer et al., 2014; Allen et al., 2014; Cingano et al., 2016). We contribute to this body of work by showing that while financial distress does not necessarily imply a reduction in actual loan volumes, it can reduce the amount of credit firms can at most obtain from banks. This is equivalent to a transfer of liquidity risk from banks to firms, a phenomenon that has received little attention so far. Last, but not least, our paper adds to the theoretical (Boot et al., 1987; Martin and Santomero, 1997; Holmström and Tirole, 1998; Acharya et al., 2014) and empirical (Sufi, 2009; Acharya et al., 2013; Berger and Udell, 1995; Shockley and Thakor, 1997; Agarwal et al., 2006; Demiroglu and James, 2011) literature that analyzes the nature, motivation and use of credit commitment contracts.

3 Background and Data

Credit lines and Basel capital regulations

Basel II, which was fully implemented in Europe in January 2008 and was practised until 2013,

requests banks to hold capital worth at least eight percent of their risk-weighted assets.[2] Independently of the risk associated with a credit commitment, the used portion and the unused portion of the commitment do not equally enter risk-weighted assets in this framework. The used portion obtains a 'credit conversion factor' (CCF) of 100%, which implies that it fully enters risk-weighted assets. The unused portion in turn only obtains a CCF of at most 50%. This implies that a rise in the usage of the credit commitment triggers an increase in risk-weighted assets for the granting bank and thus a reduction in its capital ratio, unless the bank raises additional capital.

The specific CCF of the unused portion of a credit commitment in the Basel II framework depends on the type and maturity of the credit commitment. The unused portion of an *irrevocable* credit commitment has a CCF of 20% if the original maturity is below one year and a CCF of 50% otherwise. A credit line is irrevocable if its volume cannot be reduced before the commitment matures unless the firm violates a covenant. *Revocable* commitments, which are unconditionally cancellable by the bank at any time, face no capital charge in Basel II. This is despite evidence that banks mostly honor such commitments in adverse conditions to avoid losing reputational capital (Bhalla, 2008, see p.407). While Basel II already brought the unused portion of credit commitments more on the balance sheet of banks compared to Basel I, Basel III continued this process for most types of commitments. Specifically, in Basel III irrevocable commitments have a CCF of 40% irrespective of their maturity and revocable commitments have a CCF of 10%.

Bank capital and the crisis in Austria

Austrian banks suffered a deterioration of bank capital ratios due to losses during the crisis (Schürz et al., 2009). This was especially problematic since for Austrian banks raising additional capital has been difficult. Specifically, Austria's Financial Market Stability Board (FMSB) has argued that "central risks for the Austrian banking system emanate (...) from banks' specific ownership

[2] In January 2007, the standardized approach and the foundation internal rating-based approach (F-IRB) of Basel II became applicable, while the advanced internal rating-based approach (A-IRB) could be applied from January 2008 onwards (Musch et al., 2008; Deutsche Bundesbank, 2009). The CCFs indicated in the main text apply only to the standardized and F-IRB approach. In the A-IRB approach, banks estimate CCFs themselves, at the individual credit commitment level. Among other factors, this is done based on past usage-to-granted volume ratios. This implies that on average, also in the A-IRB approach unused commitments must be backed with less capital than used commitments, which is what ultimately motivates our research question around the "capital effect". Only some of the very largest banks operating in Austria have adopted the A-IRB approach. Those banks face a trade-off. While cutting little-used credit commitments reduces the risk of sizable drawdowns, it also raises the usage-to-granted volume ratio of the commitment, which leads to an increase in the commitment-specific future CCF. Banks that apply the A-IRB approach thus might have a larger incentive not to cut credit commitments than banks applying the standardized or F-IRB approach, conditional on a given current CCF. This "works against us" in finding a negative effect of capital concerns on credit line supply and is therefore not a major concern in terms of identification.

structures, which would not fully ensure the adequate recapitalization of banks in the event of a crisis" (FMSG, 2017). The background is that many Austrian banks are part of a banking group, which makes it difficult for a specific group member to raise capital from financial markets without diluting the equity share of other members. Making things worse, Austrian banks already had relatively small capital buffers as they entered the crisis (Fonseca and González, 2010). These factors possibly contributed to the weak stock market performance and large CDS spreads of Austrian banks in 2008-09 (see Figure 2).[3] [4] This development occurred despite the Austrian banking package, which "helped prevent a liquidity squeeze and expand banks' capital buffers" (Schürz et al., 2009, p.56). The weak stock market performance in turn reduced the amount of capital that could be raised at the expense of a given loss of (perhaps voting) equity and thus aggravated the institutional problems caused by the banking group structures. These considerations imply that Austrian banks were particularly sensitive to a reduction in their capital ratio and thus additional credit line drawdowns during the 2008-09 financial crisis.

Measuring US asset exposure

We use a bank's pre-crisis holdings of US assets divided by total assets as a proxy for how the capital position of a bank operating in Austria was affected by the crisis. The data comes from the Austrian Central Bank's database of individual bank balance sheets. Pre-crisis US asset holdings are arguably the "cleanest", i.e. most exogenous proxy for the change in the health of a bank's capital position during the crisis. This is because the origins of the crisis lied in the United States and were not related to the Austrian banking sector. We measure US assets over total assets as the sum of securities and equity shares acquired from US counterparties and loans to US counterparties

[3] Supporting evidence for this claim is provided by Demirguc-Kunt et al. (2013), who study a multi-country panel of banks and find that a stronger capital position was associated with better stock market performance during the crisis.

[4] Another reason for the weak stock market performance of Austrian banks was their exposure to the CESEE region, whose performance was regarded as uncertain by financial markets at the time. The average Austrian bank's exposure to CESEE assets clearly exceeded its US assets exposure and triggered substantial news coverage during the crisis. Nonetheless, for two reasons we do not choose CESEE exposure to proxy for the effect of the crisis on a bank's capital position. First, it must be doubted that losses in the CESEE region that affected the capital position of banks operating in Austria were purely a result of the global financial crisis and in this sense exogenous to the Austrian banking sector. Second, while pre-crisis CESEE asset holdings are associated with larger CESEE-related losses during 2008-09, they do not significantly correlate with total net asset value gains over the same time period. This makes CESEE asset holdings a worse predictor of total losses than US asset holdings. Nonetheless, we do feature CESEE exposure as a control variable in our empirical analysis; see section 4.

divided by the sum of a bank's total loans, securities and equity shares, in December 2006.[5] In line with previous studies, this moment of time is chosen well ahead of the crisis.[6] Importantly, US assets as we measure them may be denominated in any currency, not only in US dollars. At the same time, assets for which the direct counterparty is not located in the United States are not included in our measure.[7] Although US assets only constituted one percent of (non-risk-weighted) total assets of the average bank in our sample (see Figure 4 for the distribution of this variable), they made up 13.6 percent of capital and almost half of a bank's capital buffer in December 2006 (see Table 1, panel II).[8] These statistics should be taken as a lower bound of the actual exposure to US asset markets, given that only direct counterparties are considered. Using confidential data at the bank level, we are able to track the distribution of US asset-specific value gains and losses due to changes in market values over time (see Figure 3). We show in section 5.3 that for the average bank, larger pre-crisis US asset holdings were significantly associated with larger US-related losses and also larger total losses during 2008-09. In September 2008 alone, the month of the Lehman default, US asset write-downs on average wiped out around five percent of the average bank's capital buffer. Since these losses have to be marked to market, they imply a smaller buffer towards the bank's regulatory minimum capital requirement. These results suggest that pre-crisis US asset exposure is not only exogenous to the Austrian banking sector but also an economically relevant predictor of capital losses incurred by banks operating in Austria during the Great Recession. Figure 3 further shows that also the volatility of net US asset value gains was elevated from 2007-09, which suggests that banks also faced increased uncertainty about the value of their US asset holdings and thus their capital during the crisis.[9] Since such increased uncertainty may also affect a bank's credit line management, pre-crisis US asset holdings is arguably a better proxy for how a bank's capital position was affected by the crisis than the incurred losses throughout the crisis.

The extent to which a bank can absorb losses on its balance sheet and a resulting capital ratio

[5] On the average balance sheet of the banks in our sample (weighted based on the frequency of the bank in our sample), 50 percent of US assets were securities, 49 percent were loans and one percent were equity shares in December 2006.

[6] This avoids for example to classify a bank that sold off its US assets with losses as the crisis began to unravel in 2007 as not exposed to the crisis.

[7] This implies that if an Austrian bank buys a security that was issued in the United States from a German bank, then the security is classified as a German security, since the direct counterparty is German.

[8] We use weights to compute the descriptive statistics in panel II of Table 1. The weight of each bank equals its share in the number of credit lines in our sample. The results are similar when we use a bank's share in the total credit line volume in our sample as weight.

[9] The actual uncertainty was arguably still higher than Figure 3 suggests, since the valuation of assets whose market completely dried up was often done using bank-internal *models* (Ellul et al., 2014).

reduction clearly depends on the bank's initial capital buffer. Therefore, we use confidential supervisory data to incorporate this variable into our analysis. We compute a bank's capital buffer as the ratio of its Tier 1 + Tier 2 capital holdings and the bank's corresponding minimum capital requirement. This variable is a more precise indicator of how well a bank can absorb capital losses than bank capital over total assets, which has been used by many studies but does not take the riskiness of a bank's asset portfolio into account. In terms of timing, we compute a bank's capital buffer as of the end of the first quarter of 2008 in order to take into account the regulatory changes that came with the full implementation of Basel II in January 2008.[10] The average capital buffer realization in our sample equals 1.81; see Figure 8 for the variable's distribution.

Liquidity problems during the crisis in Austria

The 2008-09 financial crisis was also a crisis of liquidity. For example, the cost of unsecured interbank funding increased sharply with the Lehman default (see Figure 5). This was mainly driven by a sharp increase in perceived counterparty risk, and lead to a reduction in the volume of unsecured interbank deposits on a global scale. It was difficult for banks to fully substitute interbank funding with other sources of finance during the crisis. The cost of issuing bonds increased and the sudden nature of the crisis made it impossible to increase retail deposits quickly (Brunnermeier, 2009). In the wake of these events, Austria's eight-largest bank at the time, Kommunalkredit AG, suffered an acute liquidity crisis and was subsequently taken over by the Republic of Austria under the interbank market support and financial markets stabilisation act in November 2008 (Moody's Investors Service, 2010).

Measuring dependence on interbank funding

Several studies have adopted pre-crisis dependence on interbank funding as a proxy for bank-specific exposure to wholesale funding and thus exposure to higher liquidity costs during the 2008-09 crisis (Iyer et al., 2014; Ongena et al., 2015; Cingano et al., 2016). We follow this literature and in particular Ongena et al. (2015) by using *international* interbank borrowing divided by total assets on the bank's balance sheet as our proxy. We do so since Austria is a relatively small economy and *domestic* pre-crisis interbank borrowing within, but also outside of the banking group is arguably a poor proxy for exposure to increased liquidity cost in the aftermath of the Lehman default. Again,

[10] Our results are robust to choosing the last quarter of 2006, which parallels the timing of our other bank-specific independent variables; see section 5.3.

we choose December 2006 as our point of measurement. As Table 1, panel II shows, the (weighted) average of international interbank borrowing over total assets in this month across the banks in our sample was 9.3 percent; see Figure 6 for the distribution of the variable. Figure 7 reveals that banks operating in Austria continuously reduced both international interbank lending and borrowing after a peak in late 2008, which shows that they were feeling the repercussions of the higher interbank funding rates.

The Austrian Credit Register as primary data source

Our source of credit data is the Austrian credit register. The register documents all bank-firm-specific credit relationships in a given month as long as the offered credit volume or usage exceeds €350,000.[11] This threshold implies that we study credit supply to medium-sized and large firms.[12] Our sample includes foreign banks but does not contain firms outside of Austria.[13] While Austrian banks are often organized in groups, credit decisions are typically made at the individual bank level, which is why our unit of observation is a bank-firm relationship. What we observe for such a relationship is the sum of all credit commitments the bank grants to the firm in a given month. This sum can include revolving credit lines but also other types of credit such as term loans. However, for all individual credit types the granted amount may exceed the firm's actual usage and this also frequently occurs in the data after 2010, which is when commitment data by type started to be collected. Therefore, we treat a bank's total credit commitment to a firm as one bank-firm specific credit line in our analysis. Bearing this in mind, we interchangeably use the terms 'credit commitment' and 'credit line'. Our main dependent variable is the change in this variable at the bank-firm level between January 2008 and December 2009. When evaluating this change in our empirical analysis, we always control for the initial relevance of the distinct types of credit at the bank-firm level. This is possible since we observe *usage* by credit type throughout our sample period, and is important because the initial credit composition may affect the change in the credit commitment volume over time. On average, we observe a reduction in credit commit-

[11] Credit usage may exceed the commitment volume since overdrawing may be possible.

[12] Table 1, panel III contains summary statistics on firms included in our sample, as of 2007. We only have firm-specific data for 74 percent of firms that appear in the sample of credit lines of our main specification for the year 2007. This is because not all firms are required to send their balance sheet to the Austrian Central Bank, and not all remaining firms follow the invitation to send it voluntarily. However, this is a relatively minor issue since we only rely on firm-specific data in one auxiliary regression (see Table 11). Also from a conceptual perspective, the fact that small Austrian firms are therefore underrepresented in our sample is a small problem. The reason is that larger firms have larger credit lines and thereby banks are more likely to undertake active credit line management with large firms, as we show in section 5.3 for details.

[13] We track bank mergers, split-ups, and bank identifier changes for other reasons over time in our analysis; see the Appendix for details.

ments by 4.5 percent over our sample period (see Table 1, panel I). The choice of January 2008 as beginning of our sample period comes at the cost of disregarding potential credit line reductions based on early crisis warning signs in 2007. More importantly, however, by choosing January 2008 as starting date we avoid to pick up the effect of regulatory changes across Basel I and Basel II in our estimations. December 2009 is chosen as the end of our sample period since lending standards and credit volumes continuously tightened from the borrower's perspective until the end of 2009 (see Figure 1) and due to a change in reporting requirements with January 2010 that affected the credit register variables.

For each bank-firm-pair, we compute the ratio of total credit usage and credit commitment volume in January 2008. We then compute the median of this variable across all pairs in our sample, and refer to the commitments that are used less than median as 'little-used credit lines' and to the rest as 'highly-used credit lines'. The computed median equals 0.97, while the mean is 0.84; see Figure 9 for the distribution of the variable. Both the mean and the median are relatively close to one since it is possible and frequently occurs that credit lines are "overdrawn". Among little-used lines, the average ratio of usage to granted credit equals 0.56. From the banks' perspective, the total unused volume of granted credit commitments made up 3.1 percent of assets of the average bank in our sample in January 2008. The average little-used credit line was cut by 9.9 percent between January 2008 and December 2009, while the average highly-used line was increased by one percent.

