Capital Regulations and Credit Line Management during Crisis Times*

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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, banks with a troubled capital position 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 continental 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, which makes it a particularly reliable source of debt financing (Sufi, 2009). From the granting bank's perspective, commitment fees paid on the unused portion of the line make up a considerable fraction of revenues

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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 under the Basel framework. The flip-side is that additional drawdowns result in a direct and possibly unexpected increase in a 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 its potential to absorb future losses and also harms a bank's stock market performance (Demirguc-Kunt et al., 2013). Exposure to unused credit lines may therefore put a bank's capital position at risk, especially if the bank has a small capital buffer.

While this source of risk has received virtually no attention in the academic literature, it is far from negligible. If the usage of all credit lines that we observe increased to 100 percent in early 2008, the average bank operating in Austria would have to increase its capital stock by up to six percent to keep its capital buffer constant, or instead suffer a decrease in its capital buffer by up to 15 percent. Since our data only covers the universe of relatively large credit lines, the total impact may be considerably higher.

Sizable capital buffer reductions are particularly problematic in periods of financial distress. The reason is that the capital position of banks is then typically weakened, raising capital is more costly 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. We find that during the 2008-09 financial crisis, banks whose capital position was hit relatively hard and whose initial capital buffer was low limited the risk of capital ratio reductions by substantially cutting credit lines that were used relatively little at the onset of the crisis, and thus posed a larger risk of additional drawdowns. These results empirically highlight a novel yet important link between bank capital regulations and lending to the real economy. As a second contribution, we show that relatively large *liquidity* problems during the crisis also induced banks to cut little-used credit lines over 2008-09 considerably and more than other banks, controlling for a bank's capital position. By cutting little-used lines, banks with liquidity concerns limited the scope of additional credit line drawdowns and the resulting costs.

Our findings are conditional on changes in firm-specific credit demand and bank-specific unobservables during the crisis. We therefore provide causal evidence that banks actively manage both

capital and liquidity risk due to 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. Changes in liquidity provision by banks to firms have received limited attention in the policy debate on the 2008-09 and other financial crises, as the discussion has mainly focused on variation in credit usage levels rather than commitment volumes.

Our primary data source is the Austrian credit register, which is ideally suited to pursue our research goals. The register provides information on bank-firm specific credit commitments over time and thus allows us to convincingly account for endogeneity issues such as heterogeneity in firm credit demand 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 is available for the universe of banks and firms operating in Austria, as long as the credit commitment exceeds €350,000.

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 low capital buffers compared to 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 ratio reductions and thus additional credit line drawdowns. Last, but not least, changes in bank credit commitment volumes are particularly crucial if banks are by far the most important suppliers of credit, as is the case in Austria and continental Europe in general.

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 the bank would be harmed by 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 its 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 asset value losses have to be marked to market, they directly affect 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; Acharya et al., 2018; Ongena et al., 2018). It is also in the spirit of Peek and Rosengren (1997) and Puri et al. (2011) since it exploits an exogenous shock occurring in a distant country.

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. Furthermore, 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 banks with a troubled capital position during the crisis cut little-used lines mostly as a precautionary move to limit credit line drawdowns and thus further capital problems. In addition, banks may have cut little-used lines to free capital directly, although the resulting effect is limited because the capital charge on the unused portion of most credit line types has been small (see Section 3). Our results also indicate that banks with a troubled capital position did not cut highly-used credit lines. We reason that this is because they posed a smaller risk of additional drawdowns and because 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. These concerns were clearly smaller when banks cut little-used lines, while at the same time it enabled banks to reduce the risk of a sudden capital ratio reduction in times in which capital was scarce and expensive.

We also 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 that this implied a substantial transfer of liquidity risk to the corporate sector.

Our main set of results provides an additional rationale for the policymaker's quest to ensure that banks have a sufficiently large capital buffer. Furthermore, they 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 increase. In this light, the measure of Basel III to increase the capital charge on unused credit lines 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. 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 a rise in credit line demand. Both measures might soften the magnitude of liquidity risk transfers from banks to firms in periods of financial distress.

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. To the best of our knowledge, the only study that has directly addressed this relationship before ours is a mainly theoretical and yet unpublished contribution by Foote (2011). This paper shows that the low capital charge on unused credit commitments in the Basel regulatory framework induces banks to offer larger credit line volumes than it would optimally grant if the capital charge were as high as it is for the *used* portion of a credit commitment. This creates misallocation of credit during credit market turmoil, since troubled firms then draw heavily on existing credit lines and thereby constrain the bank's ability to grant new credit. In her empirical section, Foote shows that the ratio of undrawn credit lines over regulatory capital negatively affected a bank's origination of new credit during 2008-2009. However, she is unable to control for selection issues. We add to this study by showing that over a horizon that permits to adjust or abandon commitments, banks reduce their exposure to existing credit lines

that were perhaps granted excessively earlier, while accounting for selection issues. Our result that banks cut little-used lines may partially reflect an attempt to reduce the misallocation described by Foote. However, our finding that banks with a relatively small capital buffer cut little-used credit commitments by significantly more suggests that this was (also) a move to mitigate capital concerns.

Our paper also relates to a small literature that has dealt with asset-backed commercial paper (ABCP) conduits (often called "shadow banks") and their implications (Acharya et al., 2013; Acharya and Schnabl, 2010; Covitz et al., 2013). This is because assets held by ABCP conduits 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.[1] 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 a recent study by Gropp et al. (2018). This paper finds 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 findings also add 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

[1] The implications are substantial and have concerned policymakers, as a citation in the IMF 2008 Financial Stability on liquidity lines to ABCP conduits highlights: "Using the standards of Basel I, Fitch Ratings (2007) estimated that, under a worst-case scenario, if liquidity lines were to be fully drawn down, declines in the Tier 1 capital ratio of European banks would peak at 50 percent and for U.S. banks at almost 29 percent". (International Monetary Fund, 2008, p.77)

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 on the effect of liquidity shocks on credit supply to firms without explicitly focusing on 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; Berger and Udell, 1995; Shockley and Thakor, 1997; Agarwal et al., 2006; Demiroglu and James, 2011) literature that specifically analyzes the nature, motivation and use of credit commitment contracts.

