Austrian banks' lending risk appetite in times of expansive monetary policy and tightening capital regulation

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In the past decade, the Austrian credit market was shaped by expansive monetary policy, favorable economic conditions and tightening regulatory capital requirements. Analyzing the impact of these three factors on Austrian banks' credit risk, we focus on credit risk of new nonfinancial corporate borrowers and banks' willingness to fund customers with a high risk of default. To this end, we examine borrower-by-borrower data available in the Austrian credit register. Using data from 2008 to 2019, we find evidence for a strong improvement in credit quality as estimated by banks. We relate this overall credit quality improvement to the favorable economic environment as corporate financial statements did not improve in tandem. Applying fixed effects panel regressions, we find that expansive monetary policy induces risk taking. Banks subject to tightening capital requirements reduced the probability of default and expected loss of their customers more strongly. Smaller, regional deposit-financed banks, which are to a greater extent affected by decreasing interest rates due to margin pressure, show stronger signs of risk taking.

COVID-19 update: *Austrian banks' credit quality will severely worsen as a result of the ongoing coronavirus pandemic and the related economic shutdown. Past crises showed that economies and financial stability are hit the more, the higher the levels of private sector debt and the worse the credit quality are. In our analysis, we find that the credit quality of banks' loan portfolios was good according to their own estimates when banks entered the coronavirus crisis. Low estimates of credit risk, however, also imply lower risk-weighted assets and thus lower capital requirements for a given loan portfolio. In annex 2, we depict the development of credit quality until year-end 2019 in selected service industries which were immediately hit by the policy measures taken in Austria to contain the pandemic. The overall trend, evident in recent years, toward improved credit quality according to banks' estimates holds for all those – albeit heterogenous – industries, even though credit risk parameters are worse than for the cross-industry average, especially for accommodation, food and beverage service activities.*

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During the past years, there has been mounting concern among policymakers and market analysts worldwide that amid historically low interest rates credit might have been excessively allocated to borrowers with a higher probability of default, potentially jeopardizing financial stability in the medium to long run (IMF, 2018). While greater risk taking can be part of healthy economic developments, excessive risk taking may amplify vulnerabilities in times of crisis. To identify changes in banks' credit quality, we look at disaggregated data on credit extended by Austrian banks to nonfinancial firms from 2008 to 2019.

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In the wake of the financial crisis up to year-end 2019, the Austrian credit market was directly shaped by three key developments. First, economic conditions were relatively favorable, with GDP growth in Austria exceeding that of the euro area by about 0.2 percentage points per year. Second, banking regulation was tightened. Third, monetary policymakers lowered interest rates, crossed the zero lower bound and applied unconventional policies in the euro area and elsewhere.

In this study, we evaluate how these developments affected credit risk taking by Austrian banks. We put special emphasis on lending to risky borrowers as this has been shown to be a cause of, and to have amplified, the financial crisis (Financial Crisis Inquiry Commission, 2010). We define "risky" in line with the OeNB rating master scale, which deems customers with a probability of default (PD) above 2.73% to be "highly speculative."[2] Particularly, we address the following research questions:

- How did the probability of default and other risk measures of new borrowers evolve over the period in question? Are there signs of excessive risk taking in new lending by Austrian banks?
- How much of this development can be attributed to firms' improved financial statements?
- Did banks increasingly extend credit to existing risky borrowers?
- Which factors explain different developments across banks? Did deposit-financed banks and banks affected more strongly by toughening capital regulation behave differently?

To answer these questions, we build an extensive dataset by merging three data sources: (1) balance sheet and profit and loss (P&L) data on all Austrian banks operating from 2008 to 2019; (2) average balance sheet and P&L data on borrowers by NACE sector taken from the BACH database; and (3) data on the entire loan book of Austrian banks on a borrower-by-borrower basis for outstanding amounts that exceed EUR 350,000. As we do not have financial statements data on a firm-by-firm basis, much of the paper rests on PDs as estimated and reported by banks. The validity of these estimates, especially their evolution vis-à-vis financial fundamentals is assessed in section 2.3. For the remainder of the paper, it is important to understand the implications of relying on banks' estimates. First, banks' model estimates follow the cycle (see e.g. Kerbl and Sigmund, 2009), i.e. estimates of PDs are optimistic in benign times, but PDs increase when the economic environment worsens. We therefore stress that our measure of riskiness must be understood as banks' snapshots reflecting specific points in time. Second, some banks (i.e. banks using the internal ratings-based (IRB) approach to establish minimum regulatory capital requirements – IRB banks) use these estimates of PDs and collateral for calculating their required level of own funds and thus have an incentive to use low estimates (see e.g. Behn et al., 2016). Given this incentive, banking supervisors review the accuracy and conservatism of banks' IRB models on an ongoing basis or in dedicated exercises like the euro area-wide TRIM[3] project. According to these findings, there is no indication that banks have increasingly used downward-biased estimates in their credit risk models over time.

[2] *We excluded borrowers with a PD ≥ 100%, i.e. borrowers in default.*

[3] *TRIM refers to the targeted review of internal models; see https://www.bankingsupervision.europa.eu/about/ssm-explained/html/trim.en.html.*

Our results show (1) a profound and, to our knowledge, as yet unreported decrease in bank-assessed riskiness of loans until 2019. While it is difficult to assess the underlying reasons, a tentative analysis suggests that firms' financial statements did not improve accordingly over the same time. We find that (2) deposit-financed banks tend to take greater risks than larger banks; the former are affected by monetary policy to a greater extent than larger banks and less by capital regulation. For large banks, by contrast, the effects work in the opposite direction (for related research, see Kerbl and Sigmund, 2016). To assess risky borrowers' ability to receive additional funds, we employ fixed effects panel regressions, where (3) we find that expansionary monetary policy induces risk taking by banks; (4) we confirm that this effect is stronger for deposit-financed banks and (5) we relate the overall decrease in credit risk as estimated by banks to improved economic conditions but also to the fact that capital requirements increased over the same period.

The paper proceeds as follows: in section 1, we review the literature on the link between capital regulation and banks' risk appetite and the risk-taking channel of monetary policy. We then present stylized facts about Austrian banks' credit portfolio allocation and the main variables of interest (section 2). Section 2.3 presents a simple empirical model that relates the changes in PDs to corporate fundamentals. Section 3 introduces a panel model that exploits bank heterogeneity in regulatory capital requirements, exposure to interest rates and other controlling variables to understand what drives banks' risk appetite. Section 4 concludes.

1 Literature review

Our research is particularly related to two strands of literature: (1) the link between capital regulation and banks' risk appetite and (2) the relationship between monetary policy and banks' risk taking in lending.