4 Empirical Strategy

We start our empirical analysis by analyzing the effect of US asset exposure and dependence on interbank funding on a bank's credit line supply during the crisis irrespective of how much credit lines were initially used by the respective firms. As an initial exercise, we also study the differential treatment of little-used credit lines by the *average* bank. To do so, we set up the following specification:

$$\Delta log(CreditLine_{ij}) = \alpha_1 USAssets_j + \alpha_2 Interbank_j + \alpha_3 B_j + \alpha_4 Little\text{-}used_{ij} + \alpha_5 C_{ij} + \eta_i + \epsilon_{ij} \quad (1)$$

$\Delta log(CreditLine_{ij})$ approximates the percentage change in the credit commitment volume offered by bank j to firm i between January 2008 and December 2009. $USAssets_j$ is the bank-specific ratio of US assets to total assets and $Interbank_j$ the bank-specific ratio of international interbank

borrowing to total assets in December 2006. B_j is a vector of bank-level controls that may have affected credit supply during the crisis and are likely to be correlated with US asset exposure and/or dependence on interbank funding. Contrary to equation (1), in later specifications that address our main research questions we will be able to replace this vector with bank fixed effects. B_j includes bank size as measured by log total assets, a bank's liquidity ratio, capital to asset ratio, return on assets, loan write-offs over total assets and CESEE assets over total assets, and are measured at the latest possible time in 2006.[14] All bank-specific variables are scaled by their standard deviation.[15] *Little-used*$_{ij}$ is a bank-firm-specific dummy variable that equals one if the ratio of credit line usage to the granted volume is below the median in our sample. α_4 thus indicates the differential treatment of little-used versus highly-used credit lines by the average bank during the crisis. In our preferred estimation of α_4, we replace our bank-specific variables by bank fixed effects. This allows to control for all confounding factors that affected a specific bank's *change* in credit supply between January 2008 and December 2009.

The vector C_{ij} contains bank-firm-specific variables. These include the share of bank j in total credit usage of firm i, the duration of the credit relationship and a set of dummy variables that indicate the type(s) of credit commitment(s) granted by bank j to firm i. All bank-firm-specific variables are measured in January 2008.[16] We cluster standard errors at the firm and bank level to account for possible serial correlation of errors within these groups.

Importantly, not only supply factors influence a bank's credit line management, but also firm credit demand and creditworthiness. These variables are likely to vary over time, especially across normal and crisis times. We take this into account by restricting our sample to firms that borrowed from

[14] While CESEE assets over total assets is an important control due to the exposure of some Austrian banks to the region, the prior variables are standard in the literature. The liquidity ratio is measured in December 2006 and computed as the ratio of cash and balance with central banks plus loans and advances to governments and credit institutions divided by total assets, following Jiménez et al. (2012). As Iyer et al. (2014) point out, a high liquidity ratio helps to absorb subsequent liquidity shocks. Return on assets (ROA) are measured as net income over average total assets in 2006. ROA and capital over assets, which is measured in December 2006, capture the ability of banks to take risk and absorb losses during a crisis (Cingano et al., 2016). Loan write-offs are the total as of 2006 and capture whether banks were making losses at the onset of the crisis and thus may have been particularly sensitive to shocks during the crisis (Santos, 2010). Total assets are measured in December 2006. The same holds for CESEE assets, which are defined analogously to US Assets but focus on 22 countries in central, eastern and southeastern Europe. See the Appendix for a complete list of included countries.

[15] This standard deviation is measured based on the sample of credit lines, thus banks that granted more credit lines over our sample period obtain a larger weight in the computation.

[16] Relationship duration is censored at 97 months since credit register data are only available to us from January 2000 onwards. Volumes by credit type are only recorded in terms of *usage* rather than the granted amount in the credit register over our sample period. Specifically, total credit usage in a given month is reported both as a sum and as of the following individual components: revolving loan, term loan, titrated loan, leasing loan, special purpose loan, transmitted loan, liability. We include a dummy variable for each of these categories (except revolving loan, which serves as the baseline category) which equals one if the usage of the respective credit line type is greater zero in January 2008.

multiple banks in both January 2008 and December 2009 and including the firm fixed effects η_i into our specification (Khwaja and Mian, 2008). These fixed effects absorb all factors that are specific to the firm and lead to a *change* in its granted credit commitment volume between January 2008 and December 2009.[17] While the omission of single-bank firms results in dropping 50% of firms from our sample, credit commitments to these single-bank firms only made up 17 percent of the total commitment volume in January 2008. This is partly because single-bank firms are smaller and have credit lines that are smaller in volume. The omission of these firms is therefore not a big issue since for a given ratio of credit usage to commitment volume, large credit lines have a greater potential to cause a non-negligible capital ratio reduction and also imply larger liquidity risk.[18] What's more, Figure 10 shows that the distribution of $\Delta log(CreditLine_{ij})$ is not entirely different for single-banks firms compared to multi-bank firms.

Conditional on the inclusion of firm fixed effects, there is one remaining identification assumption that must hold for an unbiased estimation of α_1 and α_2. Specifically, it must be that a firm does not disproportionally demand more or less credit during the crisis from those of its banks that are particularly strongly or weakly exposed to capital and/or liquidity problems during the crisis. This assumption would fail for example if firms first approached their relationship lender for a credit line adjustment, while banks that focus on the business model of relationship lending have higher US exposure or depend more on international interbank funding than the average bank. To test whether such issues might bias our results, we feature a series of robustness checks on our main findings in section 5.3.

4.1 Did constrained banks treat little-used credit lines differently?

We hypothesized that banks whose capital or liquidity position was particularly harmed during the crisis were more sensitive to additional credit line drawdowns. As a consequence, we expect those banks to treat little-used lines differently than other banks. We therefore interact both *US Assets* and *Interbank* with the dummy variable *Little-used*$_{ij}$. The resulting specification looks as follows:

[17] Therefore, they also control for seasonality factors that might affect a firm's change in credit demand between a January and a December.

[18] In section 5.3, we show that large little-used credit lines were cut more than small little-used lines both by capital-constrained and liquidity-constrained banks during the crisis, not only in absolute but also in percentage terms. This supports our argument that small credit lines are less relevant for banks in terms of capital and liquidity management.

$$\Delta log(CreditLine_{ij}) = \beta_1 USAssets_j + \beta_2 Interbank_j$$
$$+\beta_3[USAssets_j \times Little\text{-}used_{ij}] + \beta_4[Interbank_j \times Little\text{-}used_{ij}]$$
$$+\beta_5 Little\text{-}used_{ij} + \beta_6 B_j + \beta_7 C_{ij} + \eta_i + \epsilon_{ij} \quad (2)$$

β_1 indicates the effect of an increase in US asset exposure by one standard deviation on the bank's change in the granted credit line volume of an initially *highly*-used line, while $\beta_1 + \beta_3 + \beta_5$ indicates the effect on an initially *little*-used credit line. If β_3 is statistically significant, then this provides evidence that how differently a given bank treated little- versus highly-used credit lines in its portfolio during the crisis depended on its US asset exposure, and thus arguably its capital position during the crisis. A significant and negative β_3 would thus support our hypothesis that capital concerns affected a bank's credit line management during the crisis.

The interaction terms in equation (2) allow to replace the non-interacted bank variables with bank fixed effects. This has one conceptual disadvantage – which is why we start by estimating equation (2) – but has a key methodological advantage, which is why we also estimate the following specification:

$$\Delta log(CreditLine_{ij}) = \beta_3[USAssets_j \times Little\text{-}used_{ij}]$$
$$+\beta_4[Interbank_j \times Little\text{-}used_{ij}] + \beta_5 Little\text{-}used_{ij} + \beta_7 C_{ij} + \eta_i + \delta_j + \epsilon_{ij} \quad (3)$$

The described advantage is that the bank fixed effects δ_j control for unobserved bank-specific factors that affected the change in credit line supply between January 2008 and December 2009. Intuitively, adding bank fixed effects implies that we analyze how little- versus highly-used credit lines are treated *within* a certain bank. The mentioned cost of including bank fixed effects is that they make it impossible to estimate the *absolute* effects $\beta_1 + \beta_3 + \beta_5$ and $\beta_2 + \beta_4 + \beta_5$. Instead, they only allow the estimation of the *relative* effects $\beta_3 + \beta_5$ and $\beta_4 + \beta_5$. For example, $\beta_3 + \beta_5$ indicates the effect of an increase in US asset exposure by one standard deviation on the change in the granted credit line volume of a little-used line *relative* to a highly-used line.[19]

In order to create a stronger test whether a bank's credit line management during the crisis was influenced by capital considerations, we account for the bank's capital buffer at the onset of the

[19] $\beta_3 + \beta_5$ thus provides less information than $\beta_1 + \beta_3 + \beta_5$; for example, $\beta_3 + \beta_5$ would be negative and significant even if US-exposed banks with a small capital buffer *increased* the granted volume of little-used credit lines in their portfolio during 2008-2009, but increased the supply of highly-used credit lines significantly more. However, if that were the case, then $\beta_1 + \beta_3 + \beta_5$ would be *positive* and thereby reveal that little-used lines were actually increased in an absolute sense.

crisis. We do so by interacting the interaction of *US Assets* and *Little-used* with a variable *Small Buffer* that equals one if the ratio of the bank's regulatory capital over its minimum capital requirement in January 2008 was below the median, which equals 1.62.[20] Our main corresponding specification builds on specification (3) and looks as follows:

$$\begin{aligned}\Delta log(CreditLine_{ij}) = \gamma_1[USAssets_j \times Little\text{-}used_{ij}] \\ +\gamma_2[USAssets_j \times Little\text{-}used_{ij} \times SmallBuffer_j] + \gamma_3[Little\text{-}used_{ij} \times SmallBuffer_j] \\ +\gamma_4[Interbank_j \times Little\text{-}used_{ij}] + \gamma_5 Little\text{-}used_{ij} + \gamma_6 C_{ij} + \eta_i + \delta_j + \epsilon_{ij} \qquad (4)\end{aligned}$$

$\gamma_1 + \gamma_2 + \gamma_3$ indicates the effect of an increase in US asset exposure by one standard deviation on the change in the granted volume of a little-used credit line relative to a highly-used line if the bank had a relatively small capital buffer.

5 Results

The results of estimating equation 1 are reported in Table 2. While in column 1 we omit firm fixed effects to gauge the relevance of selection effects, column 2 shows the results estimated based on the full specification. The results suggest that neither an increase in US asset exposure nor dependence on interbank funding lead to a change in credit supply for the *average* credit line.[21] The coefficient estimates are stable across columns 1 and 2. This speaks against substantial heterogeneity in credit demand or creditworthiness across banks with higher US asset exposure and/or interbank funding dependence and other banks. Our results also show that the average bank significantly cut credit lines that were used relatively little at the onset of the crisis by almost 15 percent compared to highly-used lines. The coefficient estimate is very robust to replacing bank controls with bank fixed effects. These results suggest that the average bank substantially reduced its exposure to little-used credit lines over 2008-09.

[20] We build this median in such a way that it is not the median across banks, but across observations of the sample of our main specification, such that the number of credit lines associated with *Small capital buffer* = 1 is equal to the number of credit lines associated with *Small capital buffer* = 0. Since banks that have a relatively small capital buffer grant more credit lines in our sample, the subsample for which *Small capital buffer* = 1 includes 109 banks, while the subsample for which *Small capital buffer* = 0 includes 204 banks.

[21] The coefficients on our bank-specific control variables are largely intuitive. Banks with a higher capital ratio or larger liquid asset holdings significantly increased credit supply or reduced it less compared to their counterparts. The opposite holds for banks that had suffered more loan write-offs before the crisis and were more exposed to the CESEE region, whose performance was regarded as uncertain by financial markets during the crisis. Larger banks increased credit supply or reduced it by less compared to smaller banks, while a bank's pre-crisis profitability had no impact on its credit supply over 2008-09.

5.1 Little-used credit lines and varying capital and liquidity problems: Differential effects

Since the consequences of additional drawdowns are more severe for banks with a weaker capital position and/or a larger exposure to the liquidity dry-up during the crisis, we expect that those banks reduced exposure to little-used credit lines by even more than the average bank. This hypothesis is the motivation for the introduction of interaction terms in equations (2) and (3). The results on these specifications are reported in Table 3. In columns 1 and 2, we only interact *US Assets* with *Little-used*. This ensures that the coefficient on *Little-used* indicates how little-used credit lines are treated by banks with relatively low US asset exposure, holding other bank characteristics equal. The results in column 1 indicate that banks with an additional US exposure of one standard deviation (and thus about one percent of total assets) indeed significantly cut little-used lines more than other banks, specifically by almost six percent. Overall, these banks significantly cut little-used credit lines by about 12 percent, as can be seen from the marginal effects reported at the bottom of the table.[22] This corresponds to an average reduction of around €1.3 million. The size and significance of the coefficient estimates is robust to controlling for bank fixed effects (see column 2).[23] Since the average ratio of usage to granted volume of credit lines that we define as little-used equals around 56 percent (see Table 1, Panel I), the magnitude of the reduction does not imply acute credit constraints on the *average* holder of a little-used credit line borrowing from a bank with average or even large US exposure even if the firm was fully using all its other credit lines.[24] That said, US-exposed banks reduced liquidity insurance to their firms quite substantially by cutting little-used credit lines during the crisis.

The positive and insignificant coefficient estimate on *US Assets* in column 1 of Table 3 suggests that banks with larger US asset exposure did not significantly cut *highly*-used lines compared to other banks. This reconciles the result of Table 2 that the *average* credit line was not significantly cut by

[22] The magnitude of any given marginal effect is simply the result of adding up the relevant coefficients. In columns 1, 3 and 5, these marginal effects are absolute in the sense explained in section 4: in columns 2, 4 and 6 these effects are relative to highly-used lines.

[23] When controlling for bank fixed effects, the estimated effect of an increase in US asset exposure by one standard deviation on the volume of little-used lines *relative* to highly-used lines equals approximately -14.7% (see the marginal effect displayed in column 2). Note that this reconciles the estimated 'absolute' marginal effect of column 1, which can be seen from subtracting the effect of additional US asset exposure on highly-used lines by the estimated relative marginal effect of column 2: 0.027 - 0.147 - = -0.12. This suggests that the specific magnitude of the estimated 'absolute' effect of additional US asset exposure on the supply of little-used lines is very robust to controlling for bank fixed effects.

[24] The average realization of US Assets / Total Assets in our sample is equal to about one standard deviation of the variable, which implies that the marginal effects at the bottom of Table 3 correspond to the effect on a credit line granted by a bank with average US exposure.

US-exposed or interbank-dependent banks compared to other banks. Our primary interpretation is that highly-used credit lines posed a smaller risk of additional drawdowns and thus a reduction in a bank's capital ratio. Clearly, cutting highly-used lines would free capital and thus directly increase the buffer vis-a-vis the regulatory requirement. However, this would arguably have large costs to the bank. Specifically, it could increase the likelihood of payment defaults and relatedly, the potential imposition of credit constraints on the firm could induce the firm to switch to other banks or sources of credit in the short, medium or long run. The latter might pose a particular danger in a financial system in which relationship lending plays an important role, as is the case in Austria.[25] Last, but not least, it could contractually be more difficult to cut highly-used lines compared to little-used lines.