3 Background and Data

Credit lines and Basel capital regulations

Basel I and II have requested banks to hold capital worth at least eight percent of their risk-weighted assets. 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 has only obtained a CCF of at most 50% in the different versions of the Basel regulatory framework. 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 depends on the type and maturity of the credit commitment and has changed over time. Under Basel I, the unused portion of an *irrevocable* credit commitment with original maturity below one year had a CCF of zero percent and was thus fully off-balance-sheet, while those with maturity greater than one year had a CCF of 50%. A credit line is irrevocable if its volume cannot be reduced before the commitment matures unless the firm violates a covenant. With Basel II, which was fully implemented in January 2008 and was the applied framework over our entire sample period, the CCF on irrevocable credit commitments with maturity below one year increased to 20%. The CCF on long-term irrevocable commitments remained at 50%.[2] *Revocable* commitments, which are unconditionally cancellable by the bank at any time, had no capital charge in both Basel I and II. This is despite evidence that banks mostly honor such commitments in adverse conditions to avoid losing reputational capital (Bhalla, 2008, see p.407). In the credit commitment regulations of Basel III which were introduced in 2013, irrevocable commitments have faced a charge of 40% irrespective of their maturity while revocable

[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.

commitments have had a CCF of 10%.

Bank capital and the crisis in Austria

Austrian banks suffered a deterioration of bank capital ratios 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 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 low 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 design of many banking groups. 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 over 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 Aus-

[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.

trian Central Bank's database of individual bank balance sheets. Pre-crisis US asset holdings are arguably the "cleanest", i.e. most exogenous proxy for incurred losses. 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 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, 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. Figure 3 shows that also the volatility of net US asset value gains was elevated from 2007-09, which suggests increased uncertainty about the value of US asset holdings during the crisis.[9] Taken together, these results suggest that pre-crisis US asset exposure is not only an exogenous but also economically relevant proxy for capital losses of banks operating in Austria during the Great Recession.

[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).

The extent to which capital losses affected a bank's credit line management probably also depended 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 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]

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 4). 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

As Figure 5 shows, 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. Given this evidence, we adopt pre-crisis dependence on interbank funding as our proxy for bank-specific exposure to wholesale funding and thus exposure to higher liquidity costs during the crisis. Following Ongena et al. (2015), we measure dependence on interbank funding as total *international* interbank borrowing divided by total assets on the bank's balance sheet. We do so since Austria is a relatively small economy and *domestic* pre-crisis

[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.

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, 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 9.8 percent.

The Austrian Credit Register as primary data source

Our source of credit data is the Austrian credit register. The register documents all bank-firm 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 in later years in which commitment data by credit type is available. 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, and is important because the initial usage composition may affect the change in the credit commitment volume over time. On average, we observe a reduction in credit commitments by 4.5 percent over our sample period (see Table 1, panel I). The choice of January 2008 as beginning of our sample period

[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 9). 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.

comes at the cost of disregarding potential credit line reductions based on early crisis warning signs in 2007. However, it avoids to pick up the effect of regulatory changes across Basel I and II, which was fully implemented only in January 2008. December 2009 is chosen 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, 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. Both these numbers 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 0.557. 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. The total unused volume of granted credit commitments makes up 3.1 percent of assets of the average bank in our sample.

4 Empirical Strategy

We start our empirical analysis by analyzing the effect of US asset exposure and dependence on interbank funding on credit line supply during the crisis irrespective of how much credit lines were initially used. As an initial exercise, we also study the differential treatment of little-used 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 of 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 multiple banks in both January 2008 and December 2009 and including the firm fixed effects η_i into our specification (Khwaja and Mian, 2008). While this 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

[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 is 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.

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 imply larger liquidity risk.[17] The firm 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.[18]

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 Do troubled banks treat little-used credit lines differently?

Given our research questions, we have a special interest in credit lines that were used relatively little at the onset of the crisis. Since banks whose capital or liquidity position was particularly harmed during the crisis were more sensitive to additional drawdowns, we expect those 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:

$$\begin{aligned} \Delta log(CreditLine_{ij}) = \beta_1 USAssets_j + \beta_2 Interbank_j \\ +\beta_3[USAssets_j \times \textit{Little-used}_{ij}] + \beta_4[Interbank_j \times \textit{Little-used}_{ij}] \\ +\beta_5 \textit{Little-used}_{ij} + \beta_6 B_j + \beta_7 C_{ij} + \eta_i + \epsilon_{ij} \end{aligned} \tag{2}$$

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

[17] In section 5.3, we show that large little-used credit lines were cut more than small little-used lines by troubled banks during the crisis, both in absolute as well as in percentage terms. This supports our argument that small credit lines are less relevant for banks in terms of capital and liquidity management.

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

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 of including the bank fixed effects δ_j is to 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 their inclusion is to 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 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 crisis. We do so by interacting the interaction of *US Assets* and *Little-used* with a variable that equals one if the ratio of the bank's regulatory capital over its minimum capital requirement in January 2008 was below the median. This median equals 1.62.[20] For the test we have in mind, it is sufficient to understand whether the effect of US asset exposure on the management of little-

[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 low 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.

[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.

used lines *relative* to highly-used lines depends on a bank's capital buffer. Therefore, our main corresponding specification builds on specification (2), and looks as follows:

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

$\gamma_1 + \gamma_2 + \gamma_3$ 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 line relative to a highly-used line if the bank had a relatively low capital buffer. If γ_2 is significant, then this strengthens our interpretation that US asset exposure matters for a bank's credit line management because of its capital position during the crisis.

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. This coefficient estimate is very robust to replacing bank controls with bank fixed effects.

[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

The results of Table 2 suggest that the average bank reduced its exposure to undrawn credit lines over 2008-09. 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 would reduce this exposure 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 interaction term captures the differential treatment of little-used lines by banks with a relatively large US asset exposure and 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 a 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 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 large US exposure even if the firm was fully using all its other credit lines.