1.1 Regulatory capital requirements and banks' risk appetite in lending

Regulatory capital requirements affect banks' risk-taking behavior due to their risk-sensitive nature, which has been a goal of capital regulation at least since Basel II (Kerbl and Sigmund, 2009).[4] To comply with increasing regulatory capital requirements, banks may raise the numerator of the capital adequacy ratio, e.g. by retaining earnings, and/or reduce the denominator, e.g. by reducing the volume or the risk intensity of their assets. In fact, what banks mainly do is increase their capital, and only as a second-best option do they adapt their asset portfolio by decreasing lending, as shown by the observation of mere balance sheet changes and by bank surveys. Banks reducing their risk-weighted assets focus primarily on liquid non-core assets given the latter's typically high risk weights. As to banks' deleveraging priorities, Eidenberger et al. (2014), for instance, provide post-crisis evidence for Austrian banks, the Basel Committee on Banking Supervision (BCBS, 2019) for global systemically important banks, and a survey of the Bank of Finland (2019) for Finnish banks. The transmission mechanism of (higher) capital requirements to banks' portfolio allocation is as follows. Banks simultaneously plan their asset and

[4] *Capital requirements became more risk sensitive once Basel II was implemented in the EU in 2007 via the Capital Requirements Directive I. With the financial crisis etched in everybody's mind, capital requirements were further strengthened following the EU's 2014 implementation of Basel III via the Capital Requirements Regulation and Capital Requirements Directive IV, which also introduced macroprudential policy. See also Borio and Zhu (2008) and Kerbl and Sigmund (2009).*

liability structure (Cadamagnani et al., 2015). As banks shift to a higher share of equity funding, the opportunity cost of funding, i.e. their weighted average cost of capital, increases. Internal pricing mechanisms are responsible for how this cost is passed on – in view of banks' internal return targets, other strategic objectives, regulatory constraints and other external factors (e.g. competition with both banks and nonbank sources of financing, or the interest rate environment[5]). In turn, banks partly pass through this additional cost to new borrowers via higher credit spreads or fees. De-Ramon and Straughan (2017) present empirical evidence on short-term increases in banks' lending spreads to nonfinancial firms in the U.K. following shifts in banks' funding structures toward a higher share of equity financing. The implementation of higher (macroprudential) capital requirements might also have an impact on banks' asset composition. For example, Cappelletti et al. (2019) examine banks under the ECB's direct supervision (Single Supervisory Mechanism – SSM) in 19 euro area countries including Austria. They found that the implementation of the macroprudential buffer for other systemically important institutions (O-SII buffer) had led to a positive disciplining effect. Banks shifted their lending to less risky nonfinancial firms and households between 2014 and 2017. Overall, the relative change in banks' asset portfolio composition depends on how much equity borrowers consume (i.e. their risk weights) and on the risk-adjusted margins banks are able to generate.

The transmission mechanism is also influenced by bank health, e.g. in terms of banks' initial capitalization, their liquidity position and share of nonperforming loans (NPLs) in the credit portfolio. According to research, better capitalized banks show reduced risk-taking incentives and have more conservative loan pricing practices in the euro area (see Cappelletti et al.,2019, for SSM banks including Austria; Hirtle et al., 2016, for similar evidence on the U.S.A.). Various papers construct different measures of bank health and analyze its impact on credit quality. Andrews and Petroulakis (2019), for example, show for 11 European countries including Austria that, compared with healthy banks, weak banks were more likely to be connected to weak nonfinancial firms between 2001 and 2014.[6] Storz et al. (2017) link balance sheet data of nonfinancial firms to banks' characteristics. They show that "risky firms" are tied to stressed banks. According to their results, an increase in bank stress by one standard deviation was related to a 1% increase in the indebtedness of risky firms in euro area periphery countries from 2010 to 2014.[7]

From a financial stability perspective, it is important that banks set loan terms reflecting operating costs, expected credit losses as well as capital and funding cost. If risks are underestimated, credit growth may become excessive and credit

[5] *Changes in interest rates affect banks' cash flows, net interest margins, earnings and valuations of assets and thereby banks' capital. The interest rate environment also has an indirect impact on the balance sheets of borrowers and the overall economic situation. The strength of the link between changes in interest rates and capital varies depending on financial and economic conditions as well as on banks' specific balance sheet characteristics. The impact may be asymmetric between increases and decreases (Borio and Zhu, 2008).*

[6] *There is a 13% to 19% difference in lending to non-viable firms ("zombie firms") between healthy and weak banks. The measure of bank health used by Andrews and Petroulakis (2019) is based on a combination of several indicators (e.g. capitalization, NPL ratio, return on assets, maturity mismatch) to which the authors apply a principal component analysis. "Zombie firms" are defined as elderly firms with weak debt-servicing capacity.*

[7] *Cappelletti et al. (2019) construct an index of bank stress based on principal component analysis of five indicators (nonperforming loans, return on assets, capitalization, z-score and maturity mismatch).*

quality may deteriorate (e.g. Schularick and Taylor, 2009; Jordà et al., 2014).[8] Also, the cost of risk might surge in case of macroeconomic shocks. In sections 2 and 3, we investigate the link between capital requirements and Austrian banks' risk appetite in lending to the real economy and test whether the credit quality in banks' loan portfolios improved as regulatory capital requirements increased, which would be in line with the literature.

1.2 Monetary policy and banks' risk appetite in lending

Expansive monetary policy affects banks' asset and liability management via (1) "search for yield" triggered by squeezed profit margins and (2) an improvement in borrowers' balance sheets and asset valuations – especially during favorable economic conditions.

First, changes in short-term policy interest rates impact banks' pricing policies for loans and deposits.[9] But the pass-through of policy rates on deposits – the "retail deposit channel" – is incomplete with low or even negative interest rates. Banks become increasingly reluctant to pass on these short-term funding rates to retail deposits (Eggertsson et al., 2019). In turn, interest margins are compressed as assets are sequentially repriced, but the interest on deposits cannot go any lower. Kerbl and Sigmund (2016) show that the net interest income of small banks which are highly dependent on deposit financing is hit hardest by the low interest rate environment. Banks might compensate for the loss in interest margins in several ways, e.g. by increasing the non-interest component of banking services and/or lending to higher-yielding customers. As a case in point, banks in Italy with a higher deposit base responded to negative policy rates by raising their fees and commissions on loans more strongly than banks with a different funding structure (Bottero et al., 2019). Such an increase in fees on lending might also lead to a selection bias of borrowers as better rated customers might be offered more favorable terms and conditions by other banks.

Banks will also "search for yield" and increase their risk tolerance by lending to higher-yielding, riskier borrowers. From a bank's point of view, loans with the highest risk-adjusted margins are the most profitable, possibly enabling banks to achieve nominal returns similar to those when interest rates were higher (Gambacorta, 2009). From a financial stability perspective, such lending is justified if credit risk – and other cost components – are adequately priced in. The monetary policy rate level, the macroeconomic environment and bank-specific characteristics, e.g. capital and liquidity position, impact the intensity of the search for yield.[10]

[8] *Credit risks were mispriced in the run-up to the financial crisis, i.e. lending was made available at interest rates too low to cover risk costs. Parts of these funds went into lending for projects that only appeared to be profitable or were used for consumption. Consequently, high lending growth at low interest rates did not contribute to sustainable economic growth. Such loans placed a significant burden on the balance sheets of borrowers and banks alike (European Commission, 2019).*

[9] *Besides deposits, changes in policy interest rates also directly impact other bank funding sources, such as interbank loans and other nonbank debt financing sources (e.g. bonds) via relative changes in funding costs.*

[10] *Changes in monetary policy rates have an asymmetric impact on banks' behavior: the extent to which risk taking is encouraged by rate cuts is higher than the curtailing effect on risk taking triggered by an equivalent rate increase (Borio and Zhu, 2008). Dell'Ariccia et al. (2013) find for the U.S.A. from 1997 to 2011 that an increase in short-term policy interest rates is related to a reduction in banks' risk appetite in lending. The relationship is more pronounced for banks with high capital levels and less so during periods when banks' capital erodes.*

