From low to negative rates: an asymmetric dilemma

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With the expansionary monetary policy in several European countries continuing, the low interest rate environment is being increasingly replaced by a negative interest rate environment. We estimate a panel model to study the effects of prolonged low interest rates on banks in Austria. It shows that the profitability of banks declines in times of low interest rate environments. However, we are skeptical of extrapolating these findings to the negative environment.
In a negative environment banks face an asymmetric dilemma: While the returns on many assets follow the decreasing reference rate (e.g. EURIBOR), costs of deposits are floored at zero and cannot follow this rate. In order to include this crucial nonlinearity and to estimate which banks are expected to suffer most, we amend our approach and employ an ARIMA model on a bank-by-bank basis. First, we find that small regional banks are hit hardest. These banks have a high share of deposits and are more sensitive to changes in the reference rates. Second, by only looking at data covering low interest rates (e.g. our panel approach) one would indeed underestimate the impact of negative rates on banks' profitability. Third, we find that a reference rate close to –2% would pose a substantial burden on banks' profitability. The approach assumes little adaptation of banks to these extreme environments and therefore highlights the importance of banks' adequate and timely reaction should interest rates continue to be negative.

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What is the effect of low interest rates on banks' profitability? While it is reasonable to assume that a flat yield curve puts pressure on banks' net interest income (for banks engaging in maturity transformation), the effect of a low interest rate level (i.e. a parallel movement of the yield curve) on a bank's net interest margin (NIM) is less clear. If the asset and liability sides of a bank are symmetrically affected by the parallel shift, then there will be no impact. However, recent studies, e.g. Claessens et al. (2016), Genay and Podjasek (2014) or Busch and Memmel (2015), show that the lower the interest rate environment is, the lower net interest income from banks is. This suggests that some liability positions do not react or react more sluggishly than the asset side to changes in the interest rate level.

The contribution of our paper concerning the low interest rate environment is twofold. First, empirical studies show that there is substantial heterogeneity in the impact of the low interest rate environment on banks across jurisdictions (Claessens et al., 2016). Therefore, by analyzing the Austrian banking market, we add to these findings. Second, studies so far focused only on large international banks (Claessens et al., 2016; Borio et al., 2015) where data coverage is best. However, under the hypothesis that large banks typically have a greater ability to manage interest rate risks and can increase lending in foreign countries more easily (Claessens et al., 2016), smaller banks will be more affected by a low interest rate environment. We explicitly test this hypothesis in a panel econometric approach in section 2.

With the expansionary monetary policy in many countries continuing, the low interest rate environment is being increasingly replaced by a neg-

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ative interest rate environment. A number of countries or currency areas have introduced negative central bank deposit rates over the past few years: Denmark (July 2012), the euro area (June 2014), Switzerland (December 2014), Sweden (February 2015), Bulgaria (November 2015), Japan (January 2016) and Hungary (March 2016) (Scheiber et al., 2016). Similarly, the list of sovereign bonds trading at negative yields is growing. Bean et al. (2015) present a comprehensive background summary of these developments and the IMF (2015) provides a comparison of key related figures for several banking markets.

A central question is whether the insights gleaned from an analysis of the low interest rate environment can be extrapolated to a negative environment. While this depends on the legal setting of a country, we argue below that for Austria this is not the case and that negative interest rates are a game changer and have a profound impact on banks' profitability.

To see why the impact of a negative interest rate environment might differ from a low interest rate environment, consider the following basic banking model: A bank refinances itself at a reference rate (e.g. EURIBOR) plus an add-on (e.g. a spread depending on its credit quality). Let us call this sum "the total refinancing rate." The interest charged on its asset side is the total refinancing rate plus a surcharge to cover operational costs, (expected) risk costs and cost of equity (i.e. unexpected risk costs). The key issue of the current situation is that the refinancing rate of retail deposits is floored at zero, while this floor is not passed on to the asset side. This means that if market rates drop the asset side potentially follows suit and even drops into negative territory while the bank still pays for its refinancing. In other words: A negative interest rate environment causes the reference rate to be unrepresentative of the true refinancing rate of a bank. We see that the bank will suffer high losses if interest rates move far enough into negative territory and the bank holds deposits.