The positive and insignificant coefficient estimate on *US Assets* in column 1 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 US-exposed or interbank-dependent banks compared to other banks. Our primary interpretation is that

[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.

highly-used 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 it 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.[24] 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 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 such banks are more sensitive to credit line drawdowns and shows that they successfully reduced this risk. In columns 5-6, we interact *Little-used* both with *US Assets* and *Interbank*. This makes the interpretation of the non-interacted dummy *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 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 the state of a bank's capital position during the crisis. Specifically, a bank with relatively large US asset holdings that suffers capital losses but went into the crisis with a relatively large capital buffer may be able to absorb those losses more easily than others and thus decide not to cut little-used lines. We test this hypothesis in the next sub-section.

[24] 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

If concerns about the regulatory capital ratio affect a bank's credit line management during crisis times, then banks that have a smaller capital buffer vis-a-vis their minimum capital requirement should be more worried about undrawn credit lines and may cut them by more than otherwise similar banks. We explore this logic by distinguishing the cross-section of banks along their individual capital buffer and incorporating this variable 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 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 only significantly cut little-used credit lines 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 high capital buffer. This shows in turn 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.

5.3 Robustness checks

Testing common trends before the crisis

We can only interpret the obtained results as the effect of increased capital concerns and liquidity risk caused by undrawn credit lines 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), using the same timing of measurement as in our main

specification. The motivation for the timing of the dependent variable is to avoid picking up regulatory changes caused by the (partial) implementation of Basel II in January 2007, and otherwise to keep the length of the sample period equal. 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 effected by the crisis, and thereby were not facing larger trouble than other banks during 2007-09. We contrast this concern by showing that higher US asset holdings at the onset of the crisis lead to significantly larger US-related and also 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. Importantly, net gains of security holdings and equity shares are not affected by transactions but solely reflect changes in market value. For illustrative purposes, Figure 3 depicts the distribution of the sum of US-specific loan write-offs and net gains on security and equity share holdings over time.

We set up a regression framework in which the dependent variable is the bank-specific sum of net gains incurred by a bank due to loan write-offs and/or value changes of security and equity share holdings over the 24 months of 2008 and 2009. This period is chosen to parallel the sample period of our main analysis. 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 smaller banks. The results are reported in Table 6. In column 1, we focus on gains/losses that were specific to US assets. 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 lead to larger US-specific net asset value gains, which is again intuitive.[25] Column

[25] 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.

2 provides evidence that US asset holdings were not only significantly correlated with US-related losses during the crisis, but also a bank's total asset value losses, controlling for non-US foreign assets. Column 4 show that this was not the case before the crisis. These results are consistent with our claim that US asset exposure is a good proxy for how the crisis affected a bank's capital position.

'Augmented' firm fixed effects

The success of Khwaja-Mian firm fixed effects to control for demand effects hinges on an assumption. Specifically, it is necessary that 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. To test whether such issues might bias our results, we feature two robustness checks on our main findings of Table 4, column 2. The first check (see Table 7, column 2) consists of 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.[26] This implies that we do not only estimate our coefficients "within the firm", but also within types of credit, specifically revolving credit lines and other types of credit commitments. The underlying idea is that the more similar the credit commitments of distinct banks to a firm are, the more likely it is that the firm asks these banks for a similar adjustment along the extensive margin (in percent) as the firm's credit demand changes, if at all it asks banks for an adjustment. Along similar lines, in column 3 we include 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. This implies that we estimate equation 4 within the banks of a firm that appear relatively important and within the banks that are relatively unimportant. Despite losing a fair degree of statistical power, our results are robust to these two checks.

Are we picking up firm-specific exposure?

Banks with larger US asset exposure might match with firms that export to the United States. 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

[26] 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.

volume to reduce commitment fee payments, but not ask other banks for a reduction. If this pattern were common in our sample, then our finding that US-exposed banks reduced the supply of little-used credit lines would not (only) represent supply but (also) demand effects. In methodological terms, the assumption underlying the Khwaja and Mian (2008) firm fixed effects approach would be violated due to a correlation of bank-firm specific credit demand and a bank's US asset exposure. Ideally, we would address 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 produce in sectors that are generally regarded as non-traded.[27] 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.[28] The results of this robustness check are reported in column 4 of Table 7. Interestingly, the effect on the average non-traded firm is *larger* in magnitude than the effects on the average firm. This speaks against the concern that the described demand effects are an important driver of our results, if at all.

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 5 of Table 7, we time the measurement at the end of the last quarter of 2006, in order to parallel the timing of our other bank-specific variables. The results are very robust to this modification.

Accounting for a credit line's size

If banks cut little-used credit lines because they want to avoid a regulatory 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. For small credit lines, it might thus not be "worth to bother" the holder by cutting its line given the small effect. This might induce banks to cut small credit lines by less, not only in absolute but also in percentage terms. If we observe this behavior, then this would strengthen our interpretation that banks cut

[27] 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.

[28] Firm balance sheet and income statement data is 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.

little-used lines to limit capital or liquidity concerns. We therefore estimate a version of equation (3) that features interaction terms of our variables of interest with a dummy variable *Large Credit Line* that equals one if the line is larger than the median in our sample. The results are presented in Table 8. The estimated marginal effects at the bottom of the table indicate that banks with relatively high US asset exposure on average did not cut little-used lines if they were small, but significantly cut them if they were large. Banks with a relatively large dependence on interbank funding also cut small little-used lines, but the coefficient is only marginally significant. In turn, large little-used lines were cut by significantly more by these banks. These results are conditional on potential differences in credit demand across holders of small versus large credit lines, since we include firm fixed effects into our specification. Furthermore, since we control for the strength of the bank-firm relationship as in our main specification, it is unlikely that the results are driven by small credit lines being more often held by small firms that rely more heavily on relationship lending and therefore face smaller cuts. Therefore, our findings provide supporting evidence that the significant and, compared to other banks, larger reduction of little-used lines by banks exposed to capital and liquidity issues due to the crisis is indeed motivated by limiting the severity of these problems.