We may summarize empirical evidence as follows: Gaggl and Valderrama (2014) analyze the link between the short-term interest rate and the risk composition of banks' loan portfolios in Austria between 2003 and 2005. Their results suggest that banks allow more (expected) default risk in their loan portfolios if interest rates are sufficiently and persistently low and economic activity is improving significantly at the same time (Gaggl and Valderrama, 2014). Jiminez et al. (2008) show for Spain that low interest rates at loan origination are positively linked to the probability of extending loans to existing risky borrowers with a bad credit history. Following the introduction of negative interest rates by the ECB in mid-2014, banks in Italy rebalanced their asset portfolios by reducing liquid assets, namely interbank loans, and expanding credit supply (Bottero et al., 2019). Banks with higher ex ante net short-term interbank positions expanded credit especially to smaller and riskier firms and cut interest rates on loans (Bottero et al., 2019). Also, interest rate risk may rise as banks increasingly issue fixed rate loans. Kerbl et al. (2019) provide evidence that interest rate risks of Austrian banks have risen markedly during the phase of negative interest rates and relate this to the search for yield in times of margin compression.

Moreover, accommodative monetary policy aims at increasing aggregate demand and stimulating the business cycle, thereby reducing the frequency of defaults. Additionally, it can lead to increased collateral values. It also improves borrowers' debt-servicing capacity (e.g. Jordà et al., 2014). All these channels may lead to reduced credit risk in times of a (ceteris paribus) more expansive monetary policy stance.

However, these developments may also alter banks' risk perception, e.g. as the volatility of asset prices decreases. As a result, banks may take on more risk in their loan portfolio and may loosen their credit standards (Gambacorta, 2009). Existing riskier borrowers might find it easier to receive additional funds from banks. Also, banks might extend lending to existing borrowers with a view to preventing their default. In the extreme case, banks may keep existing insolvent borrowers alive, which is referred to as "evergreening" (Andrews and Petroulakis, 2019; Banerjee and Hofmann, 2018; McGowan et al., 2017). Clearly, evergreening is a variant of risk taking: instead of writing off a loan, the bank increases its stacks in hopes of a turnaround. Both the potential loss and gain increase as a result.

Maddaloni and Peydro (2011) find for the euro area and the U.S.A. that banks loosen credit standards when interest rates are lowered. In the U.S.A., loan pricing of riskier corporate borrowers was more favorable (relative to safer borrowers) during periods of expansive monetary policy as shown by Paligorova and Santos (2012). These results suggest that the price of loans did not adequately reflect the cost of risk.

More risk taking does not necessarily reduce financial stability if, for instance, risks are adequately priced and asset valuations are in line with fundamentals. However, if higher risk taking turns into excessive risk taking combined with asset overvaluations, financial imbalances are built up which can be particularly harmful to financial stability in times of crises. In section 3, we investigate whether expansive monetary policy encouraged risk taking in the past decade and whether deposit-financed banks are more inclined to risk taking compared to large banks.

2 Banks' lending risk appetite: data and stylized facts

We first describe the indicators and underlying data used to measure banks' risk taking before presenting stylized facts on Austrian banks' risk profile in lending to nonfinancial firms.

2.1 Defining risk appetite and related data applied in the analysis

Banks' risk appetite captures how much risk banks actively take on in their loan portfolio given their strategic objectives.[11] We specifically analyze PDs and the expected loss (EL) for both outstanding loans and new loans, as estimated by banks. We specifically focus on the existing risky part of banks' loan portfolios, exploring whether banks increasingly extended credit to existing risky borrowers over the past decade.

We use the Austrian credit register which contains data on a borrower-by-borrower basis of nonfinancial corporate borrowers whose exposure exceeds EUR 350,000 per bank. Among other items, each observation supplies us with the time-invariant ID of the borrower, the exposure, the borrower's rating, the PD and the collateral value.[12] Our sample covers all Austrian banks[13] from year-end 2008 to year-end 2019. We aggregate the individual loan data per bank to assess banks' risk profile in lending to the real economy and to exploit the variation across banks and time. The following risk parameters are calculated on a bank-by-bank basis for both outstanding and new loans.

First, the *borrower's PD* is the bank's internal estimate of a given customer's one-year default probability. In case of IRB banks,[14] the reported PDs correspond to those used by the banks to calculate their own funds requirements. In case of non-IRB banks, the PDs correspond to bank-internal estimates used for risk management. When we compare PDs that IRB banks and non-IRB banks use for identical customers, we find that non-IRB PDs tend to be higher, namely by 0.07 percentage points on average across the entire sample (whose weighted average is 1.58 percentage points). While this difference is no cause for concern, we will nevertheless control for this factor in our panel estimation in section 3.

Our data lack the second important risk parameter, the *loss given default (LGD),* which is why we approximate LGD values as follows: *LGD = 1 – collateral values/exposure*. Here, we only use the collateral values of eligible assets. This approximation is rather crude: workout of collateral values comes at a cost and realized values are typically below market values, while even unsecured parts of the exposure have recovery rates well above zero.[15]

[11] *For more information on the supervisory view on banks' risk appetite framework, see Nouy (2018).*

[12] *Changes in banks' pricing policies cannot be considered in the analysis as interest rates on a client-by-client basis are not available for the entire period of observation. Price information is only available for the newest time points that are based on the new supervisory data collection framework capturing individual loan information, which is harmonized across euro area countries (AnaCredit).*

[13] *"Austrian" refers to banks with a bank license issued in Austria.*

[14] *IRB is short for the internal ratings-based approach under which banks use these PDs for calculating their required level of own funds.*

[15] *We ran the analysis below, assuming a 50% recovery rate on unsecured exposures (approximately in line with regulatory parameters in IRB) and a 10% haircut on collateral values. Our results are valid under this alternative LGD proxy.*

The *expected loss (EL)* is calculated as follows: $EL = PD \times LGD \times EAD^{*}$ where the reported PD and LGD per borrower as well as a proxy for the exposure at default (EAD^{*}) are approximated by the total exposure.[16] While the EL of a portfolio varies through time, our dataset allows us to filter for new customers only and thus gain insight in banks' risk taking. For each bank, we look at the mean of the EL of new customers $(EL\_mean_{i,t})$. According to the literature reviewed in section 1, a search for yield might particularly affect the high-risk parts of the portfolio. Apart from the mean, we thus also look at the 95% quantile of the EL of new customers per bank and time $(EL\_q95_{i,t})$. To disentangle the effect on PD and LGD, we also look at the trajectory of the PDs separately $(PD\_mean_{i,t}, PD\_q95_{i,t})$.

Most importantly, we also calculate the *share of risky customers receiving additional funds* in outstanding loans: this measure sheds light on existing risky customers' access to additional bank credit. We define "risky" in line with the OeNB rating master scale which denotes customers with a PD > 2.73% as "highly speculative."[17] For those customers, we calculate the share of risky customers that received additional funds compared to all customers with a PD above that threshold[18], i.e.

$$\textit{Share of risky customers receiving additional funds}_{i,t} =$$
$$= \frac{\textit{number of risky borrowers}_{i,t,additional=TRUE}}{\textit{number of risky borrowers}_{i,t}}.$$

We further limit our cases to those where banks deliberately took on risk. To this end, we use a variation of this indicator by applying a restricted version of the numerator: banks that increased their lending to risky customers which at the same time showed increases in PD, LGD or both.