In columns 3 and 4, we interact *Little-used* only with *Interbank*. Our results show that banks with a one standard deviation larger ratio of international interbank borrowing over total assets significantly cut little-used credit lines by around seven percent more than other banks. This confirms our hypothesis that liquidity-constrained banks are more sensitive to credit line drawdowns and shows that they successfully reduced the risk of further liquidity problems. In columns 5-6, we interact *Little-used* both with *US Assets* and *Interbank*. This makes the interpretation of the non-interacted dummy variable *Little-used* less straightforward, but allows to simultaneously account for both the capital and liquidity channel and trace out their relevance conditional on the other. The coefficient on the interaction term *Interbank* $\times$ *Little-used* is very robust to this modification. However, the coefficient on *US Assets* $\times$ *Little-used* becomes smaller in magnitude and loses statistical significance. While this suggests that high US asset exposure and large dependence on interbank funding often come hand in hand, it may also reflect that US asset market exposure alone may not yet fully reflect a bank's capital concerns during the crisis. Specifically, a bank that suffers capital losses or increased uncertainty due to US asset exposure but went into the crisis with a relatively large capital buffer is better able to absorb those losses and thus may decide to cut little-used lines less or not at all. We test this hypothesis in the next sub-section.

[25] As Table 2 reveals, banks with larger exposure to the CESEE region significantly cut credit commitments compared to banks with smaller CESEE exposure. In order to better understand whether not only US-exposed banks but banks that were affected by the crisis along other measures cut highly-used lines less than little-used lines and thus whether banks avoided imposing credit constraints on their firms, we additionally interact *CESEE Assets* with *Little-used* in equation (3). The results, which are available from the authors upon request, indicate that indeed, CESEE-exposed banks cut highly-used lines by only 2.7 percent (compared to an effect of -5% for the average credit line), and the coefficient is only significant at the 10% level. We further note that our baseline results are largely robust to the inclusion of the additional interaction term.

5.2 Accounting for a bank's initial capital buffer

We distinguish the cross-section of banks along their individual capital buffer and include the variable *Small Buffer* into our empirical analysis, as described in section 4. The results are reported in Table 4. Column 2 estimates specification (4), while column 1 estimates the corresponding specification with bank controls instead of bank fixed effects. The triple interaction of *US Assets* and the dummy variables *Little-used* and *Small capital buffer* is negative and statistically significant in both specifications. This confirms our hypothesis that US-exposed banks with a small capital buffer cut little-used credit lines by significantly more than those with a larger buffer. The marginal effects at the bottom of the table actually indicate that a bank with higher US exposure significantly cut little-used credit lines if and only if it had a relatively small capital buffer. These findings strengthen the interpretation that banks with relatively high US asset exposure cut little-used credit lines in order to avoid (additional) capital problems. The estimate on *Little-used* $\times$ *Small capital buffer* indicates that a bank with relatively little US exposure and a small capital buffer did not significantly cut little-used credit lines by more than a bank with little US exposure but a large capital buffer. This in turn shows that a bank's capital buffer was not the sole driver of our results, but that how a bank's capital position was affected by the crisis played a crucial role as well, as we would expect. These results indicate that a larger capacity to absorb a given loss on a bank's balance sheet directly translates into softer credit supply cuts during a financial crisis.

5.3 Robustness checks

Testing common trends before the crisis

We can only interpret our coefficients as reflecting active credit line management by banks in order to lower capital and liquidity risk during a financial crisis if our key explanatory variables do not affect lending in normal times. In other words, it is necessary that we observe a *common trend* in credit line volume before the crisis across banks whose capital and/or liquidity position was differently affected by the crisis. We test for this common trend by regressing the change in credit line volume granted by bank j to firm i between January 2005 and December 2006 on the right-hand side variables of equation (4). The motivation for choosing this early period and thus disregarding the year 2007 on the left-hand side is to avoid picking up regulatory changes caused by the partial implementation of Basel II in January 2007. The bank-specific regressors are measured at the

same time period as in our main specification to ensure that the "treatment" is equally defined. Bank-firm-specific variables are measured in January 2005. The results are reported in column 1 of Table 5. In order to avoid capturing anticipation effects of the partial implementation of Basel II, we repeat the analysis for the period January 2004 - December 2005 (see column 2). Both specifications contain bank fixed effects. The hypothesis that the lending behavior of "treated" and "non-treated" banks followed the same trend before the crisis cannot be rejected for both time periods; all coefficients and marginal effects are not significantly different from zero.

US Asset holdings and gains and losses over time

While our empirical results suggest the contrary, one might be concerned that the banks in our sample were mostly holding safe US assets whose value was not negatively affected by the crisis, and thereby were not facing larger trouble than other banks during 2008-09. We contrast this concern by showing that higher US asset holdings at the onset of the crisis lead to significantly larger US-related losses over 2008-09. Furthermore, we also find that larger US asset holdings were negatively associated with larger *overall* losses during the crisis. This analysis is based on confidential monthly data on write-offs on loans and net value gains on security holdings and equity shares at the bank level, both US-specific and in general. See Figure 3 for the distribution of the US-specific sum of the mentioned items over time. Importantly, by definition net gains of security holdings and equity shares are not affected by transactions but solely reflect changes in market value.

The dependent variable in the regression framework underlying the mentioned results is the bank-specific sum of net value gains on security holdings and equity shares and write-offs on loans ("net gains" in the following) over the 24 months of 2008 and 2009. The main independent variable is the sum of US securities, equity shares and loans on the bank's balance sheet in December 2006. Variables are measured in Euros rather than in logs because the dependent variable takes both positive and negative values, and US asset exposure equals zero for around 20 percent of the banks in our sample. The results are reported in Table 6. In column 1, we focus on US-specific net gains during the crisis. The coefficient estimate on pre-crisis US asset holdings is negative and significant. In column 3 we show that *before* the crisis, larger US asset holdings in contrast lead to larger US-specific net gains.[26] Column 2 provides evidence that US asset holdings were significantly and negatively correlated with a bank's net gains, controlling for non-US foreign assets. Column 4 show

[26] We choose 2005-2006 as the pre-crisis period since US asset markets experienced a downturn already in 2007. Due to data availability, net total asset value gains in 2005 are computed based on the months June-December, and initial US asset holdings are measured in June 2005.

that there was no such correlation before the crisis.

Accounting for a credit line's size

If banks cut little-used credit lines because they want to avoid a capital ratio reduction or reduce liquidity risk, then it is less effective to cut credit lines that have a small total commitment volume compared to cutting credit lines with a large volume. This might induce banks to cut small credit lines by less, not only in absolute but also in percentage terms. To test whether this holds true, we estimate a version of equation (3) that features interaction terms of our key regressors with a dummy variable *Large Credit Line* that equals one if the line is larger than the median in our sample (see Table 7). The estimated marginal effects at the bottom of the table indicate that banks with relatively high US exposure on average cut credit lines significantly only if they were relatively large. Banks with a relatively large dependence on interbank funding also cut large little-used credit lines by significantly more than small ones. These results are conditional on potential differences in credit demand and creditworthiness across holders of small versus large credit lines, since we include firm fixed effects into our specification. Furthermore, as always we control for the strength of the bank-firm relationship, which may be correlated with the size of the firm and granted credit lines as well as how credit lines are treated by the bank in crisis times. Our evidence thus strengthens our interpretation that banks cut little-used credit lines to limit capital or liquidity concerns during the crisis.

Bank-firm-specific credit demand

The success of Khwaja-Mian fixed effects to control for firm-specific credit demand effects hinges on an assumption. Specifically, it is necessary that during the crisis a firm did not disproportionally demand more or less credit from those of its banks with particularly high or low US asset exposure or dependence on interbank funding, or those of its banks with which its usage-to-granted credit volume at the onset of the crisis was relatively low. While this is not impossible, it is important to realize that the type of bank-firm credit demand that would lead to a bias in our setting is firms asking their bank to change the *granted volume* rather than choosing to simply change their actual credit *usage* level. Since credit lines provide insurance for firms in terms of funding, a firm's (first) reaction to a reduced need for credit is arguably the latter rather than the prior, but nevertheless we estimate four robustness checks on the results of Table 4 to address such concerns. Our first check addresses the potential worry that firms that face low credit demand during the crisis sys-

tematically ask those banks with which in January 2008 they had a relatively little-used credit line for a reduction in the granted credit line volume, rather than another bank with which it had a highly-used line. Specifically, we estimate a specification that is conceptually similar to equation 2 but only features little-used credit lines, such that the dummy *Little-Used* – and therefore also bank fixed effects – are omitted. The results are displayed in column 2 of Table 8; in column 1 we repeat the results of column 1 of Table 4, but the coefficients are not directly comparable across rows. While the results in column 2 are estimated on a smaller and different sample compared to column 1 and the marginal effects do differ, the coefficient on our main variable of interest *US Assets* × *Small Capital Buffer* (which relates to *US Assets* × *Little-Used* × *Small Capital Buffer* in column 1) remains negative and statistically significant. Since bank-firm-specific credit demand in the fashion of above is absent here, this corroborates that banks that are exposed to the US *and* have a small capital buffer cut little-used credit lines more than other banks cut little-used lines. Regarding interbank dependency, we note that the coefficient turns insignificant in this robustness specification, which makes us less confident about the liquidity channel.

In the following two checks, which we perform in columns 2 and 3 of Table 9, respectively, we return to our main specification but compare credit supply in bank relationships that are relatively similar to each other in a given firm and thus might be characterized by more similar firm demand patterns during the crisis. In the first check (column 2), this boils down to not only estimating our coefficients "within the firm", but also within types of credit, specifically revolving credit lines and other types of credit commitments.[27] This is done by adding interaction terms of the firm fixed effects and a dummy which takes the value one if a positive fraction of the credit line was used as a *revolving* credit line in January 2008. Along similar lines, in our third check we estimate equation 4 within the banks of a firm that appear relatively important and within the banks that are relatively unimportant. This is achieved by including an interaction of the firm fixed effects with a dummy that equals one if the pre-crisis share of bank j in the firm's total credit line usage is above the median; see column 3 for the results. Despite losing a fair degree of statistical power, our results are robust to both checks.

Our fourth robustness check addresses the concern that bank-firm-specific credit demand arises because firms that export to the United States borrow from banks with larger US asset exposure.

[27] A revolving credit line is a credit commitment that the firm can use over and over again after it has repaid the outstanding debt. We only know which fraction of the total credit line is *used*, i.e. drawn down, as a revolving credit line. The same holds for other specific loan types. We do not know the specific *supply* structure of the bank in terms of the different types of credit. For this reason, we define the revolving credit dummy in terms of usage.

These firms might finance their US operations, for example the acquisition of inputs from U.S. firms, primarily via its US-exposed bank. If the firm experiences a downturn in export demand from the United States, then it might ask the US-exposed bank for a reduction in its credit line volume to reduce commitment fee payments, but not ask other banks for a reduction. If this pattern were present in our sample, then our coefficient estimates would be contaminated by demand effects. Ideally, we would test this issue by excluding firms that export to the US, or firms that export in general. Since we do not have any information on the export activity of our firms we instead restrict our sample to those firms that belong to sectors that are generally regarded as non-traded.[28] Information on a firm's sector is available for all firms for which we have balance sheet information, and thus about 80 percent of firms.[29] The results of this robustness check are reported in column 4 of Table 9. Interestingly, the coefficients on the average non-traded firm are *larger* in magnitude than the effects on the average firm, which speaks against the described concern.

Alternative measures of the dummy-variable Little-Used

In column 5 of Table 9, we define little-used credit lines as those for which the usage-to-granted volume ratio is smaller than the 33^{rd} percentile of this ratio in our baseline sample, which equals 0.78. Highly-used lines are defined as those with a ratio larger than the 66^{th} percentile, which is equal to one. The absolute value of the coefficient on our main interaction term of interest is larger than for our baseline (median) definition (compare column 2). In column 6, we use the 25^{th} percentile (=0.633) and 75^{th} percentile (again =1) to define *Little-Used*, and again the coefficient is larger. These results strengthen our interpretation that little-used lines are cut because they pose a threat to the capital buffer of (some) banks.

Timing of measurement of capital buffer

In our baseline specification, we measure the capital buffer at the end of the first quarter of 2008, in order to capture a bank's capital buffer given Basel II regulations. In column 7 of Table 9, we time the measurement at the end of the last quarter of 2006, in order to parallel the timing of our

[28] These include: energy supply; water supply and waste management; construction; traffic and storage; hotels and restaurants; other services; education; health and social services; arts, entertainment and leisure; professional, scientific and technical activities; public administration; private households. The excluded traded sectors are: agriculture; mining; manufacturing; car trade and repair; information and communication; financial services; other economic services.

[29] Firm balance sheet and income statement data are obtained from firms that are either required to send this information to the Austrian Central Bank every year or voluntarily share it. We have at least one balance sheet over the period 2000-2009 for about 80% of the firms we observe in the credit register over our sample period.

other bank-specific variables. The results are very robust to this modification.

Robustness checks related to the nature of our dependent variable

As we discussed in Section 3, our dependent variable subsumes different types of credit commitments, not only revolving credit lines. This must not be an issue since all commitment types may have a usage-to-granted volume ratio of below one, and conditional on the original maturity and bank-specific ability to revoke the particular commitment, credit conversion factors do not depend on the type of commitment. Furthermore, in our baseline specification we somewhat account for the bank-firm-specific credit commitment structure via controlling for the composition of credit usage. Nevertheless, one may for instance worry that our results reflect that highly-used lines (for which the usage-to-granted volume ratio is often larger than one) are simply harder to cut, for example because they include more term loans which are irrevocable, and thus can also not be reduced in volume. While this does not endanger our interpretation that banks cut little-used lines in order to "protect" their capital buffer, we estimate two specifications to address such types of concerns. In column 2 of Table 10, we only include credit commitments with a drawn-to-granted volume ratio below one, define little-used lines based on the resulting sample using our baseline "median-criterion" and re-run our baseline analysis with this alternative sample.[30] In column 3, we do the same but only include those commitments which do not include a term loan at all (in terms of usage) and do include a revolving credit line.[31] For both samples, which are within themselves more homogeneous in different dimensions, the coefficient on the interaction term *US Assets* × *Little-Used* × *Small capital buffer* and the corresponding marginal effect remain negative and statistically significant, which is reassuring. We note however that the interactions with *International Interbank Borrowing* turn insignificant.

5.4 Graphical Analysis

To complement our regression analysis, we plot the development of granted credit volumes and usage levels over our sample period across different types of banks. While this graphical analysis clearly cannot take heterogeneity in credit demand across borrowers of different banks into account,

[30] The average usage-to-granted volume ratio in this sample equals 0.606, while the average among little-used lines equals 0.328 and the average across highly-used lines equals 0.885.