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, it helps to get a better sense of the time dimension of the effect of the crisis on bank credit (see Figure 6). 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. The sum of credit usage increased slightly. While this is consistent with an increased likelihood of drawdowns during periods of financial distress, the graphical results do not parallel the U.S. evidence of a run on credit lines during the crisis (Ivashina and Scharfstein, 2010).

The graphs on the right of the figure shows that banks with an above-median US exposure or interbank funding dependence cut little-used credit lines between January 2008 and December 2009, consistent with our regression results. Reductions 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 in the same period 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 potentially upcoming periods of financial distress grant credit lines to those firms that are less likely to increase drawdowns in such times. This 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 banks' assessment of the probability of default of their client firms, we are able to test this hypothesis of Ippolito et al. (2016) in a novel way. Assuming that firms with a larger probability of default have less alternative sources of funding and may also require larger additional funds during financial distress, they increase credit line drawdowns more than other firms during a financial crisis. Banks that actively try to manage liquidity risk already in normal times would then arguably grant credit lines that are subsequently used relatively little mostly to firms with a relatively low probability of default. 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 9. 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 assumption regarding probability of default and credit demand 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 how bank capital regulations affect lending to the corporate sector. Specifically, we highlight that unused credit lines are largely off-balance-sheet and may therefore pose risk to the capital ratio of banks, particularly in periods of financial distress. We show that banks whose capital position was hit relatively hard during the 2008-09 financial crisis and whose initial capital buffer was low reduced this risk by substantially cutting little-used credit lines over 2008-09. While this is good news from the perspective of banking system stability, it implies a reduction of liquidity provision 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 ensure that banks have sufficiently large capital buffers. What's more, our findings might justify the increased capital charge on the unused portion of most credit commitment types in Basel III. This is because the higher charge makes banks more reluctant ex ante to grant excessively high credit line volumes that cannot be sustained during crisis times. Basel III could therefore limit liquidity risk transfers from banks to firms and reduce the potential impact of runs on unused credit lines on banks in periods of financial distress.

As a second contribution, we show that banks with larger liquidity problems cut undrawn credit lines and thus reduced liquidity provision more than other banks during the 2008-09 financial crisis, 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 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

Table 2: Capital and liquidity issues, initial credit line usage and 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 commitments (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, apart from the bank's capital buffer, which is measured at the end of the first quarter of 2008. *US Assets* is defined as the sum of securities and shares acquired from counterparts 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 commitments 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 across exposed and less-exposed banks

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12					
	Only US	Only US	Only IB	Only IB	US & IB	U &
	(1)	(2)	(3)	(4)	(5)	(
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.
	(0.030)	(0.035)	(0.026)	(0.028)	(0.030)	(0.
US Assets × Little-used	-0.059**	-0.063**			-0.025	-0
	(0.025)	(0.027)			(0.025)	(0.
Int'l Interbank Borrowing × Little-used			-0.072***	-0.071***	-0.056**	-0.
			(0.024)	(0.023)	(0.025)	(0.
Bank Controls	Yes	No	Yes	No	Yes	
Bank-Firm Controls	Yes	Yes	Yes	Yes	Yes	Y
Firm FE	Yes	Yes	Yes	Yes	Yes	Y
Bank FE	No	Yes	No	Yes	No	Y
Observations	8419	8427	8419	8427	8419	8
# Banks	313	290	313	290	313	2
# Firms	2560	2558	2560	2558	2560	2
adj. R^2	0.117	0.102	0.118	0.103	0.118	0.
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.
	(0.025)	(0.025)			(0.027)	(0.
...of interbank dependence on little-used credit lines			-0.119***	-0.147***	-0.099**	-0.
			(0.033)	(0.024)	(0.042)	(0.

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 a of credit firm i can obtain from bank j, between January 2008 and December 2009. The sample consists of credit commitments to firms that borrowe 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 me 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 colum only with dependence on interbank funding and in columns 5-6 with both. *Bank Controls* includes all bank-specific variables of Tables 2 that are not re here. The marginal effects at the bottom of the table display the sum of the coefficients of the respective bank variable and its interaction with *Littl* 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 dependen spectively. 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 re 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 low capital buffer	0.008	
	(0.020)	
...of US exposure on little-used credit lines if high capital buffer	-0.009	-0.039
	(0.039)	(0.037)
...of US exposure on little-used credit lines if low capital buffer	-0.057*	-0.068**
	(0.033)	(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 commitments 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 fulfill the regulatory capital requirement. *Small capital buffer* equals one if this ratio is smaller than the median across our sample of credit commitments 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

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 high capital buffer	-0.018	-0.035
	(0.037)	(0.037)
...of US exposure on little-used credit lines if low 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, same as in Table 4. Both specifications contain bank-firm controls, firm fixed effects and bank fixed effects. Bank-firm-specific variables are all measured in January 2005 or 2004, respectively. 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 study the same conceptual variable but extend the scope to all countries, not only the US. 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 Euro equivalents. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 7: Robustness Checks