With these indicators we try to measure the risk-taking effect of easy money. A risky customer is expected to receive further funds only if the bank has abundant access to cheap money and if it is not constrained by tighter regulatory capital requirements, especially if the customer is not able to back the additional funds with additional collateral (and consequently the LGD increases). These indicators and their variations will serve to assess banks' risk taking and thus form the cornerstone of our analysis.

In section 3, we try to explain the cross-time and cross-section variance of these indicators by means of explanatory variables consisting of (1) macro variables, importantly the short-term policy interest rate, and (2) bank-specific characteristics. We derive data on bank-specific characteristics from the OeNB's regulatory reporting system. The data on banks include total assets, net interest margins, liquidity situation and – crucially – regulatory capital requirements. To capture the overall level of capital requirements and the amount of free capital per bank, i.e. the capital in excess of regulatory capital, we account for the regulatory changes

[16] *We did not use the unexpected loss (UL) as the UL is highly dependent on correlation coefficients which are hard to estimate.*

[17] *We excluded borrowers with a PD ≥ 100%, i.e. borrowers in default.*

[18] *Note that to qualify as a risky customer PD > 2.73% must hold for both the time point before and after the extension of additional funds.*

of the post-crisis era: the entry into force of Pillar II capital requirements[19] in 2009, as well as the implementation, in 2016, of the capital conservation buffer (CCoB) and of macroprudential capital buffers, such as the buffer for other systemically important institutions (O-SII buffer) and the systemic risk buffer (SyRB). We consider all phase-in arrangements for the buffer sizes and any changes in the levels of the buffers over time.[20] As banks anticipate changes in capital requirements ahead of the effective implementation date, we antedate changes in capital requirements by one year. Table A1 in annex 1 provides detailed definitions on the explanatory variables, and table A2 in annex 1 provides summary statistics.

2.2 Aggregate statistics on banks' risk taking in lending

Chart 1 depicts the main variables of interest. Panel (a) shows the general decline in interest rates, proxied by the 6-month EURIBOR, which characterized the period under investigation. Panel (b) highlights another fundamental change: increasing regulatory capital requirements. The panel differentiates between Austrian banks which are deposit financed (share of deposits exceeds 80% of total liabilities[21]) and large Austrian banks (total assets exceed EUR 30 billion). Deposit-financed banks tend to be smaller regional banks. While they too were impacted by general changes in regulation (e.g. the introduction of the CCoB), they were initially not charged with a capital add-on in Pillar II and are not subject to macroprudential buffers like the SyRB in Austria. Thus, we see a marked difference in the levels for the two groups of banks and a lagged pickup of capital requirements for deposit-financed banks.

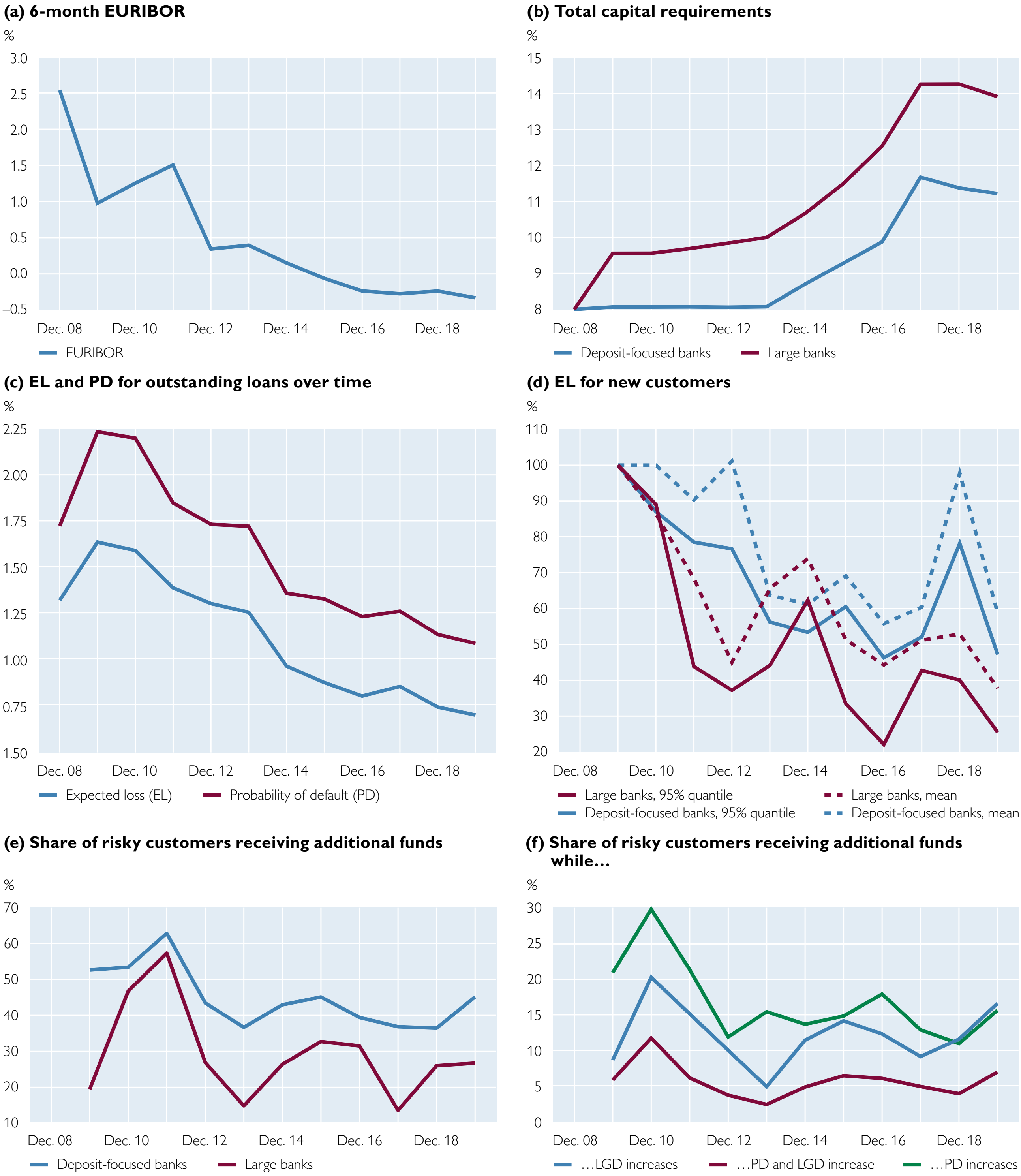
[19] *As the results for individual banks' Pillar II requirement are not available for the period up to 2018, we assume a 2% Pillar II capital requirement for any bank subject to the Pillar II process until the point in time when exact data are available. Given the low variation across time where data are available and across banks, we think this proxy is well justified. Before 2016, only large banks were subject to binding Pillar II requirements and these banks show a particularly stable distribution around 2%.*

[20] *The countercyclical capital buffer (CCyB) has been at 0% since its introduction in 2016, but foreign CCyB rates are relevant for Austrian banks with cross-border exposures.*

[21] *An 80% deposit share is a high threshold, so "deposit financed" might rather be thought of as "deposit focused." At year-end 2019, 336 deposit-financed banks had aggregated total assets of EUR 197 billion and six large banks had aggregated total assets of EUR 338 billion on an unconsolidated basis. The conditions for falling into either category are applied at each moment in time, which allows for in- and outward migration.*

Chart 1

Main variables of interest and measures of Austrian banks' risk taking in lending to nonfinancial firms



Source: OeNB: regulatoray reporting system, authors' calculations.