[31] The average usage-to-granted volume ratio in this sample equals 0.737, while the average among little-used lines equals 0.398 and the average across highly-used lines equals 1.07.

it helps to get a better sense of the time dimension of the effect of the crisis on bank credit (see Figure 11). The top-left graph shows that the sum of all types of credit commitments across all banks hardly changed between January 2008 and December 2009. In turn, the sum of credit usage increased slightly, which is consistent with an increased likelihood of drawdowns during periods of financial distress. While the magnitude does not parallel the U.S. experience (Ivashina and Scharfstein, 2010), this does not rule out that banks were ex ante concerned about substantial drawdowns. The graphs on the top right and bottom right of the figure show that banks with an above-median US exposure and interbank funding dependence, respectively, did cut little-used credit lines between January 2008 and December 2009, consistent with our regression results. Interestingly, cuts occurred especially after the Lehman default in September 2008. Since it is unlikely that firms of US-exposed or interbank funding-dependent banks had lower credit demand exactly at that time and usage levels are roughly constant around September 2008, this was arguably a direct supply response to the Lehman default and its effect on global financial markets. The bottom-left graph shows that especially those US-exposed banks with a small capital buffer cut little-used lines between January 2008 and September 2009. What's more, we see a sharper reduction after the Lehman default in September 2008 for these banks compared to otherwise similar banks with an average capital buffer. Combined with the fact that the largest US-related losses occurred in September 2008 (see Figure 3), this graphical evidence thus provides further (suggestive) evidence that capital concerns played a crucial role in the credit line management of banks during the crisis.

5.5 Pre-crisis risk management

The results of Ippolito et al. (2016) suggest that banks that foresee to be more exposed to liquidity problems during periods of financial distress grant credit lines to those firms that are less likely to increase drawdowns in such times. This evidence complements the findings of our study as it suggests that banks do not only manage the risk of drawdowns during a crisis, but also before. Since we have confidential data on how banks assess the probability of default of their client firms, we are able to test this hypothesis of Ippolito et al. (2016) in a novel way. The underlying assumption is that firms with a larger probability of default have less alternative sources of funding and may also require larger additional funds during financial distress, and therefore increase credit line drawdowns more than other firms during a financial crisis. Based on this reasoning, we regress our dummy variable *Little-used* on a firm's probability of default measured as the average assessment

by its banks at the earliest available month in 2008. The results are reported in Table 11. In column 1, we estimate a simple linear probability model, while in column 2, we estimate a logit model. Both specifications include firm-specific controls, in particular log assets, return on assets, sales over assets, cash holdings over assets and capital holdings over assets. The results of both specifications reveal that the firms that used their credit line less than median in January 2008 had a significantly lower probability of default, according to their lenders. If our assumptions hold, then this confirms that banks managed the risk of runs on credit lines already before (the peak of) the crisis, and thus tried to keep the risk associated with credit commitment fees as source of revenues relatively low. In this sense, our results therefore confirm those of Ippolito et al. (2016). Further, they are in line with Sufi (2009), who shows that firms need a certain credit rating and visibility in the market to be granted a credit line in the first place.

6 Conclusion

In this paper, we shed light on a novel channel through which bank capital regulations affect lending to the real economy in crisis times. We departed by highlighting that exposure to undrawn credit lines may put a bank's regulatory capital buffer at risk, since additional credit line drawdowns increase the size of the bank's balance sheet. This is particularly problematic during periods of financial distress, since the capital position of banks is then typically weakened, raising capital is more costly and credit line drawdowns are more likely. We then showed that banks whose capital position was hit relatively hard during the 2008-09 financial crisis and whose initial capital buffer was low reduced the risk of additional drawdowns by substantially cutting the volume of little-used corporate credit lines over 2008-09. While this is good news from the perspective of banking system stability, it implies a reduction of liquidity provision and insurance to firms exactly at a time in which they need it most. Our results therefore provide an additional rationale for the regulator's quest to strengthen bank capital buffers. What's more, our findings justify the higher capital charge on the unused portion of most credit commitment types in Basel III, and may call for a further increase. This is because a higher capital charge makes banks more reluctant ex ante to grant excessively high credit line volumes that cannot be sustained during crisis times. This limits liquidity risk transfers from banks to firms and reduces the potential impact of runs on unused credit lines on banks in periods of financial distress.

As a second contribution, we showed that also larger liquidity problems induced banks to substantially cut little-used credit lines over 2008-09, controlling for a bank's capital position. The introduction of the Liquidity Coverage Ratio (LCR) in Basel III may weaken such effects in periods of financial distress and thereby increase future financial stability, similar as the higher capital charge on unused credit commitments.

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Tables

Table 1: Descriptive Statistics

	Mean	Median	Min	Max	sd	N
I: Bank-Firm Variables						
Δ Log Credit Line	-0.045	-0.051	-8.569	7.110	0.723	8419
... if Little-used	-0.099	-0.046	-8.569	4.299	0.693	4209
... if Highly-used	0.010	-0.055	-7.357	7.110	0.749	4210
Credit Line Usage/Granted Volume	0.843	0.970	0	1.988	0.423	8419
... if Little-used	0.557	0.633	0	0.970	0.322	4209
... if Highly-used	1.129	1	0.970	1.988	0.299	4210
Share of Bank in Total Credit Line Usage	0.288	0.206	0	1	0.271	8419
Relationship Duration in months (max=97)	65.051	74	1	97	33.587	8419
Revolving Loan	0.393	0	0	1	0.488	8419
Term Loan	0.679	1	0	1	0.467	8419
Titrated Loan	0.023	0	0	1	0.151	8419
Liability	0.358	0	0	1	0.479	8419
Transmitted Loan	0.053	0	0	1	0.225	8419
Leasing Loan	0.010	0	0	1	0.102	8419
Special Purpose Loan	0.017	0	0	1	0.127	8419
II: Bank Variables (weighted based on freq. in sample)						
US Assets / Total Assets 2006:12	0.010	0.007	0	0.055	0.010	313
Int'l Interbank Borrowing / Total Assets 2006:12	0.093	0.063	0	0.748	0.093	313
Capital / Total Assets 2006:12	0.085	0.088	0.017	0.995	0.038	313
Liquid Assets / Total Assets 2006:12	0.214	0.203	0.004	0.946	0.120	313
Total Assets (bn. euros) 2006:12	32.088	9.907	0.034	129.920	45.012	313
Return on Assets 2006	0.005	0.004	-0.031	0.061	0.003	313
Loan Write-offs / Total Assets 2006	0.000	0.000	0	0.042	0.002	313
CESEE Assets / Total Assets 2006:12	0.075	0.044	0	0.807	0.106	313
Tier 1&2 Capital / Capital Requirement 2008:Q1	1.814	1.617	1.099	26.120	0.636	313
US Assets / Tier 1&2 Capital 2006:Q4	0.142	0.099	0	1.412	0.171	313
US Assets / Tier 1&2 Capital Buffer 2006:Q4	0.472	0.228	0	5.754	0.653	313
Required capital rise if full drawdowns 2008:01	0.058	0.043	-0.133	1.053	0.105	313
Net US Value Gains 2008-09 / Cap. Buffer 2008:Q1	-0.020	0	-0.413	0.214	0.078	313
Net US Value Gains 2008:Sep / Cap. Buffer 2008:Q1	-0.042	-0.003	-0.470	0.007	0.085	313
% Fall in capital buffer if full drawdowns 2008:01	-0.148	-0.053	-1.312	0.120	0.237	313
III: Firm Variables (weighted based on freq. in sample)						
Number of Banks	5.471	3	2	38	5.802	2558
Total Assets (mn. euros)	282.7	43.4	0.9	18243.7	1080.9	1909
Employment	378.6	89	1	27241	1459.4	1909
Return on Assets	0.082	0.044	-2.683	0.855	0.173	1909
Cash holdings / Assets	0.044	0.015	0	0.786	0.078	1909
Capital / Assets	0.287	0.268	-1.854	0.999	0.2117	1909
Probability of Default	0.026	0.005	0	1	0.103	1321

This table provides descriptive statistics on the bank-firm and bank variables used in our specifications, as well as firm-level statistics. Δ *Log Credit Line* is the change between 2008:01 and 2009:12; the other bank-firm-specific variables are measured in January 2008. *Relationship Duration in months* is censored at 97 months since we only have data from January 2000 onwards. *Revolving Loan* is a dummy variable that equals one if the total credit commitment by the specific bank in January 2008 includes a revolving credit line. The variables that are listed below *Revolving Loan* in panel I are conceptually defined in the same way. *Net US Value Gains 2008-09* equals the sum of monthly net US asset value gains caused by changes in market values and loan write-offs in the 24 months of 2008 and 2009. *Required capital rise if full drawdowns 2008:01* and *% Fall in capital buffer if full drawdowns 2008:01* are based on our incomplete coverage of credit lines and, within our sample, an upper bound as it assumes that all observed credit lines are revocable. The corresponding lower bound is half of the indicated values, and holds under the assumption that all credit lines are irrevocable and have an original maturity of more than one year. See Section 3 for details. Firm-specific variables are measured as of 2007, apart from *Number of Banks* (2008:01) and *Probability of Default* (earliest available moment in 2008). The latter variable corresponds to the average assessment across banks that lend to the firm.

Table 2: Determinants of credit line supply

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12		
	(1)	(2)	(3)
US Assets	0.004	0.004	
	(0.011)	(0.011)	
Int'l Interbank Borrowing	-0.000	-0.003	
	(0.022)	(0.022)	
Little-used	-0.122***	-0.147***	-0.146***
	(0.024)	(0.028)	(0.030)
Capital	0.037**	0.034***	
	(0.018)	(0.013)	
Liquid assets	0.022	0.024*	
	(0.014)	(0.013)	
Log assets	0.049*	0.071***	
	(0.029)	(0.020)	
CESEE Assets	-0.050***	-0.047**	
	(0.018)	(0.018)	
Return on Assets	-0.004	0.015	
	(0.014)	(0.011)	
Loan Write-Offs	-0.015***	-0.010**	
	(0.005)	(0.005)	
Bank-Firm Controls	Yes	Yes	Yes
Firm FE	No	Yes	Yes
Observations	8429	8419	8520
# Banks	313	313	295
# Firms	2570	2560	2567
adj. R^2	0.013	0.115	0.100

This table shows the results of estimating equation 1. The dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample consists of credit lines (bank-firm pairs) to firms that borrowed from at least two banks in those two months. Bank-specific variables are measured at the latest possible time in 2006. *US Assets* is defined as the sum of securities and shares acquired from counterparties located in the United States and loans to US customers – in whichever currency – divided by the bank's total amount of securities, shares and loans. *Capital* is the ratio of bank capital to total assets; *Liquid Assets* stands for the ratio of cash and balance with central banks and loans and advances to governments and credit institutions to total assets; *Return on Assets* equals net income divided by the average total assets in 2006. *CESEE Assets* is defined analogously to *US Assets*, but focuses on 22 countries in central, eastern and southeastern Europe. All bank variables are scaled by their individual standard deviation in our sample (see Table 1). *Little-used* equals one if the bank-firm-specific ratio of usage to the granted amount is smaller than the median in our sample. *Bank-Firm Controls* are measured in January 2008 and include the ratio of the credit line usage from bank j over the total usage of firm i, the duration of the bank-firm relationship and a set of dummy variables that indicate the types of credit granted by bank j to firm i in January 2008. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 3: Treatment of little-used lines by capital- and liquidity-constrained banks

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12					
	Only US	Only US	Only IB	Only IB	US & IB	US & IB
	(1)	(2)	(3)	(4)	(5)	(6)
US Assets	0.027		0.003		0.013	
	(0.017)		(0.011)		(0.015)	
Int'l Interbank Borrowing	0.000		0.030		0.024	
	(0.022)		(0.023)		(0.022)	
Little-used	-0.088***	-0.085**	-0.077***	-0.076***	-0.067**	-0.063*
	(0.030)	(0.035)	(0.026)	(0.028)	(0.030)	(0.034)
US Assets × Little-used	-0.059**	-0.063**			-0.025	-0.028
	(0.025)	(0.027)			(0.025)	(0.027)
Int'l Interbank Borrowing × Little-used			-0.072***	-0.071***	-0.056**	-0.055**
			(0.024)	(0.023)	(0.025)	(0.023)
Bank Controls	Yes	No	Yes	No	Yes	No
Bank-Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	No	Yes	No	Yes	No	Yes
Observations	8419	8427	8419	8427	8419	8427
# Banks	313	290	313	290	313	290
# Firms	2560	2558	2560	2558	2560	2558
adj. R^2	0.117	0.102	0.118	0.103	0.118	0.103
Marginal Effect (columns 1,3,5: absolute; col. 2,4,6: relative to highly-used credit lines)						
...of US asset exposure on little-used credit lines	-0.120***	-0.147***			-0.079***	-0.091***
	(0.025)	(0.025)			(0.027)	(0.029)
...of interbank dependence on little-used credit lines			-0.119***	-0.147***	-0.099**	-0.118***
			(0.033)	(0.024)	(0.042)	(0.037)

This table presents the results of estimating equation 2 (columns 1,3,5) and 3 (columns 2,4,6). The dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample consists of credit lines to firms that borrowed from at least two banks in those two months. Bank-specific variables are measured at the latest possible time in 2006. Bank-firm-specific variables are measured in January 2008. See Table 2 for a description of independent variables. In columns 1-2 we interact *Little-used* only with US asset exposure, in columns 3-4 only with dependence on interbank funding and in columns 5-6 with both. *Bank Controls* includes all remaining bank-specific variables from Tables 2. The marginal effects at the bottom of the table display the sum of the coefficients of the respective bank variable and its interaction with *Little-used*. In columns 1,3,5 this marginal effect is absolute in the sense that the coefficient compares to a bank with less US asset exposure or interbank dependence, respectively. In column 2,4,6 we only obtain this effect relative to highly-used credit lines. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 4: Accounting for a bank's capital buffer

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12	
	(1)	(2)
US Assets	0.025	
	(0.023)	
Int'l Interbank Borrowing	0.033	
	(0.025)	
US Assets × Little-used	0.076**	0.060*
	(0.036)	(0.036)
US Assets × Little-used × Small capital buffer	-0.124***	-0.107**
	(0.043)	(0.045)
US Assets × Small capital buffer	-0.017	
	(0.028)	
Int'l Interbank Borrowing × Little-used	-0.098***	-0.095***
	(0.026)	(0.026)
Little-used	-0.110***	-0.099**
	(0.039)	(0.042)
Small capital buffer	-0.018	
	(0.040)	
Little-used × Small capital buffer	0.092*	0.078
	(0.050)	(0.057)
Bank Controls	Yes	No
Bank-Firm Controls	Yes	Yes
Firm FE	Yes	Yes
Bank FE	No	Yes
Observations	8419	8379
# Banks	313	284
# Firms	2560	2549
adj. R^2	0.121	0.107
Marginal Effect (column 1: absolute; col.2: relative to highly-used lines)		
...of US exposure on highly-used credit lines if small capital buffer	-0.010	
	(0.036)	
...of US exposure on little-used credit lines if large capital buffer	-0.034	-0.039
	(0.035)	(0.037)
...of US exposure on little-used credit lines if small capital buffer	-0.075**	-0.068**
	(0.037)	(0.034)
...of interbank dependence on little-used credit lines	-0.174***	-0.194***
	(0.047)	(0.048)