Dependent variable	$\Delta Credit\ Line_{ij}$ 2008:01 - 2009:12				
	Baseline	Firm × CL Type FE	Firm × CL Weight FE	Non-traded Firms	Cap.Buffer measured in 06Q4
	(1)	(2)	(3)	(4)	(5)
US Assets × Little-used	0.060*	0.064	0.044	0.138**	0.052
	(0.036)	(0.044)	(0.040)	(0.059)	(0.038)
US Assets × Little-used × Small capital buffer	-0.107**	-0.104*	-0.099*	-0.188***	-0.095*
	(0.045)	(0.058)	(0.051)	(0.070)	(0.049)
Little-used	-0.099**	-0.114**	-0.109**	-0.226**	-0.097**
	(0.042)	(0.049)	(0.052)	(0.099)	(0.049)
Little-used × Small capital buffer	0.078	0.087	0.050	0.134	0.061
	(0.057)	(0.069)	(0.072)	(0.123)	(0.061)
Int'l Interbank Borrowing × Little-used	-0.095***	-0.099***	-0.073**	-0.083*	-0.089***
	(0.026)	(0.033)	(0.034)	(0.048)	(0.026)
Observations	8379	6925	6890	2417	8379
# Banks	290	269	269	162	284
# Firms	2558	2013	1970	764	2549
adj. R^2	0.107	0.009	0.048	0.065	0.107
Marginal effect (relative to highly-used credit lines)...					
...of US exposure on little-used credit lines if high capital buffer	-0.039	-0.050	-0.065	-0.092	-0.046
	(0.037)	(0.047)	(0.050)	(0.103)	(0.036)
...of US exposure on little-used credit lines if low capital buffer	-0.068**	-0.067*	-0.113**	-0.142*	-0.080**
	(0.034)	(0.039)	(0.046)	(0.075)	(0.033)
...of interbank dependence on little-used credit lines	-0.194***	-0.212***	-0.182***	-0.309***	-0.187***
	(0.048)	(0.057)	(0.054)	(0.102)	(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 commitments 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 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 granted 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, while in column 5 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 8: 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 this 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

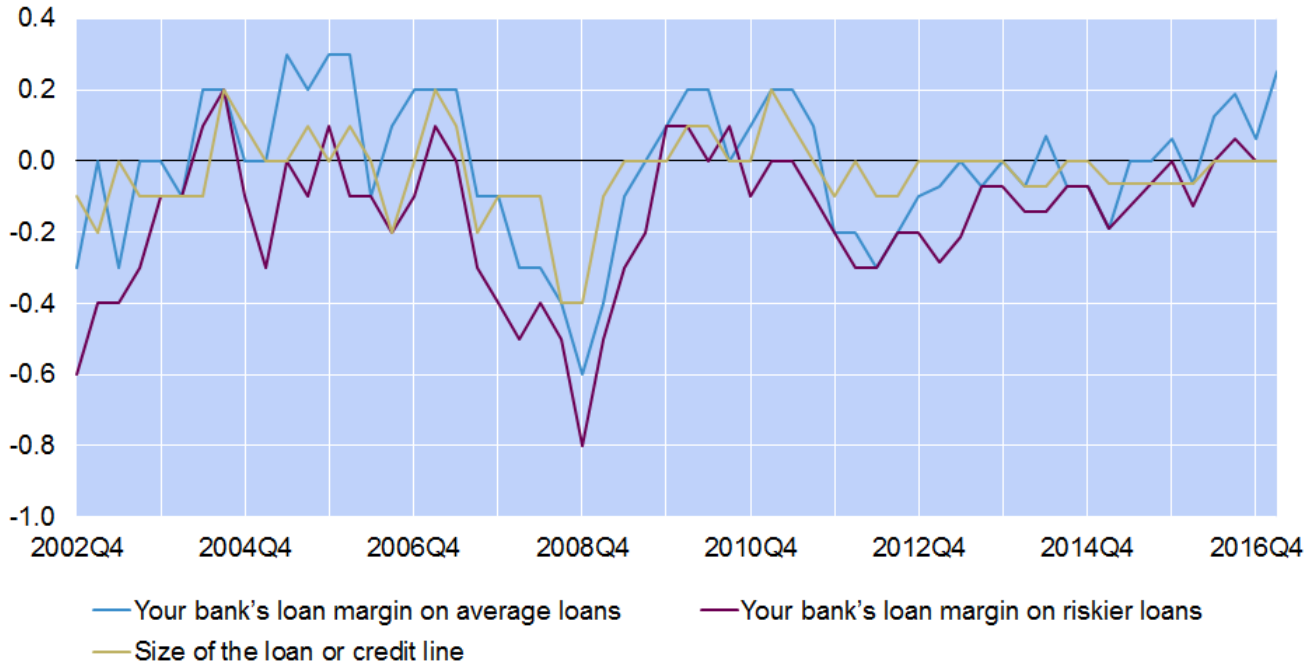
Table 9: Probability of default and credit line usage before the crisis

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 credit line usage at the beginning of our sample period. The underlying sample is the set of credit commitments 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 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.