Panel (c) shows aggregate results for Austrian banks' estimates of credit risk. We restrict the sample to existing loans, i.e. filter out new customers for each point in time, in order to observe risk metrics of outstanding loans over time. The panel shows a substantial reduction of both the expected loss and probability of default of existing borrowers from 2010 onward. Risks in the loan book increased between 2009 and 2010, before dropping slightly between 2010 and 2011. Around that time, the turmoil of the financial crisis began to fade and the quality of loans as assessed by banks steadily increased, with EL and PD reaching values that were about half as high as the starting points. The financial crisis may have increased risk aversion among lenders. As our findings in sections 2.3 and 3 will show, this positive evolution of risk metrics relates to the favorable economic conditions in Austria, the increase in asset/collateral valuations (at least for EL) and the persistently low interest rate environment during the period under review. These developments may have also altered banks' risk perception as outlined in section 2.1.

Shedding light on banks' risk taking, panel (d) shows the expected loss for *new* customers only. Here we provide a breakdown of large banks versus deposit-financed banks and also show the mean of the EL of new customers and the 95% quantile[22]. Again, we observe a strong decrease in banks' PDs and ELs over the period under investigation. For both risk measures, we diagnose a stronger decline for larger banks vis-à-vis deposit-financed banks. This finding is in line with our expectations that deposit-financed banks are affected less by tightening regulatory capital requirements than by decreasing policy rates (Kerbl and Sigmund, 2016).

Panels (e) and (f) explore whether existing risky borrowers find it easy to receive additional funding, illustrating the share of risky customers receiving additional funds in all risky customers. In the past decade of monetary easing and tightening regulation (see panels (a) and (b)), this share decreased considerably, starting from initially high values. However, after this initial drop, the share of risky customers receiving additional funds hovered around the same level for the remainder of the period, with increases in the most recent observations (see panel (e)). Most recently, around 40% of existing risky customers received additional funds from deposit-focused banks (about 30% from large banks). Again, the split between deposit-financed and large banks in panel (e) indicates a higher risk appetite for deposit-financed banks, which supports the hypothesis that deposit-financed banks face greater margin pressure. Panel (f) indicates that only a relatively small share of risky customers whose PD (and/or LGD) worsened received additional funds. Since 2014, there has, however, been an increase in cases of additional funds being extended to risky customers whose LGD worsened at the same time, which suggests that these borrowers cannot provide additional collateral. There has also been a slight rise in cases where both LGD and PD increased.

To study the drivers of this development, we approach the dataset from two perspectives. First, we examine whether the marked PD and EL improvement evident in panels (c) and (d) is supported by stronger corporate financial statements (see section 2.3). Second, we exploit bank heterogeneity in section 3 to understand which bank characteristics determine banks' differing risk appetite.

[22] *For each bank and time point, we calculate the exposure-weighted distribution of EL across new customers. We first take the mean and the 95% quantile of this distribution for each individual bank and then for each time point average across banks (again exposure weighted).*

2.3 Decrease in credit risk attributable to stronger corporate financials?

Corporate financials ("hard facts") are a key input for banks' rating models. Lower PDs in banks' books can thus be traceable to three sources: (1) banks' customers have become healthier and show stronger financials (hard facts) in their financial statements, (2) economic conditions have reduced the general probability of default for a given level of hard facts, (3) banks' model-based PDs have not moved in line with the physical, true probabilities. In other words, lower PDs are not attributable to hard facts or better economic conditions but to changes in banks' rating models. From a financial stability perspective, (1) means that objective fundamentals back the reduced risk measured by the banks and is therefore the least worrisome of the three possible sources, (2) means that there is a strong cyclical component to credit risk in banks' books, and (3) means that either current risk metrics are too optimistic (alarming for supervisors) or earlier ones were too pessimistic.

We lack firm-by-firm accounting data that match our credit data, which would be necessary for a detailed distinction of the three sources. However, we can supplement our credit dataset with balance sheet and P&L data that provide average financials per industry and time (Bank for the Accounts of Companies Harmonized (BACH) database; see BACH-ESD Database, 2020). As in the BACH database financials are currently only available until year-end 2017, we must restrict our sample accordingly. In a simple regression, we regress industry-averaged PDs coming from our credit data on the financials of the BACH database. We add time-fixed effects, which should be zero under the hypothesis that the improvement in PDs can be solely attributed to improved financials (source (1) above). In this case, the relation of PDs and financials would be constant over time.

$$\overline{PD}_{i,t} = \alpha + \mu_i + \theta_t + \beta_1 Debt\ Ratio_{i,t} + \\ + \beta_2 EBITA_{i,t} + \beta_3 Turnover_{i,t} + \varepsilon_{it}$$

Where $\overline{PD}_{i,t}$ is the average PD per two-digit NACE sector i and time t, $Debt\ Ratio_{i,t}$ and $Turnover_{i,t}$ are the corresponding average hard facts[23], μ_i are sector-specific, time-invariant effects and Θ_t are time-fixed effects. If we set μ_i to zero, we obtain a pooled regression whose results are listed in the first columns of table 1. The hard facts are significant and meaningful, i.e. a higher debt ratio increases PDs, a higher EBITA lowers them. Once we allow for sector-fixed effects (right columns of table 1), these dominate the hard facts, which become insignificant.

Table 1

A simple rating model

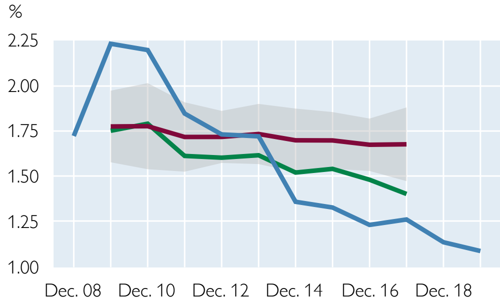
Variable	Pooled		Fixed effects	
	Estimate	Standard error	Estimate	Standard error
(Intercept)	0.002	0.249		
Debt ratio	0.028	0.004***	–0.001	0.006
EBITA to turnover	–0.008	0.002***	–0.000	0.003
Turnover mean	–0.002	0.001**	0.000	0.0001***
Time2009-12	0.484	0.172***	0.460	0.102***
Time2010-12	0.409	0.203**	0.423	0.122***
Time2011-12	0.236	0.182	0.130	0.098
Time2012-12	0.129	0.165	0.014	0.074
Time2013-12	0.105	0.143	–0.013	0.085
Time2014-12	–0.163	0.125	–0.342	0.09***
Time2015-12	–0.215	0.127*	–0.373	0.080***
Time2016-12	–0.251	0.121**	–0.445	0.074***
Time2017-12	–0.142	0.139	–0.418	0.105***
R^2	0.46		0.4	
Number of observations	782		782	

Source: OeNB, authors' calculations.
*Note: Codes denoting statistical significance: *** p < 0.01; ** p < 0.05; * p < 0.1. We use HAC robust standard errors.*

[23] *These key financial variables typically feature in standard rating models. Robustness checks by adding other financial variables (especially lags of those) did not produce any reason to deviate from our conclusion.*

Chart 2

Adjusted PD for outstanding loans over time



Source: Authors' calculations.