This table shows the results of estimating equation 4 (see column 2) and the corresponding specification without bank fixed effects (see column 1). The specifications extend the analysis of Table 3 by controlling for the size of a bank's capital buffer. The dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample consists of credit lines to firms that borrowed from at least two banks in those two months. Bank-specific variables are measured at the latest possible time in 2006, apart from the bank's capital buffer, which is measured at the end of the first quarter of 2008. Bank-firm-specific variables are measured in January 2008. We compute the size of a bank's capital buffer as the ratio of Tier 1 & Tier 2 capital and the amount of capital the bank is required to hold to meet its regulatory capital requirement. *Small capital buffer* is a dummy variable that equals one if this ratio is smaller than the median across our sample and zero otherwise. See Table 3 for a description of the other independent variables. The marginal effects at the bottom of the table are the result of adding up the relevant coefficients for the respective groups of credit lines and/or banks. In column 1, this marginal effect is absolute in the sense that the coefficient compares to a bank with less US asset exposure or dependence on interbank funding, respectively. In column 2, we only obtain this effect relative to highly-used credit lines. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 5: Placebo tests

Dependent variable	$\Delta Credit\ Line_{ij}$ 2005:01 - 2006:12	$\Delta Credit\ Line_{ij}$ 2004:01 - 2005:12
	(1)	(2)
US Assets × Little-used	0.006	-0.025
	(0.037)	(0.038)
US Assets × Little-used × Small capital buffer	-0.007	0.014
	(0.037)	(0.038)
Little-used	-0.024	-0.011
	(0.037)	(0.037)
Little-used × Small capital buffer	-0.014	-0.028
	(0.053)	(0.055)
Int'l Interbank Borrowing × Little-used	-0.034	-0.011
	(0.027)	(0.025)
Observations	8236	8023
# Banks	297	275
# Firms	2415	2369
Marginal Effect (relative to highly-used credit lines)		
...of US exposure on little-used credit lines if large capital buffer	-0.018	-0.035
	(0.037)	(0.037)
...of US exposure on little-used credit lines if small capital buffer	-0.039	-0.049
	(-0.037)	(0.037)
...of interbank dependence on little-used credit lines	-0.058	-0.022
	(0.046)	(0.042)

In this table, we show the results of two placebo tests on the results of Table 4, column 2. In column 1, the dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2005 and December 2006. In column 2, we focus on the period January 2004 - December 2005. The sample consists of credit lines to firms that borrowed from at least two banks in the respective two months. Bank-specific variables are measured at the latest possible time in 2006, apart from the bank's capital buffer, which is measured at the end of the first quarter of 2008. Both specifications contain bank-firm controls, firm fixed effects and bank fixed effects. Bank-firm-specific variables are all measured in January 2005 (column 1) or January 2004 (column 2). See Tables 3 and 4 for a description of the independent variables. The marginal effects at the bottom of the table are the result of adding up the relevant coefficients for the respective groups of credit lines and/or banks. These effects are relative to highly-used credit lines. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 6: US assets and gains and losses around the crisis

	Net US Asset Value Gains 2008-09	Net Total Asset Value Gains 2008-09	Net US Asset Value Gains 2005-06	Net Total Asset Value Gains 2005-06
	(1)	(2)	(3)	(4)
US Assets 2006:12	-0.0158***	-0.717***		
	(0.003)	(0.187)		
Non-US Foreign Assets 2006:12		-0.0275***		
		(0.008)		
US Assets 2005:06			0.0112***	-0.109
			(0.000)	(0.105)
Non-US Foreign Assets 2005:06				0.0217***
				(0.004)
N	347	347	366	366
adj. R^2	0.056	0.584	0.602	0.379

In this table we analyze the relationship between pre-crisis US asset holdings (independent variable) and net asset value gains during and before the crisis (dependent variable) at the bank level. In columns 1 and 3, the dependent variable is the net total asset value gains incurred by a bank due to changes in the market value of US securities and equity share holdings and/or write-offs of loans to US clients. In columns 2 and 4, we extend the scope beyond the US to all countries. In columns 1 and 2, we focus on net gains over 2008-2009, in columns 3 and 4 on net gains over 2005-2006. For the latter period, we only have data from June 2005 onwards. *US Assets* equals the sum of US securities, equity shares and loans on the bank's balance sheet, in whichever currency. *Non-US Foreign Assets* equals the sum of a bank's non-US, non-Austrian assets. Both the dependent and independent variables are measured in Euros. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 7: Accounting for the size of a credit line

Dependent variable: $\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12

	(1)
US Assets × Little-used	-0.007
	(0.040)
Int'l Interbank Borrowing × Little-used	-0.091***
	(0.031)
Little-used	0.001
	(0.045)
US Assets × Large Credit Line	0.005
	(0.032)
Int'l Interbank Borrowing × Large Credit Line	-0.121***
	(0.033)
US Assets × Little-used × Large Credit Line	-0.031
	(0.042)
Int'l Interbank Borrowing × Little-used × Large Credit Line	0.062*
	(0.035)
Little-used × Large Credit Line	-0.041
	(0.061)
Large Credit Line	-0.118***
	(0.042)
Bank-Firm Controls	Yes
Firm FE	Yes
Bank FE	Yes
Observations	8427
# Banks	290
# Firms	2558
adj. R^2	0.120
Marginal Effect (relative to highly-used credit lines)	
...of US asset exposure on little-used SMALL credit lines	-0.006
	(0.038)
...of interbank dependence on little-used SMALL credit lines	-0.090*
	(0.047)
...of US asset exposure on little-used LARGE credit lines	-0.192***
	(0.041)
...of interbank dependence on little-used LARGE credit lines	-0.308***
	(0.050)

This table shows a robustness check on the findings displayed in Table 3. Specifically, we take the size of a credit line, measured by its volume in January 2008, into account. The dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample consists of credit lines to firms that borrowed from at least two banks in those two months. Bank-specific variables are measured at the latest possible time in 2006, apart from a bank's capital buffer, which is measured as of the end of the first quarter of 2008. *Large Credit Line* equals one if the credit line is larger than the median credit line in our sample. See Tables 2 and 4 for a description of the other independent variables. The marginal effects at the bottom of the table are the result of adding up the relevant coefficients for the respective groups of credit lines and/or banks. These effects are relative to highly-used credit lines. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 8: Robustness Checks I

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12	
	(1)	(2)
US Assets	0.025	0.133***
	(0.023)	(0.033)
Int'l Interbank Borrowing	0.033	-0.013
	(0.025)	(0.033)
US Assets × Little-used	0.076**	
	(0.036)	
US Assets × Little-used × Small capital buffer	-0.124***	
	(0.043)	
US Assets × Small capital buffer	-0.017	-0.159***
	(0.028)	(0.040)
Int'l Interbank Borrowing × Little-used	-0.098***	
	(0.026)	
Little-used	-0.110***	
	(0.039)	
Small capital buffer	-0.018	0.101**
	(0.040)	(0.045)
Little-used × Small capital buffer	0.092*	
	(0.050)	
Bank Controls	Yes	Yes
Bank-Firm Controls	Yes	Yes
Firm FE	Yes	Yes
Bank FE	No	No
Observations	8419	3365
# Banks	313	258
# Firms	2560	1245
adj. R^2	0.121	0.113
Marginal Effect		
...of US exposure on highly-used credit lines if small capital buffer	-0.010	
	(0.036)	
...of US exposure on little-used credit lines if large capital buffer	-0.034	0.133***
	(0.035)	(0.033)
...of US exposure on little-used credit lines if small capital buffer	-0.075**	0.075*
	(0.037)	(0.040)
...of interbank dependence on little-used credit lines	-0.174***	-0.013
	(0.047)	(0.033)

This table provides a robustness check on the results displayed in column 1 of Table 4, which are displayed again for convenience. The dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample in column 2 consists of *little-used* credit lines to firms that borrowed from at least two banks in those two months. See Table 3 and Table 4 for a description of the independent variables. The marginal effects at the bottom of the table are the result of adding up the relevant coefficients for the respective groups of credit lines and/or banks. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 9: Robustness Checks II

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12						
	Base-line	Firm × CL Type FE	Firm × CL Weight FE	Non-traded Firms	Alt-Def I Little-Used	Alt-Def II Little-Used	Cap.Buffer measured in 06Q4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
US Assets × Little-used	0.060*	0.064	0.044	0.138**	0.079	0.103	0.052
	(0.036)	(0.044)	(0.040)	(0.059)	(0.049)	(0.066)	(0.038)
US Assets × Little-used × Small capital buffer	-0.107**	-0.104*	-0.099*	-0.188***	-0.129**	-0.157**	-0.095*
	(0.045)	(0.058)	(0.051)	(0.070)	(0.055)	(0.069)	(0.049)
Little-used	-0.099**	-0.114**	-0.109**	-0.226**	-0.216***	-0.271***	-0.097**
	(0.042)	(0.049)	(0.052)	(0.099)	(0.060)	(0.072)	(0.049)
Little-used × Small capital buffer	0.078	0.087	0.050	0.134	0.117	0.137	0.061
	(0.057)	(0.069)	(0.072)	(0.123)	(0.078)	(0.095)	(0.061)
Int'l Interbank Borrowing × Little-used	-0.095***	-0.099***	-0.073**	-0.083*	-0.115***	-0.123***	-0.089***
	(0.026)	(0.033)	(0.034)	(0.048)	(0.034)	(0.043)	(0.026)
Observations	8379	6925	6890	2417	5775	4922	8379
# Banks	290	269	269	162	262	247	284
# Firms	2558	2013	1970	764	1862	1604	2549
adj. R^2	0.107	0.009	0.048	0.065	0.075	0.069	0.107
Marginal effect (relative to highly-used credit lines)...							
...of US exposure on little-used credit lines if large capital buffer	-0.039	-0.050	-0.065	-0.092	-0.138***	-0.168***	-0.046
	(0.037)	(0.047)	(0.050)	(0.103)	(0.049)	(0.064)	(0.036)
...of US exposure on little-used credit lines if small capital buffer	-0.068**	-0.067*	-0.113**	-0.142*	-0.150***	-0.187***	-0.080**
	(0.034)	(0.039)	(0.046)	(0.075)	(0.055)	(0.070)	(0.033)
...of interbank dependence on little-used credit lines	-0.194***	-0.212***	-0.182***	-0.309***	-0.331***	-0.394***	-0.187***
	(0.048)	(0.057)	(0.054)	(0.102)	(0.067)	(0.085)	(0.054)

This table shows robustness checks on the findings displayed in Table 4. The dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample consists of credit lines to firms that borrowed from at least two banks in those two months. Bank-specific variables are measured at the latest possible time in 2006, apart from the bank's capital buffer, which is measured at the end of the first quarter of 2008, same as in Table 4. All specifications contain bank-firm controls, firm fixed effects and bank fixed effects. See Tables 2 and 4 for a description of the independent variables. For convenience, column 1 displays our main results, i.e. those of Table 4, column 2. In column 2, we add interaction terms of the firm fixed effects and a dummy variable that equals one if the bank was granting a revolving credit line to the firm in January 2008. In column 3, we add interaction terms of the firm fixed effects and a dummy that equals one if the share of the bank in the firm's total credit line usage is larger than the median. In column 4, we restrict our sample to firms in non-traded sectors. In column 5 we define little-used credit lines as those for which usage divided by the granted volume is below the 33rd percentile (which equals 0.78) in our sample, and highly-used as those for which the ratio is larger than or equal to the 66th percentile (=1). In column 6 we do the same for the 25th percentile (=0.633) and 75th percentile (=1 again). In column 7 we time the measurement of a bank's capital buffer at Q4:2006 instead of Q1:2008. The marginal effects at the bottom of the table are the result of adding up the relevant coefficients for the respective groups of credit lines and/or banks. These effects are relative to highly-used credit lines. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 10: Robustness Checks III

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12		
	(1)	(2)	(3)
US Assets × Little-used	0.060*	0.192***	0.091
	(0.036)	(0.056)	(0.133)
US Assets × Little-used × Small capital buffer	-0.107**	-0.223***	-0.146**
	(0.045)	(0.058)	(0.072)
Int'l Interbank Borrowing × Little-used	-0.095***	-0.032	0.024
	(0.026)	(0.042)	(0.064)
Little-used	-0.099**	-0.294***	-0.447**
	(0.042)	(0.060)	(0.184)
Little-used × Small capital buffer	0.078	0.194**	0.187
	(0.057)	(0.075)	(0.235)
Bank Controls	No	No	No
Bank-Firm Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Observations	8379	3897	511
# Banks	284	207	60
# Firms	2549	1395	218
adj. R^2	0.107	0.104	0.238
Marginal Effect (relative to highly-used lines)			
...of US exposure on little-used credit lines if large capital buffer	-0.039	-0.101	-0.356***
	(0.037)	(0.062)	(0.100)
...of US exposure on little-used credit lines if small capital buffer	-0.068**	-0.131**	-0.314*
	(0.034)	(0.058)	(0.176)
...of interbank dependence on little-used credit lines	-0.194***	-0.326***	-0.423**
	(0.048)	(0.068)	(0.187)

This table shows the results of additional robustness checks on the results of Table 4, column 2. The dependent variable is the change in the maximum amount of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample consists of credit lines to firms that borrowed from at least two banks in those two months. See Table 3 and Table 4 for a description of the independent variables. The marginal effects at the bottom of the table are the result of adding up the relevant coefficients for the respective groups of credit lines and/or banks. The marginal effects at the bottom of the table are relative to highly-used credit lines. Standard errors are clustered at the bank and firm level and reported in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

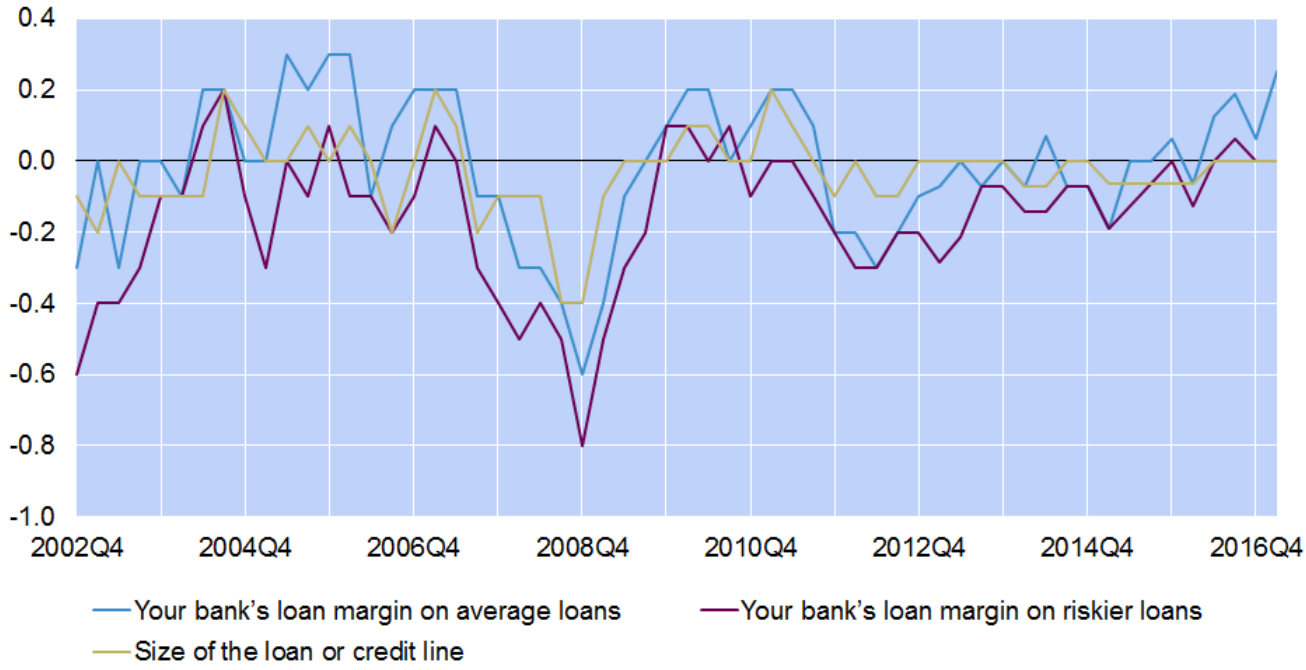
Table 11: Probability of default and credit line usage before the crisis