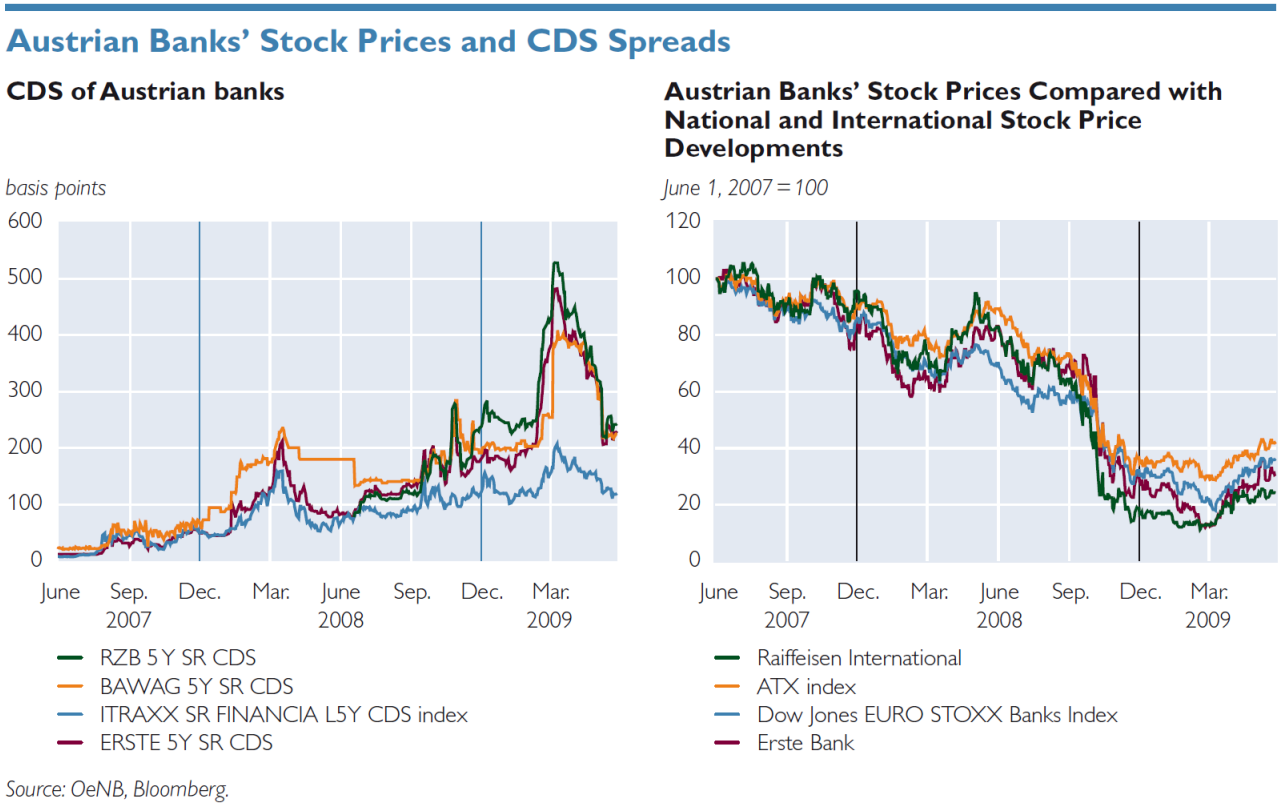
Figures

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



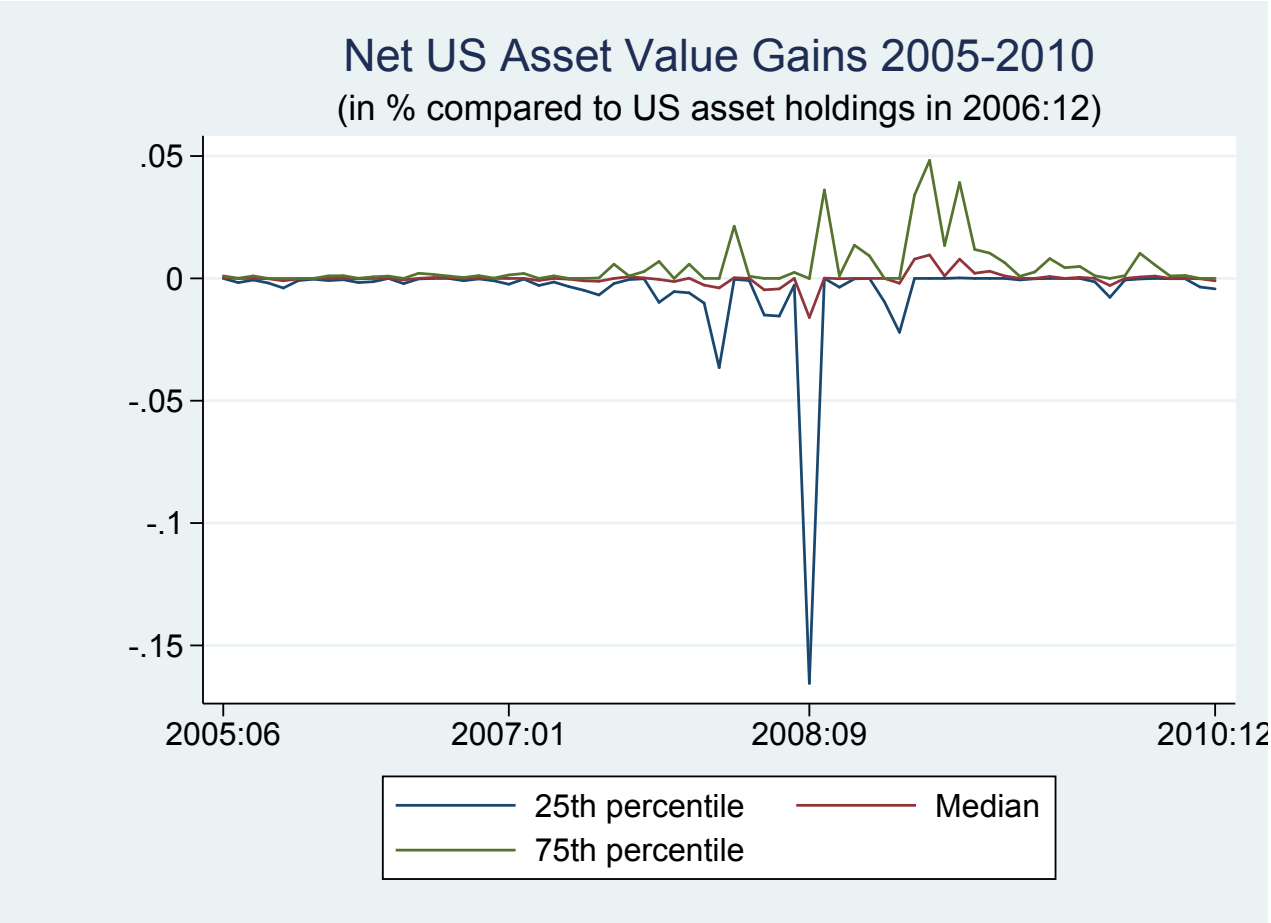
This figure depicts lending standards of the most important Austrian banks over time according to the Austrian version of the Euro area bank lending survey administered by the European Central Bank. A negative number indicates a deterioration/tightening of lending standards from the perspective of the 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