From a financial stability perspective, this risk is of high relevance as many financial institutions are exposed to it at the same time. We focus on the situation in Austria, where the zero floor on deposits rests on a Supreme Court decision.[2] Banks in other European countries face a similar situation (see e.g. Drescher et al. (2016) for the situation in Germany). On the asset side zero or negative rates are clearly relevant for sovereign bonds holdings, for interbank claims and – most crucially – also for customer loans typically tied to the EURIBOR. According to several court decisions[3] a negative reference rate has to be passed on to the interest charged on customer loans.

In other words, banks experience a systemic mispricing of assets, not because the risk has been incorrectly assessed, but because the refinancing rate does not reflect the true conditions the bank faces once rates move into the negative.

[2] *See court case decision 5 Ob 138/09v of the Supreme Court of Justice (October 13, 2009).*

[3] *While total negative interest on customer loans is ruled out, negative reference rates need to be passed on until the total rate reaches zero (Oberlandesgericht Innsbruck, 4 R 58/16k, July 14, 2016, AK vs. Hypo Tirol). See also court case decisions dealing with Swiss franc-denominated foreign currency loans where the reference rate, CHF Libor, had already moved into negative territory at the end of 2014: Landesgericht Feldkirch (5 Cg 18/15z, August 28, 2015, VKI vs. Raiffeisenbank am Bodensee), Handelsgericht Wien (57 Cg 10/15v, September 24, 2015, VKI vs. Uni Credit BA) and Landesgericht Eisenstadt (27 Cg 32/15x, November 15, 2015, VKI vs. HYPO-BANK Burgenland). A case at the Supreme Court of Justice is currently pending.*

This asymmetric dilemma is as new to banks as negative rates are to history.

To estimate banks' profitability under negative rates we use an ARIMA[4] forecast modeling approach that is adjusted to account for the floor on deposits. This allows us to simulate banks' profitability under hypothetical negative rates (section 3) and the assumption that banks do not adjust their product pricing substantially.

Importantly, we do not intend to make a judgment on monetary policy by conducting these simulations as we take a narrow look at the effect of interest rates whilst monetary policy must be based on a comprehensive view of the transmission mechanism. In addition, banks' reactions to negative rates will be more dynamic (e.g. adjusting fees for certain products) than assumed here.

1 Low interest rate environment: a panel econometric approach

In this section we estimate the effect of changes in the interest rate environment on the NIM of banks by employing a panel econometric approach. The NIM is the main source of income for Austrian banks accounting for around two-thirds of their total earnings.

1.1 The data

Our empirical analysis is based on quarterly unconsolidated supervisory data reported by domestically operating banks according to national Generally Accepted Accounting Principles (GAAP). A considerable advantage compared to other studies is that our dataset features all banks in Austria, small or large, whereas other studies typically oversample large banks for data availability reasons.

Bank-specific variables are built using data from balance sheet items, the profit and loss statement and data on regulatory capital and capital requirements. The observation span runs from the first quarter of 1998 to the first quarter of 2016, yielding $T=73$ time periods. We consider all institutions that held a banking license at some point during the sample period, but exclude special purpose banks and affiliates of foreign banks in Austria, thus arriving at a sample of $N=946$ banks.

As control variables we use a wide set of bank-specific and macroeconomic variables (see table 1). Macroeconomic data are taken from the OeNB's macroeconomic dataset. To prevent outliers from distorting the empirical analysis, we apply a two-stage cleaning algorithm to the variables used. First, we eliminate outliers across banks for each time period. An observation is considered an outlier if it is too far from the median (more than four times the distance between the median and the 2.5% or 97.5% quantile). In a second stage, we eliminate outliers across time for each bank. Here, the threshold distance is defined as 12 times the distance between the median and the 10% or 90% quantile.[5] Such parameters ensure that the number of removed observations remains limited and the resulting distributions exhibit a reasonable shape when judged from a qualitative perspective. This procedure eliminates 0.77% of observations that are considered as reporting errors and leaves us with around 48,000 observations.