Dependent variable	Drawn/Granted < Median 2008:01	
	Linear Probability Model	Logit Model
	(1)	(2)
Probability of Default	-0.002**	-0.008**
	(0.001)	(0.004)
Firm Controls	Yes	Yes
Marginal Effect (dy/dx)		-0.002**
		(0.001)
Observations	3393	3393
# Banks	237	237
# Firms	1049	1049
adj. R^2	0.004	

This table analyzes the correlation between a firm's probability of default and the usage levels of its credit lines at the beginning of our sample period. The underlying sample is the set of credit lines for which we have information on the probability of default of the respective firm. The dependent variable is a dummy variable which equals one if the ratio of the credit line usage to the granted volume in January 2008 is smaller than the median ratio across the original sample (see Table 2). The dependent variable is thus equivalent to the dummy variable *Little-used* included in earlier tables. *Probability of Default* is the simple average assessment across all banks lending to the firm, and is measured in percent (e.g. if the probability of default equals one percent, then *Probability of Default* = 1.) We measure this variable in the earliest available month of the year 2008. In column 1, we estimate a simple linear probability model, while in column 2, we estimate a logit model. Both specifications include firm-specific controls, in particular the log of assets, return on assets, sales over assets, cash holdings over assets and capital holdings over assets. Standard errors are clustered at the bank and firm level and are in parentheses. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

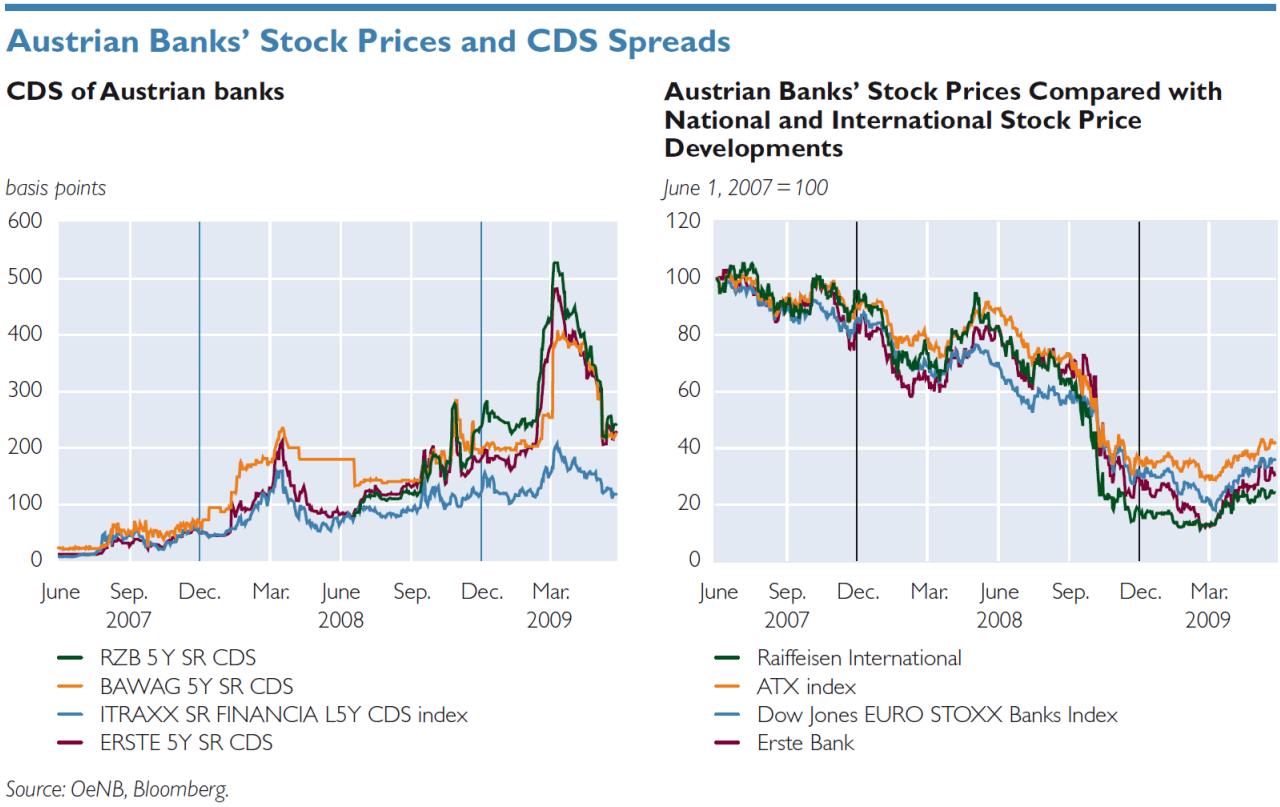
Figures

Figure 1: Lending Standards and Volumes of Austrian Banks, Diffusion Index



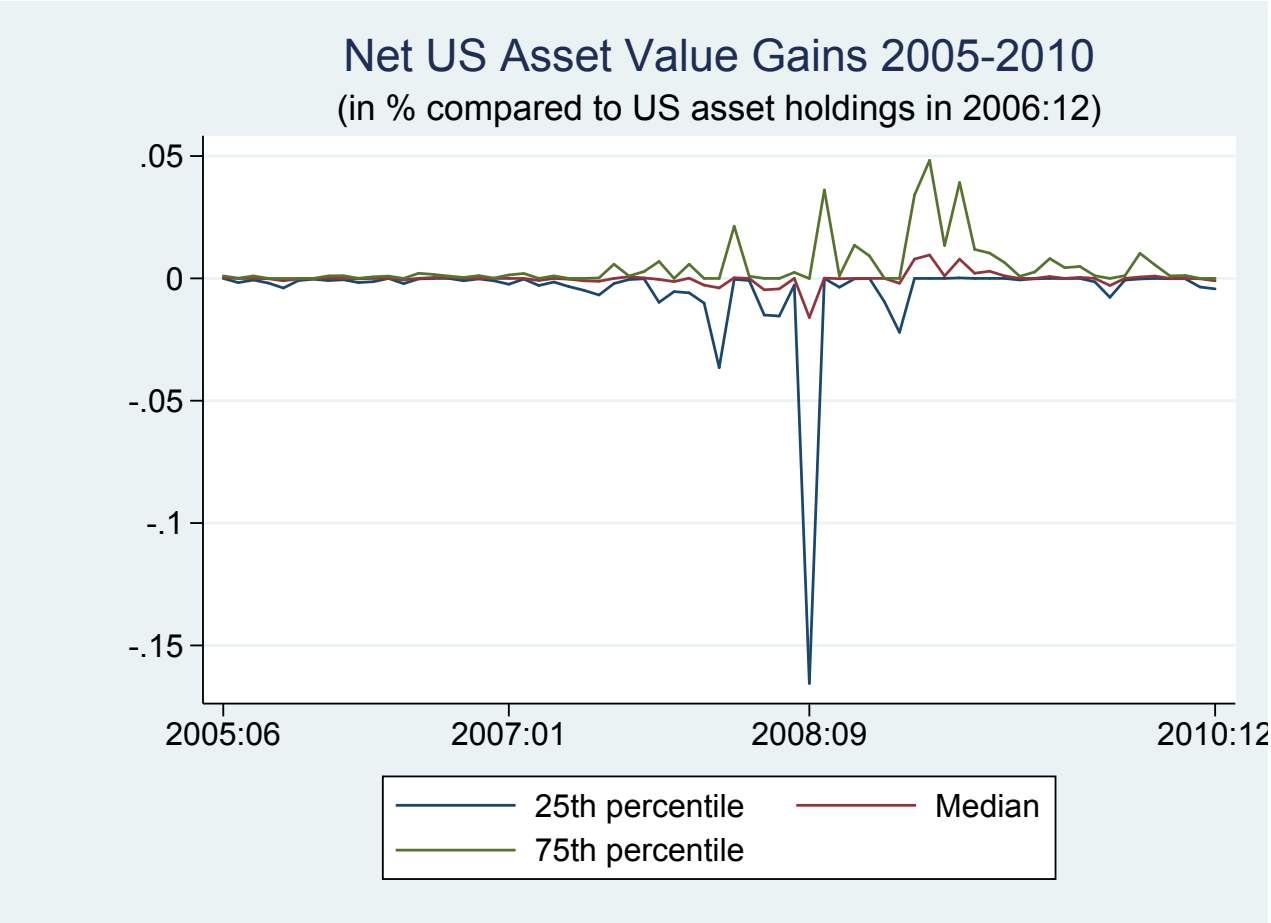
This figure depicts lending standards of the most important Austrian banks over time according to the Austrian version of the Euro area bank lending survey administered by the European Central Bank. A negative number indicates a deterioration/tightening of lending standards from the perspective of the borrower compared to the previous quarter. The graph also shows the development of volumes of loans and/or credit lines (as reported by the bank), in relative terms to the previous quarter. Source: OeNB.

Figure 2: CDS spreads and stock market performance of Austrian banks



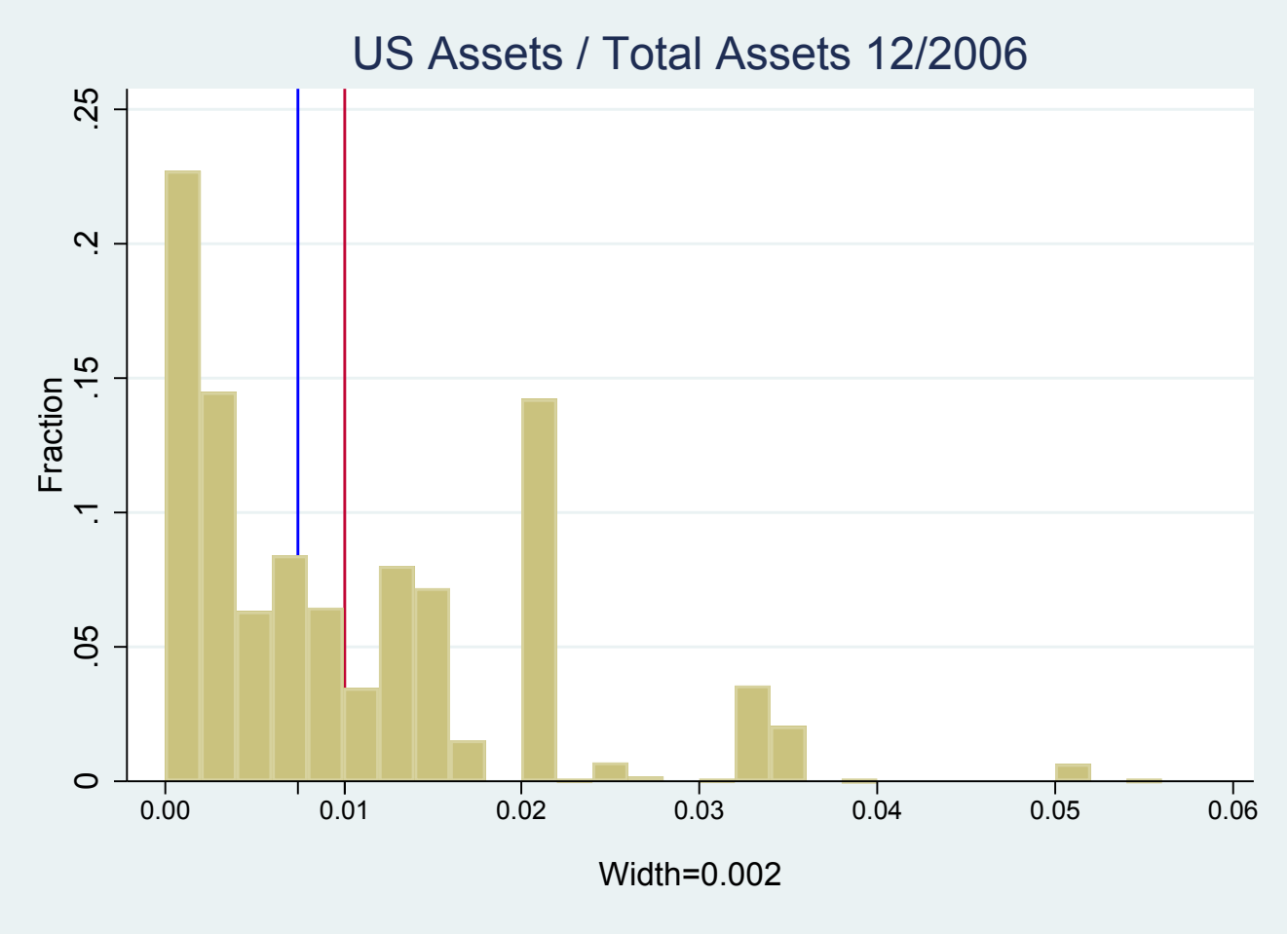
This graph shows the development of Credit Default Swaps (CDS) spreads of three Austrian major banks (left panel) and the development of two Austrian banks' and the overall Austrian stock market performance (right panel), in an international comparison. ITRAXX SR FINANCIAL 5Y CDS index is the brand name for the family of credit default swap index products covering different regions – in the present graph we plot the European index. The ATX index is the most important stock market index of the Vienna Stock Exchange. The Dow Jones EURO STOXX Banks Index is an index of stock market prices of the major banks within the European Union, and is weighted based on the market capitalization of the included banks. SR stands for senior debt.