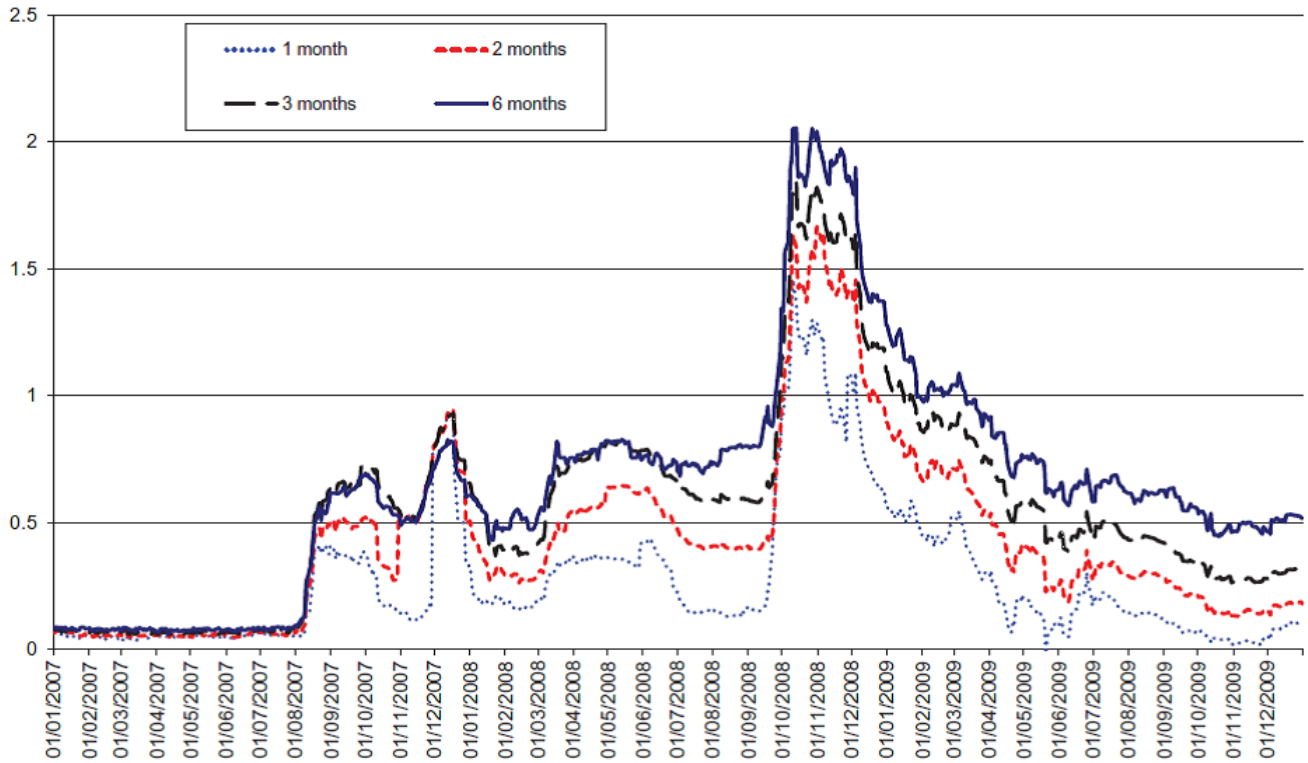
This graph shows the development of three Austrian major banks' Credit Default Swaps (CDS) spreads (left panel) and the development of two Austrian banks' and the overall Austrian stock market performance, in an international comparison. ITRAXX SR FINANCIAL 5Y CDS index is the brand name for the family 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



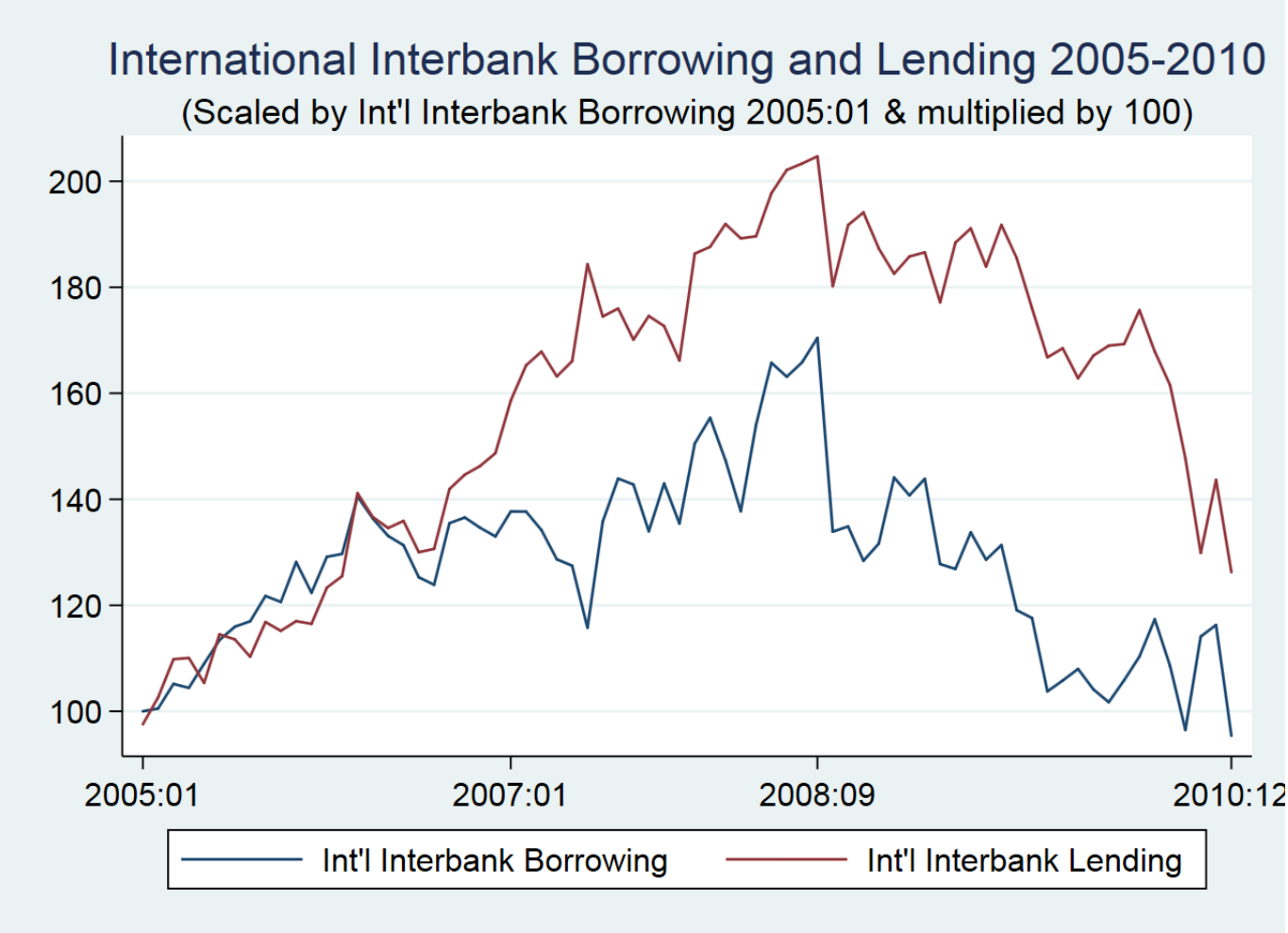
This graph shows the distribution of the sum of US-specific loan write-offs and net gains on security and equity share holdings across banks operating in Austria over 2005-2010. Net gains of security holdings and equity shares are not affected by transactions but solely reflect changes in market value. We scale net gains by the amount of 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, we compute the 25^{th} and 75^{th} percentile of the resulting variable as well as the median, and plot these series over time. Source: OeNB.