[4] *ARIMA stands for autoregressive integrated moving average.*

[5] *This procedure was not invented for this exercise but is an established good practice used to remove reporting errors in the regulatory reporting system in many supervisory applications relying on regressions (Gunter et al., 2013).*

1.2 The model

To assess the average effect of the interest rate level on a bank's interest margin we employ a static one-way panel regression that reads as follows:

$$y_{i,t} = \alpha + \beta' X_{i,t} + u_i + e_{i,t}; \quad i = 1,\cdots,N; \; t = 1,\cdots,T, \qquad (1)$$

where $y_{i,t}$ denotes the dependent variable (NIM), $X_{i,t}$ the K explanatory variables and $e_{i,t}$ the idiosyncratic error term. α in equation 1 represents the global intercept, β' the K regression coefficients of the explanatory variables and u_i the bank-specific effect. We chose the specification after running a set of statistical tests (see annex B) and building on the previous

Table 1

Description of variables

Name	Description	Normalized by total assets	Expected sign on NIM
Dependent variable:			
NIM	Net interest income over total assets	by definition	n.a.
Explanatories of particular interest:			
EURIBOR	Short-term nominal interest rate (3-month EURIBOR) p.a.	no	+
EURIBOR^2	EURIBOR squared (but with the sign kept)	no	±
Term spread	10-year Austrian government bond yield minus short-term interest rate	no	+
Interaction: EURIBOR x RBD	Interaction effect including regional bank dummy (see below)	no	+
Bank-level control variables:			
RBD	Regional bank dummy: 1 if at least one branch per EUR 25 million of total assets and at least 60% of deposits financed, otherwise 0.	no	+
Total assets	log of total assets	no ±	
Euro loans to domestic customers	Loans to domestically domiciled nonbanks (i.e. customers) in euro	yes	+
FX loans to domestic customers	Loans to domestically domiciled nonbanks (i.e. customers) in currencies other than euro	yes	+
Loans to foreign customers	Loans to foreign domiciled nonbanks (i.e. customers)	yes	+
Interbank loans	Loans to domestic and foreign banks, all currencies	yes	+
Interest-bearing securities	Exchange-traded interest-bearing securities (held as assets) issued by domestic and foreign banks and nonbanks	yes	+
Nonbank deposits	Deposits taken from domestic and foreign nonbanks (i.e. customers)	yes	–
Bank deposits	Deposits taken from domestic and foreign banks, all currencies	yes	–
Securitized debt	Liabilities in the form of securitized debt obligations and transferable certificates	yes	–
Net fee income	Net fee and commission income	yes	–
Staff expenses	Staff expenses	yes	+
Other administrative expenses	Administrative expenses other than staff expenses	yes	+
RWAs to total assets	Average risk-weight (credit risk only)	by definition	±
LLP ratio	Specific loan loss provisions over gross exposure (loans to domestic and foreign nonbanks)	no	±
Macroeconomic control variables:			
GDP growth	Annual growth of quarterly real GDP	no	+
Unemployment growth rate	Harmonized unemployment growth rate	no	–

Source: OeNB.

Note: Theoretical considerations and/or evidence in the existing literature suggest that the impact of a variable on the NIM is either positive (+), negative (–) or mixed (±).

work of Gunter et al. (2013). In this notation, $X_{i,t}$ includes explanatories labeled explanatories of particular interest, bank-level control variables and macroeconomic control variables (see table 1).

1.3 The results

Table 2 displays the coefficient estimates of the panel model. For brevity, we will focus here on the regressors that are of interest to us. Our results suggest that a drop of 1 percentage point in the EURIBOR is on average associated with a drop in the NIM of around 15 basis points. However, the nonlinear term is also highly significant and negative: The higher the EURIBOR rate, the less effect a change in interest rate levels has on the NIM. This pronounced nonlinearity effect is in line with the findings of Borio et al. (2015) and Claessens et al. (2016) and is also depicted in chart 1.

Furthermore, the model output suggests that a 1 percentage point decrease in the difference between long and short rates, i.e. a flattening of the yield curve, causes the NIM to drop by 11 basis points. While regional banks have on average a higher NIM (by 10 basis points), they are more affected by changes in market rates, although only slightly, i.e. by +1.7 basis points compared to other banks. That smaller banks are more strongly affected is in line with the findings of Genay and Podjasek (2014). See annex C for a discussion on the regression coefficients that are not directly connected with the interest rate level.