Figure 3: Net US Asset Value Gains, 2005-2010



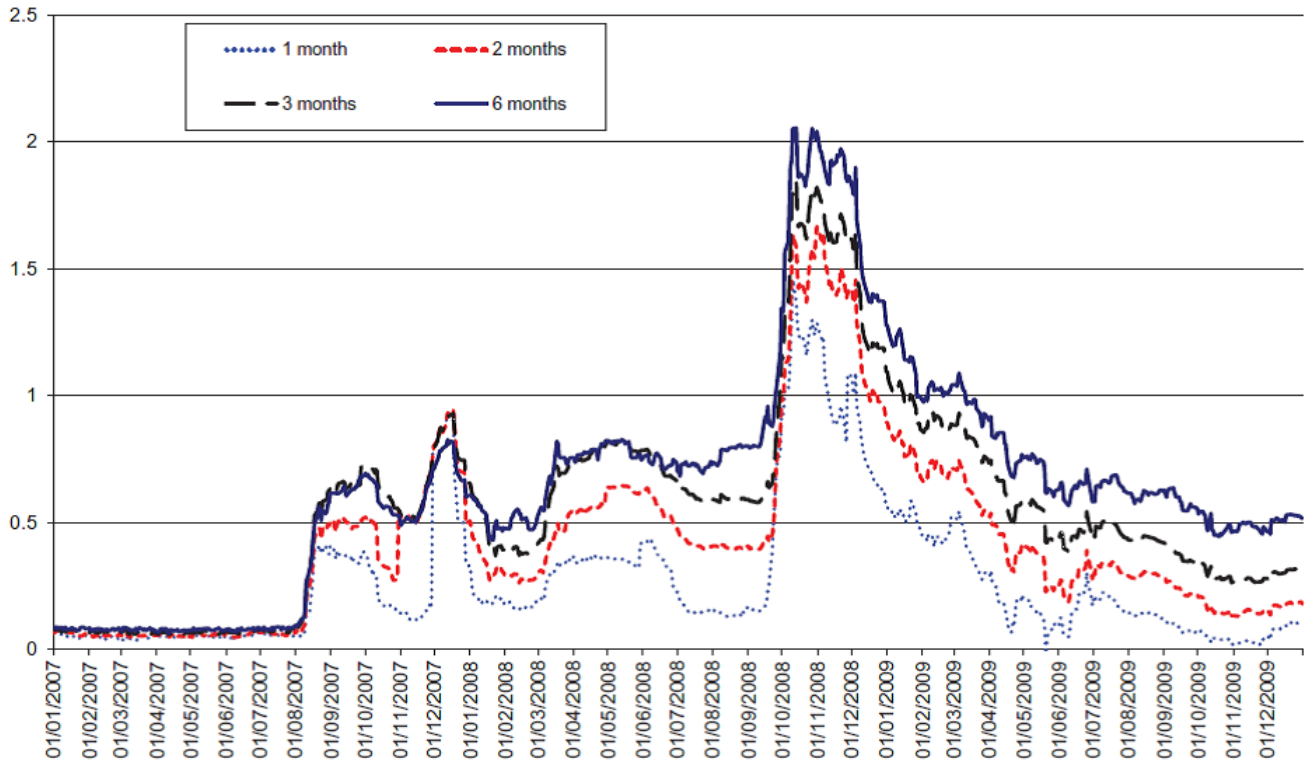
This graph shows the distribution of the sum of US-specific loan write-offs and net gains on security and equity share holdings at the bank level across all banks in our sample, over 2005-2010. The variable is scaled by the amount of a bank's US asset holdings in December 2006, the moment in time in which we measure US asset exposure in our empirical analysis. For each month over our time period, the graph shows the 25^{th} and 75^{th} percentile as well as the median, based on the individual bank-time observations. Net gains of security holdings and equity shares are not affected by transactions but solely reflect changes in market values. Source: OeNB.

Figure 4: Distribution of US Assets / Total Assets



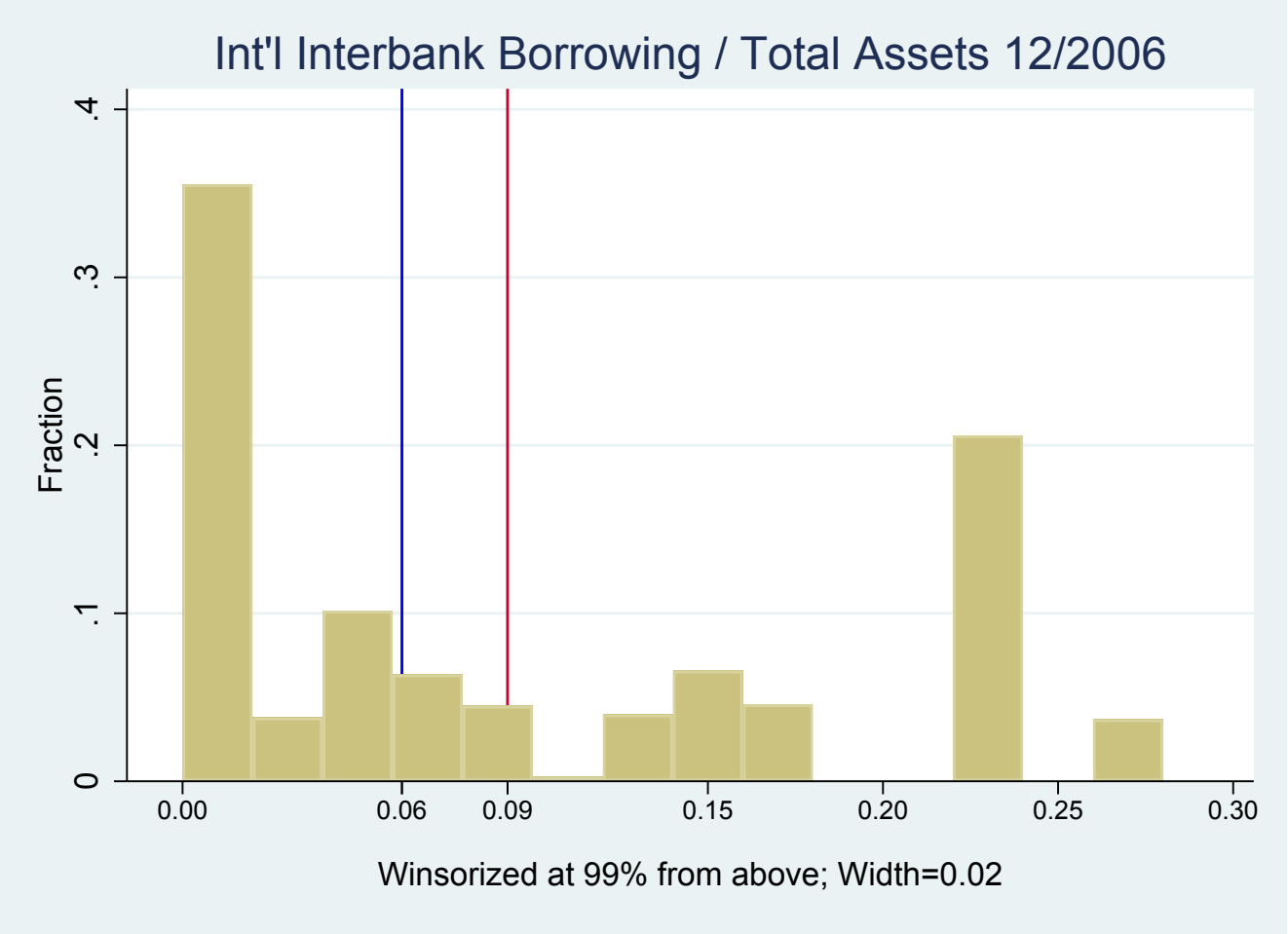
This figure displays the distribution of US Assets / Total Assets across our sample in December 2006. The underlying sample is not individual banks, but the US exposure of the banks associated to individual credit lines. This ensures that the realizations of individual banks are properly weighted based on their importance in our sample of credit lines. The blue vertical line indicates the median across our sample, while the red vertical line displays the mean. The individual bars indicate the fraction of credit lines that are associated with a lender that has a realization of US Assets / Total Assets within the respective interval. Source: OeNB.

Figure 5: The cost of Interbank funding



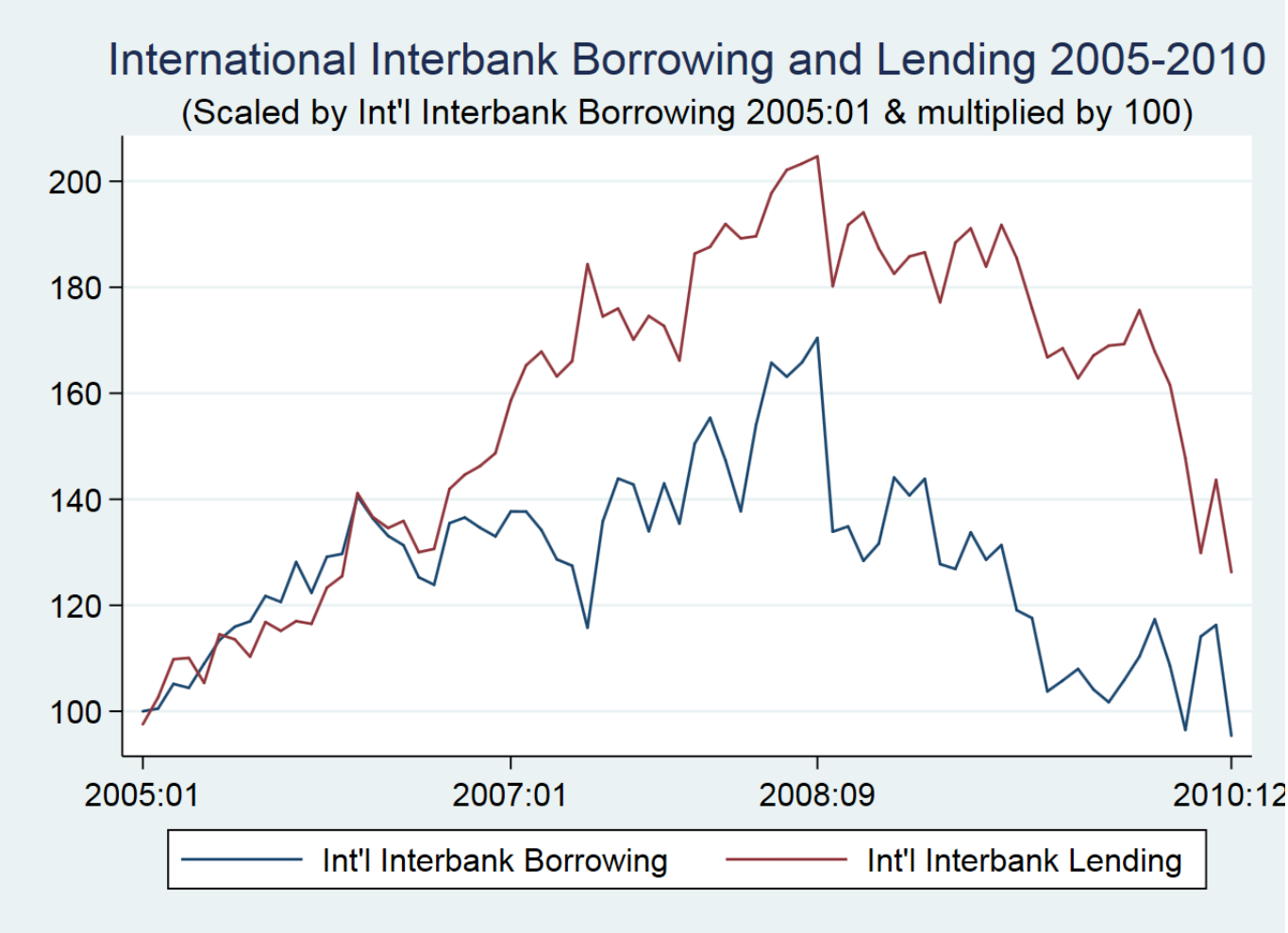
This figure depicts the spread between the unsecured ("Euribor") and secured ("Eurepo") interbank lending rates between 2007 and 2009 for different maturities. Source: European Central Bank, Cingano et al. (2016).

Figure 6: Distribution of International Interbank Borrowing / Total Assets



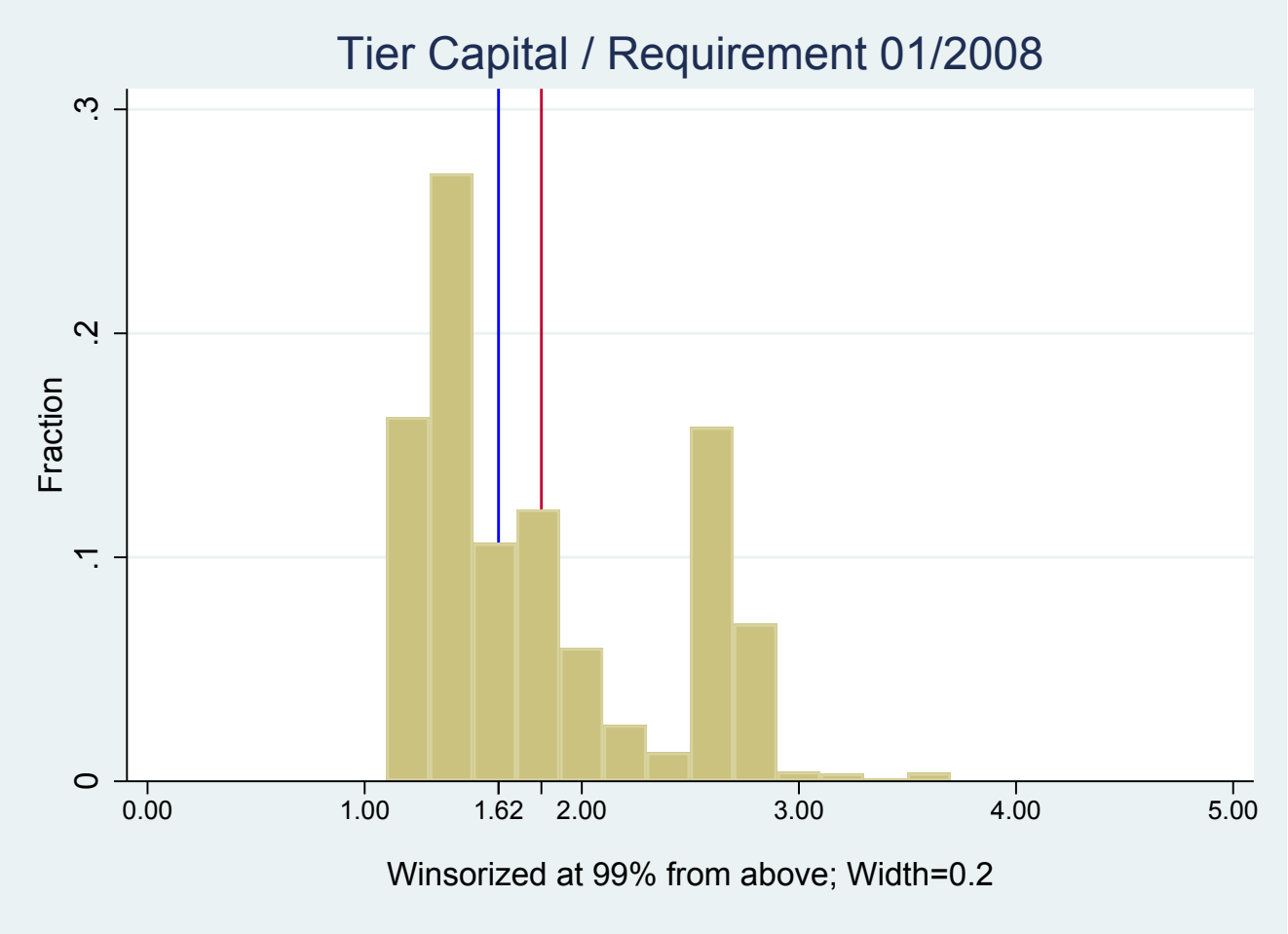
This figure displays the distribution of International Interbank Borrowing / Total Assets across our sample in December 2006. The underlying sample is not individual banks, but the interbank funding dependence of the banks associated to individual credit lines. This ensures that the realizations of individual banks are properly weighted based on their importance in our sample of credit lines. The blue vertical line indicates the median across our sample, while the red vertical line displays the mean. The individual bars indicate the fraction of credit lines that are associated with a lender that has a realization of International Interbank Borrowing / Total Assets within the respective interval. For illustrative purposes, the data is winsorized from above at the 99% level. Source: OeNB.