Note: Adjustment of PDs according to time dummies of pooled regression and fixed effects regression (with 95% confidence bands) of table 1. Confidence bands for the pooled regression are omitted to avoid overplotting.

Irrespective of whether we include sector-fixed effects, we see that the time dummies start with a positive sign in 2009, become smaller over time and turn negative around 2014. After that, the models disagree on the size of the coefficients, whose statistical significance likewise varies. However, if we ignore the methodological issues discussed below, this means that a part of the reduction in PDs cannot be explained by better financials; otherwise, the time dummies would be zero. As a case in point, the fixed effects regression in table 1 shows that PDs in 2017 are estimated to be 0.41 percentage points lower than those in 2008 for the same fundamentals. Chart 2 updates panel (c) of chart 1 accordingly and adds the estimated time-fixed effects to the evolution of the average PDs. Whereas under the pooled regression model the decline in PDs is still visible and strong, it is almost flat for the fixed effects model. This strong disagreement with regard to the size of the adjustment (33% vs. nearly 100%) shows the high level of uncertainty in the estimations.

A part of the improvement in PDs thus either results from a changed macroeconomic environment that produces fewer defaults for the same financials (source (2) above), or from a shift in the relation between banks' PD estimates and true PDs (either toward greater alignment, or away from it; source (3) above).

This is difficult to ascertain for lack of better data linking financials to credit on a firm-by-firm basis. Also, we must emphasize the limitations of the simple model of table 1 and warn against overemphasizing these results for the following reasons. As the BACH database provides only industry aggregates and no microdata, we cannot establish a link to a specific bank. In technical terms, there is an identification problem: perhaps gross industry financials have not improved while those parts that banks lend to have. For instance, advances in risk management, especially in the loan granting and customer selection process, could have improved banks' credit risk ratings. More research with microdata is needed to tackle this shortcoming.

In the next section, we exploit bank heterogeneity to try to disentangle different developments across the banking sector.

3 Bank heterogeneity

To better understand the drivers of banks' risk appetite in lending, especially with regard to the interest environment and capital regulation, we set up a panel model to control for bank characteristics. Do banks which are more affected by the low interest rate environment and/or tougher banking regulation act differently?

The specification regresses our metrics of credit risk ($EL_{i,t}$, $PD_{i,t}$ and *Share of risky customers receiving additional funds*$_{i,t}$; see section 2.1) on the change of the interest rate, a dummy indicating whether the bank is classified as deposit financed and not a large bank (>80% deposit share of liabilities and total assets of < EUR 30 billion), on an interaction term of these two variables to elicit whether deposit-financed banks are affected differently, on the level of capital requirements the bank is exposed to and on further control variables. These control variables comprise bank-specific variables, such as liquidity position and net interest margin, as well as macroeconomic variables like growth of house prices and GDP. To further account for the favorable economic situation, we add the economy-wide improvement in PDs of outstanding loans. We add fixed effects for banks and time and differentiate those variables for which the augmented Dickey-Fuller test does not reject the null hypothesis of non-stationarity (interest rates, house prices and total capital requirements).

The general specification looks as follows:

$$\begin{aligned} &credit\ risk\ metric_{i,t} \\ &\qquad = \alpha + \mu_i + \theta_t + \beta_1 intr_t + \beta_2 deposit\ focused_{i,t} \\ &\qquad + \beta_3 deposit\ focused_{i,t}\ x\ intr_t + \beta_2 capital\ requirement_{i,t} \\ &\qquad + \beta_3\ further\ control\ variables_{i,t} + \varepsilon_{it} \end{aligned}$$

where $i=1,..,N$ is the bank index and $t=1,..,T$ is the time index, βs represent the parameters, μ_i the bank-fixed effects, Θ_i the time-fixed effects and $\varepsilon_{i,t}$ is the disturbance term.

The results are shown in table 1, with asterisks marking statistical significance using HAC robust standard errors. Controlling for the general macroeconomic environment, a reduction in the interest rate is associated with increased risk taking. This is in line with previous research (e.g. Gaggl and Valderrama, 2014). By our estimate, a 1- percentage-point reduction in interest rates increases the EL of new customers by 2 percentage points and the share of risky customers receiving additional funds by 20 percentage points. Deposit-focused banks tend to be less prepared to extend additional funding to risky customers, but the effect is small and insignificant with regard to the EL and PD of loans to new customers. Importantly, a reduction in interest rates affects deposit-focused banks more strongly as shown by the interaction term of such banks and the interest rate. This is in line with the assumption that deposit-focused banks come under stronger margin pressure and therefore react more strongly to rate cuts by extending funding to risky customers.

Capital requirements, the second major focus of the study, reduces risk taking across all metrics. Surprisingly, even when controlled for overall capital requirements and the amount of a bank's free capital, the SyRB further reduces lending to risky customers if they cannot provide additional collateral (see columns with LGD increases in table 2). Also, together with free capital and the change in total capital requirements, the introduction of a 1% SyRB reduces the EL of new customers by around 30 basis points, which is a modest but not negligible effect. Concerning the share of risky customers receiving additional funds, the coefficients of these three variables add up to an approximate 4-percentage-point reduction given a 1-percentage-point increase in capital requirements.

Table 2

Explaining bank heterogeneity regression results

Variable	Share of risky customers receiving additional funds	…while PD increases	…while LGD increases	…while PD and LGD increase	EL for new loans	PD for new loans
(Intercept)	0.047	–0.193***	0.128***	0.021	0.06***	0.062***
d EURIBOR	–22.617***	–19.043***	–2.906*	–0.271	–2.255***	–2.279***
Deposit focused	–0.016*	–0.028***	–0.019***	–0.014***	0	–0.001
Interact Deposit focused x d EURIBOR	–5.005***	–3.105***	–2.43***	–0.749*	0.133	0.16
d Total capital requirement	–2.188***	–3.046***	–0.38**	–0.864***	–0.102**	–0.134**
SyRB	–1.515***	0.552	–0.812**	–0.564**	–0.254***	–0.334***
Total capital free	0.598***	–0.023	–0.171***	–0.071***	–0.025***	–0.021***
Liquidity to total assets	–0.285***	–0.206***	–0.045**	0.022*	0.016***	0.017***
Macro effect	–63.84***	–41.677***	–19.028***	–1.991	–5.533***	–5.595***
d House prices	–0.009**	–0.008**	–0.005**	–0.002	–0.001*	–0.001**
GDP growth	2.045**	7.621***	–1.589***	0.859**	1.063***	0.951***
IRB yes	–0.074***	–0.074***	–0.052***	–0.049***	–0.002	–0.004**
Interact Total capital free x d EURIBOR	23.608***	–1.906	–6.651***	–2.316**	–4.605***	–4.603***
R^2	48	38	49	36	35	36
Number of observations	5,508	5,508	5,508	5,508	6,229	6,229

Source: OeNB, authors' calculations.