Figure 4: The cost of Interbank funding



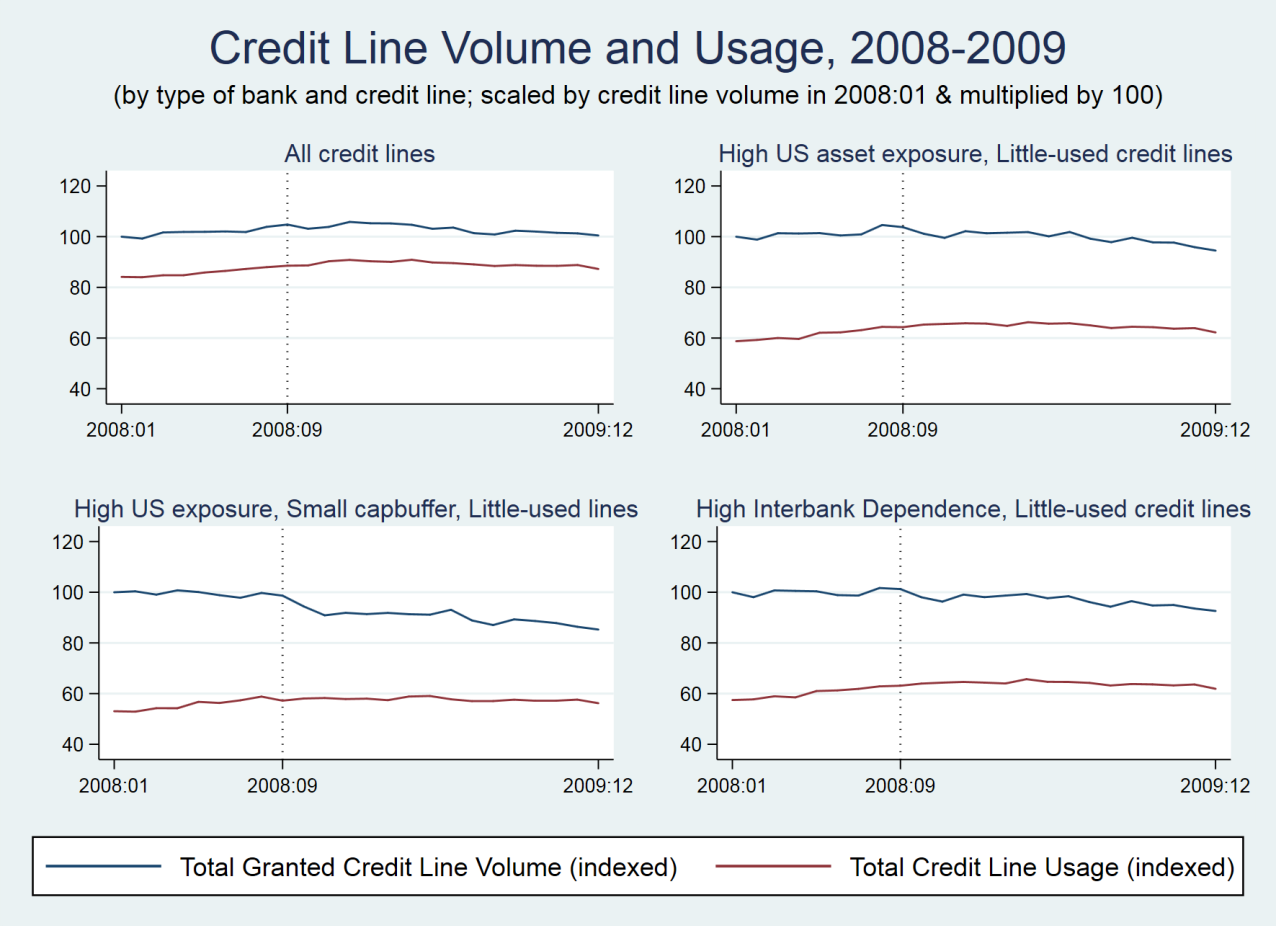
This figure depicts the spread between unsecured ("Euribor") and secured ("Eurepo") interbank lending between 2007 and 2009 in Euros at different time horizons. Source: European Central Bank, Cingano et al. (2016).

Figure 5: 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 6: 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. In the top-left graph, we plot 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 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 interbank funding dependence.

Appendix

List of CESEE countries

We define a bank's CESEE assets as the sum of securities and shares acquired from counterparts in CESEE countries and loans to CESEE counterparts, divided by the sum of a bank's total loans, securities and shares. CESEE countries include 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).