Figure 7: International Interbank Borrowing and Lending 2005-2010



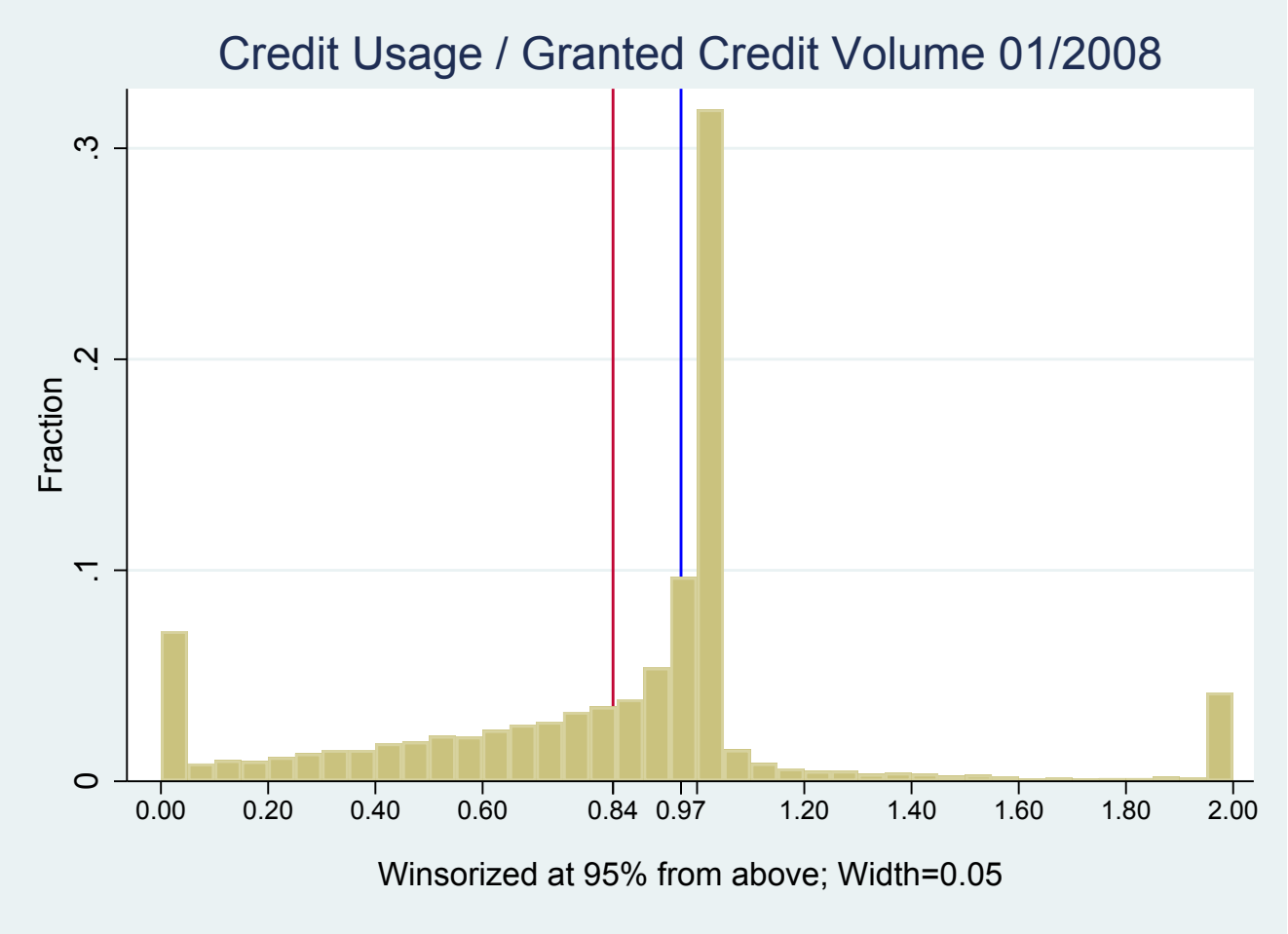
This figure depicts the sum of total international interbank borrowing and lending, respectively, of banks operating in Austria from 2005-2010. Both series are scaled by total international interbank borrowing in January 2005, and then multiplied by 100. Source: OeNB.

Figure 8: Distribution of Capital Buffers



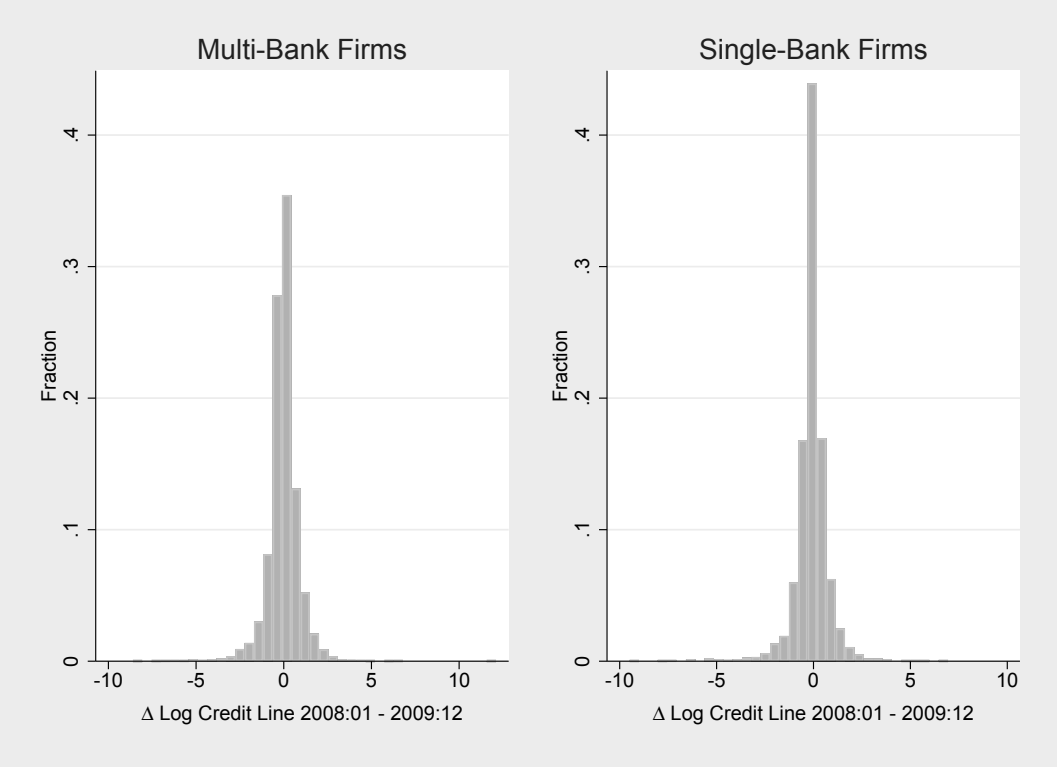
This figure displays the distribution of capital buffers across our sample in January 2008. The underlying sample is not individual banks, but the capital buffers of the banks associated to individual credit lines. This ensures that the realizations of individual banks are properly weighted based on their importance in our sample of credit lines. We measure a bank's capital buffer as the ratio of its Tier 1 + Tier 2 capital holdings divided by the individual bank's minimum capital requirement. The blue vertical line indicates the median, while the red vertical line displays the mean. The individual bars indicate the fraction of credit lines that are associated with a lender that has a capital buffer realization within the respective interval. For illustrative purposes, the data is winsorized from above at the 99% level. Source: OeNB.

Figure 9: Distribution of Credit Usage / Granted Volume



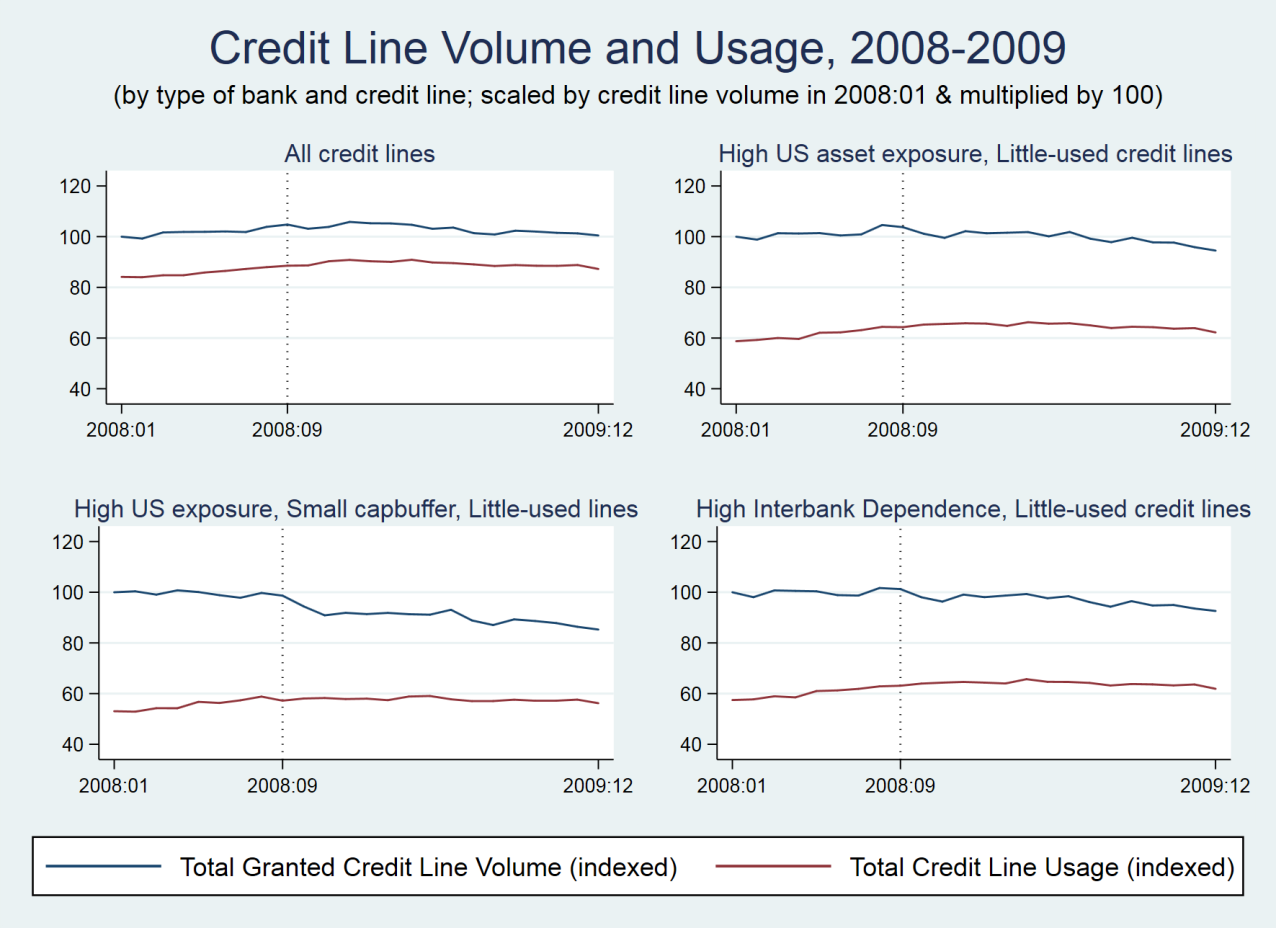
This figure shows the distribution of the bank-firm-specific ratio of credit line usage and granted credit volume in January 2008 over our sample. The blue vertical line indicates the median, while the red vertical line displays the mean. The individual bars indicate the fraction of credit lines that have a given usage-to-granted ratio within the respective interval. For illustrative purposes, the data is winsorized from above at the 95% level. Source: OeNB.

Figure 10: Distribution of $\Delta log(CreditLine_{ij})$ across Multi-Bank firms and Single-Bank firms



This figure shows the distribution of $\Delta log(CreditLine_{ij})$ over 01/2008 - 12/2009, our main dependent variable, across two samples. On the left-hand side, the sample is the credit lines of firms with multiple banks, thus the sample used in our specifications. On the right-hand side, the sample is all credit lines held by firms that only borrowed from one bank in January 2008 (and also borrowed from the same bank in December 2009). The individual bars indicate the fraction of credit lines whose log change in granted volume was within the given interval, each of which has a width of 0.5 log points. Source: OeNB.

Figure 11: Credit Line Volume and Usage 2008-2009



In these four graphs we plot the development of granted credit volumes and usage levels over 2008:Q1 - 2009:12 for different types of banks and credit lines. The top-left graph shows the total granted credit volume as well as the total usage across all banks and firms in the sample based on which which we estimate our main specification. The volumes are normalized by the granted volume in January 2008, same as in the other graphs. In the top-right graph, we plot the total granted volume and usage of *little-used* credit lines granted by banks with above-median US asset exposure; in the bottom-left graph we further restrict banks to those with a below-median capital buffer. In the bottom-right graph we focus on little-used credit lines granted by banks with above-median dependence on international interbank funding. Source: OeNB.

Appendix

List of CESEE countries

We define a bank's CESEE assets as the sum of securities and shares acquired from counterparties in CESEE countries and loans to CESEE counterparties, divided by the sum of a bank's total loans, securities and shares. CESEE countries are: Albania, Azerbaijan, Bulgaria, Belarus, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia.

Tracking bank mergers and changes in bank identifiers

We track bank mergers and split-ups and resulting changes in bank identifiers (which correspond to the bank's actual bank codes) as well as identifier changes that are not related to mergers or split-ups over 2004-2009. This is necessary because these changes are not taken into account in the raw credit register data. Data on bank mergers, splits and identifier changes is provided by the Austrian Central Bank. While especially mergers have been quite common over 2004-2009 (around 10 cases per year), mostly very small banks which hardly appeared in the credit register were taken over by other banks. For our main specification, we track changes between January 2008 and December 2009.

Considering mergers, three cases have to be distinguished. If bank j merges with bank k (such that only k remains thereafter) and firm i has a credit line with j but not with k in January 2008 and a credit line with k in December 2009, we treat j and k as one bank from the perspective of i (zero cases). If i has a credit line with k in both January 2008 and December 2009 and no credit line with j in January 2008, we ignore k's merger with j. If i has a credit line with both j and k in January 2008 and a credit line with k in December 2009, we sum all credit line variables across j and k for January 2008 (zero cases). Bank-specific pre-crisis variables are chosen as those of j.

In case of bank splits, by which we mean bank j splitting from bank k such that both j and k remain thereafter, several cases must be distinguished. If firm i has a credit line with k in January 2008 and a credit line with only k in December 2009, we ignore the split. If firm i has a credit line with k in January 2008 and a credit line with only j in December 2009, we treat j and k as one bank, from the perspective of i (one case=split, which affects 47 credit lines). If i has a credit line with k in January 2008 and credit lines with both j and k in December 2009, we sum all credit line variables across j and k for December 2009 (one split, which affects 27 credit lines).

Finally, we also keep track of banks changing identifier for other reasons (zero cases).