*Note: Codes denoting statistical significance: *** p < 0.01; ** p < 0.05; * p < 0.1. We use HAC robust standard errors.*

Across the various specifications, there are mixed results for the amount of free capital: more capital in excess of regulatory requirements increases banks' willingness to extend additional funds to risky customers, except when borrowers' credit standing deteriorates. At the same time, more free capital tends to reduce the EL and PD of new customers, but the effect on the expected loss of new customers is small (a 1-percentage-point increase in free capital decreases the EL of new customers by 2 to 3 basis points). However, we caution against over-interpreting these coefficients as they must be seen in tandem with total capital requirements and the SyRB. The same holds true for the macro effect, house prices and GDP growth, i.e. our indicators meant to capture the economic environment. The macro effect, i.e. whether the PDs of all outstanding loans increase or decrease, has a low scale, with a maximum value of around 0.004, thus giving rise to a large coefficient. For all three indicators, favorable economic conditions reduce the metrics of risks banks take on in their balance sheets, although the coefficient for GDP in isolation indicates the opposite. During the period under investigation, economic conditions tended to be favorable and capital requirements tended to increase. Still, due to cross-time and cross-section variance in these trends, i.e. not all years exhibit benign conditions and for some banks the increase in capital requirements came sooner and more strongly, the model is able to disentangle the causes.

IRB banks tend to be more cautious in lending to risky customers, which may relate to the higher risk sensitivity of their capital requirements. Over time, IRB banks reduced their PDs of new customers more strongly than non-IRB banks, but the economic significance of this effect is small, with the EL being neither economically nor statistically significant.

On the question whether banks with high levels of free capital are affected more, or less, by changing monetary policy, the results for the interaction term of free capital with the interest rate indicate that such banks take on higher risks with regard to new customers when policy rates drop (in line with Dell'Ariccia et al., 2013), while the results are mixed as to lending to risky customers.

4 Summary and conclusions

To learn more about Austrian banks' lending risk appetite over the past decade, we created and examined an extensive dataset comprising individual corporate loans exceeding EUR 350,000 that were granted by Austrian banks between 2008 and 2019. The data revealed a profound improvement in banks' estimates of loan quality, as measured by (1) banks' estimated expected loss (EL) per loan, banks' probability of default (PD) per borrower and (2) the share of existing risky customers receiving additional funds. We found, however, that firms' financials did not improve in tandem with the PDs (see section 2.3). This suggests that macroeconomic factors directly affect the relation between such hard facts and banks' PDs. Also, banks subject to tightening capital requirements reduced their PDs and ELs more markedly. Easing monetary policy – after controlling for the macroeconomic environment – increased banks' risk taking. The latter effect, though smaller than the effect triggered by economic conditions and tightening regulation, was particularly pronounced for banks relying on customer deposits in their funding structure. We explain the difference in banks' behavior by the fact that as interest rates go to zero and beyond, deposit-financed banks come under an ever-stronger margin pressure, which they compensate by taking more risks in lending. While our findings relate to overall credit developments, specific banks and specific portfolios might show a different development. From 2019 onward, the situation needs to be reassessed. Already before the COVID-19 crisis, economic forecasts predicted growth to slow in 2020. Since the outbreak of the coronavirus pandemic, the economic situation – which we found to be particularly important for overall credit quality – has worsened substantially. For this reason, we zoomed in on the credit risk development of industries hardest hit by the pandemic and the related shutdown of most parts of the economy (see annex 2). In times of crisis, loan quality will deteriorate at a pace and in size corresponding to the effectiveness of policy measures. But for the severity of a crisis, the starting point matters, too. Basing our analysis on banks' estimates, we concluded that at least on this issue no alarm bells need to be sounded. On a cautious note, improving asset quality in the past implies lower risk-weighted assets. Importantly, the macroprudential capital buffers applicable in Austria will help absorb the shock. Such buffers, which are intended to cushion severe shocks, will need to be replenished after the crisis in order to rebuild financial stability. This is to safeguard that banks will have renewed absorbing capacity for future shocks.

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Annex 1: Definitions and summary statistics

Table A1

Description of main variables of regression table 2 (bank heterogeneity estimates)

Abbreviation used in regression table	Variable description	Source
Share of risky customers receiving additional funds	Share of risky customers receiving additional funds, see section 2.1	OeNB
…while PD increases	Share of risky customers receiving additional funds while PD increases, see section 2.1	OeNB
…while LGD increases	Share of risky customers receiving additional funds while LGD increases, see section 2.1	OeNB
…while PD and LGD increase	Share of risky customers receiving additional funds while PD and LGD increase, see section 2.1	OeNB
EL for new loans	EL for new customers, see section 2.1	OeNB
PD for new loans	PD for new customers, see section 2.1	OeNB
d EURIBOR	Year-on-year change in 6-month EURIBOR	OeNB
Deposit focused	Deposit-focused bank, dummy variable (1 = if bank has a share of total deposits/total assets at the unconsolidated level > 80% and has total assets of > EUR 30 billion)	OeNB
d Total capital requirement	Year-on-year change in total regulatory capital requirements consisting of: 8% Pillar I + 2% Pillar II approximation + 2.5% CCoB (with phase-in period) + 2% max. O-SII and SyRB buffer (with phase-in period) + 0% CCyB	OeNB
SyRB	Regulatory capital requirement of the systemic risk buffer of 2% max. (with phase-in period)	OeNB
Total capital free	Excess capital (or deficit) in % of risk-weighted assets, at the consolidated banking level	OeNB
Liquidity to total assets	Liquid assets in % of total assets, at the unconsolidated banking level	OeNB
Macro effect	Year-on-year change in the weighted mean of PDs of loans outstanding to all banks	OeNB
d House prices	Year-on-year change in nominal house prices, Austria (index 2015=100)	ECB
GDP growth	Year-on-year change in real GDP, Austria	ECB
IRB yes	Dummy variable (1 if bank applies IRB approach; 0 otherwise)	OeNB

Source: Authors' compilation.

Table A2

Summary statistics of the main variables of interest of regression table 2 (bank heterogeneity estimates)

Variable	Minimum	Median	Mean	Maximum	Standard deviation
Share of risky customers receiving additional funds	0.00	0.33	0.37	1.00	0.28
…while PD increases	0.00	0.11	0.19	1.00	0.25
…while LGD increases	0.00	0.05	0.13	1.00	0.19
…while PD and LGD increase	0.00	0.00	0.07	1.00	0.15
EL for new loans	0.00	0.01	0.02	1.00	0.04
PD for new loans	0.00	0.02	0.03	1.00	0.04
d EURIBOR	–0.02	–0.00	–0.00	0.00	0.01
d Total capital requirement	–0.06	0.00	0.00	0.09	0.01
SyRB	0.00	0.00	0.00	0.02	0.00
Total capital free	–0.06	0.07	0.13	40.54	0.78
Liquidity to total assets	0.00	0.15	0.18	1.00	0.16
Macro effect	–0.00	0.00	0.00	0.00	0.00
d House prices	2.68	4.14	4.93	9.77	2.18
GDP growth	–0.04	0.02	0.01	0.03	0.02
IRB yes	0.00	0.00	0.07	1.00	0.26

Source: Authors' calculations.

Note: The sample covers year-end data from 2008 to 2019 (last data point: Q4 2019).

Annex 2: COVID-19: Zoom-in on selected industries immediately hit by the pandemic-induced economic crisis

This short section was written with a view to better understand the starting position of Austrian banks vis-à-vis the pandemic-induced economic crisis. Research has shown that the starting point to enter a crisis determines how severely financial stability and the real economy are hit (e.g. Arcand et al., 2012). In order to limit the spread of the coronavirus, Austrian authorities implemented, and continuously tightened, containment measures, such as travel bans, prohibiting large gatherings in public spaces, school closures and full lockdown of several regions in Austria. International supply and value chains became disrupted due to the international dimension of the crisis, with many countries taking containment measures. While nearly all economic industries will be affected by a supply and/or a demand shock, it is generally agreed that the following NACE industries are hit particularly hard:

(1) Air transport (H51),
(2) Accommodation (I55), food and beverage service activities (I56),
(3) Arts, entertainment and recreation (R)
(4) Other services activities (S)

Below, we show the development of important credit risk metrics for these industries. First, we show the exposure-weighted probability of default (PD); second, the exposure-weighted expected loss (EL), which takes collateral into account. The EL equals PD x loss given default (LGD), where the latter needs to be proxied in our dataset. We use a crude estimation for the LGD, *1 – eligible collateral / exposure*. See section 2.1 of the paper for details and panel (c) of chart 1 for total credit.

We see that the credit metric in all four industries is diverse (see table B1 and chart B1 of annex 2). Airline exposure at the beginning of the time series was marked by extraordinarily high PDs, so high actually that we checked data accuracy line by line and did backup research on the cases. The data are correct, and the high average PDs in those times resulted from foreign airlines hit by aircraft failure and corporate mismanagement. These exposures were stripped down and the credit quality subsequently improved around 2014 and stayed around this level. The small difference between PD and EL is due to little eligible collateral in this industry. At 0.3%, its year-end 2019 share in Austrian banks' loan exposure is very small.

Also, for the other industries, which exhibit a higher exposure, a downward trend can be diagnosed. Accommodation, food and beverage service activities, which account for a share of 5% in total outstanding loans, rank among the industries that are generally riskier, with higher-than-average PDs and a high share of risky exposures (see table B1 of annex 2). In the same vein, arts, entertainment and recreation showed above-average PDs in the past, but credit indicators converged to average values of total corporate loans outstanding. At about 0.5%, its share in outstanding loans is small. Credit risk parameters of other services activities, which include e.g. cosmetic and repair services, broadly mirrored the developments seen for overall outstanding loans. Therefore, exposure to customers with a high PD is very low compared to the other industries shown in table B1 of annex 2.

From a financial stability perspective, the improvement in credit quality as assessed by banks over the past years is reassuring. Less comforting are the higher PD and EL levels evident in particular for accommodation, food and beverage service activities, compared to average credit risk in outstanding loans. Authorities in Austria have introduced a variety of measures to support the economy to prevent firms from suffering from undue liquidity shortages. For banks, the improved asset quality in the past implies a good starting point, while also implying lower risk weights for these assets. Importantly, the buildup of macroprudential capital buffers in the past was worth the effort, as the buffers now help cushion the shock. This cushion is intended to be used in times of crisis, implying no supervisory consequences other than payout restrictions concerning dividends, bonuses and additional tier 1 (AT1) coupons. When the crisis is over, the buffers will need to be replenished.

Table B1

Credit risk metrics of industries immediately hit by the ongoing coronavirus pandemic and the related economic shutdown (at year-end 2019)

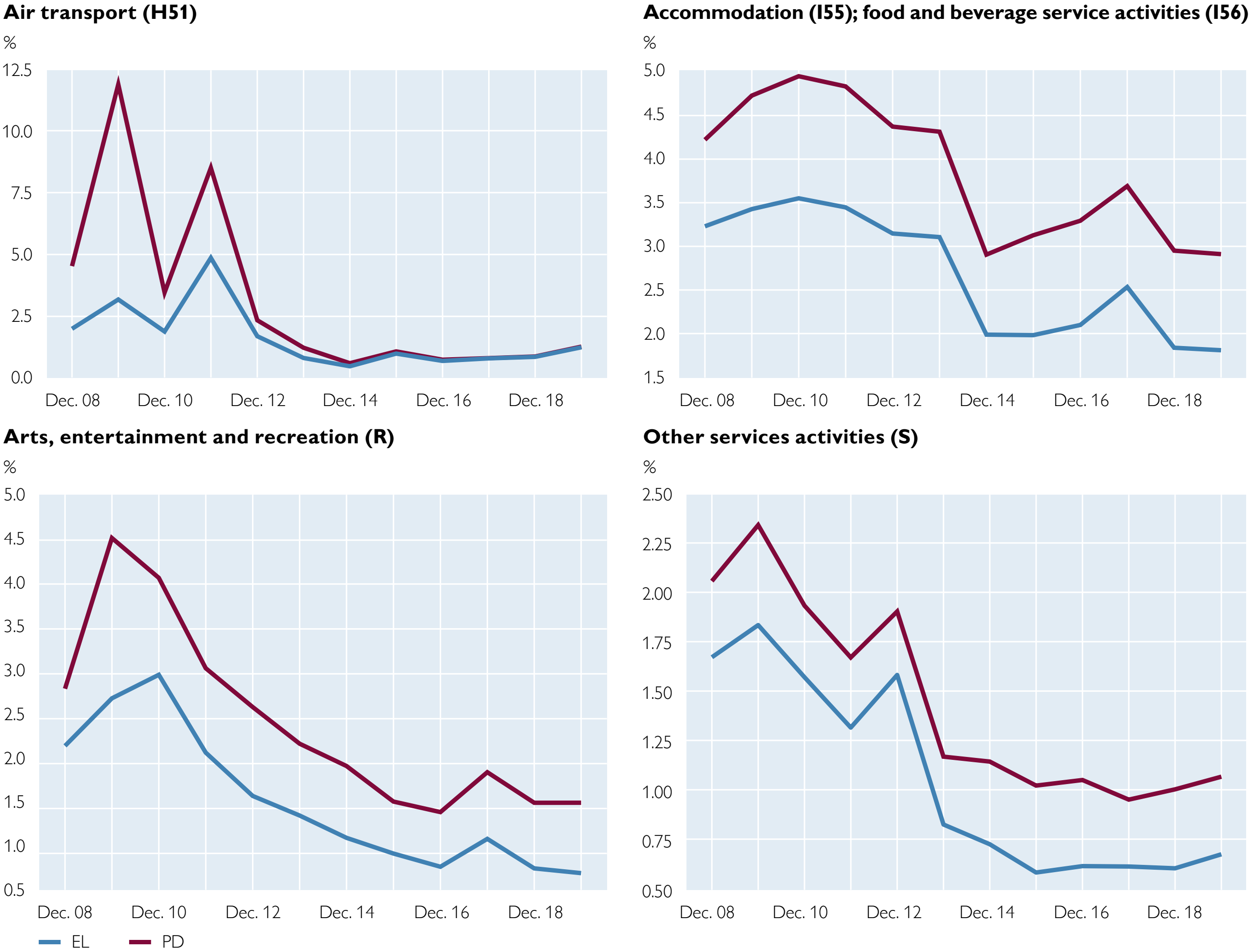
Industry	Exposure	Expected weighted PD	Share of exposure with PD > 2.7%
	EUR million	%	
Air transport (H51)	935	1.6	8.7
Accommodation (I55); food and beverage service activities (I56)	10,365	3.2	20.4
Arts, entertainment and recreation (R)	1,159	1.7	16.4
Other services activities (S)	2,304	1.0	5.7
All sectors	300,929	1.1	8.0

Source: OeNB (central credit register).

Note: Codes in parentheses indicate the NACE (2008) industry codes. For information on exposures, see section 2.1.

Chart B1

PD and EL for loans outstanding to service industries immediately hit by the coronavirus crisis



Source: OeNB.