Table 2

Panel estimation result: coefficients and robust standard errors

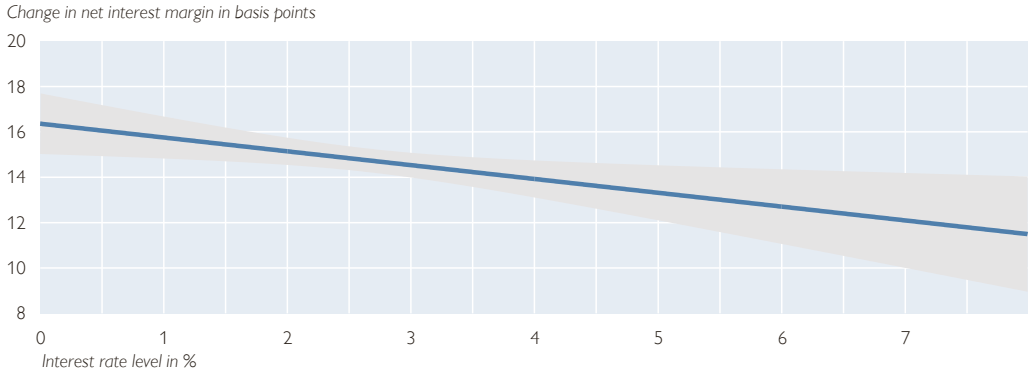
	Coefficients	(Standard errors)
EURIBOR	0.164	(0.005)***
EURIBOR^2	–0.003	(0.001)**
Term spread	0.115	(0.003)***
Interaction: EURIBOR x RBD	0.017	(0.003)***
RBD	0.098	(0.010)***
Total assets	–0.400	(0.009)***
Euro loans to domestic customers	4.270	(0.042)***
FX loans to domestic customers	3.312	(0.067)***
Loans to foreign customers	3.770	(0.061)***
Interbank loans	2.719	(0.041)***
Interest-bearing securities	3.398	(0.046)***
Nonbank deposits	–1.571	(0.054)***
Bank deposits	–1.875	(0.057)***
Securitized debt	–1.892	(0.092)***
Net fee income	–0.036	(0.003)***
Staff expenses	–0.083	(0.024)***
Other administrative expenses	0.162	(0.011)***
RWAs to total assets	0.215	(0.016)***
LLP ratio	–2.558	(0.087)***
GDP growth	0.020	(0.001)***
Unemployment growth rate	0.001	(0.000)***
R^2	0.550	
Adj. R^2	0.540	
Number of observations	47,980	

Source: OeNB.

*Note: *** p < 0.001, ** p < 0.01, * p < 0.05. The dependent variable, NIM, is in percentage points.*

Chart 1

Estimated effect of a 100 basis point NIM change depending on the interest rate environment



Source: OeNB.

Note: Shaded areas represent 95% confidence bands using robust errors.

2 From low to negative rates

2.1 Why negative rates are a game changer

Can the results from the previous section be extrapolated to negative market rates? As argued in the introduction, we are skeptical of this: The floor on deposit rates constitutes a nonlinearity that the panel approach of section 1 does not take into account. In nontechnical terms, these floors are invisible to the model as negative rates have not yet been observed in history.[6] We therefore outline below an approach which is suited to address this nonlinearity.

2.2 The approach

To simulate hypothetical negative rates for each bank we estimate a set of separate econometric models: one for each bank and profit and loss (P&L) item. This is necessary to account for the floor on deposits. A drawback of such a high number of models is that each one uses only a small dataset; a merit thereof is that it allows for bank-specific sensitivities to changes in the interest rate level. Bank-by-bank results that pay heed to the individual portfolio sensitivity of banks mean that these results can also be included in top-down stress tests. Additionally and most importantly, we can restrict the forecast for those P&L items with a legal floor to zero and thereby simulate the effect of interest rates never before visited in history.

Using the regulatory reporting system containing detailed P&L statements for each bank and quarter, we forecast these individual P&L items with an ARIMA($p_{i,j}$, $d_{i,j}$, $q_{i,j}$) time series model:

$$\varphi(B)(1-B)^{d_{ij}}(y_{t,i,j}-\mu_{i,j}) = \\ = \theta(B)\varepsilon_{t,i,j}, \qquad (2)$$

where $\{\varepsilon_{t,i,j}\}$ is a white noise process with mean zero and variance $\sigma^2_{i,j}$, B is the back-shift operator, $\varphi(z)$ and $\theta(z)$ are polynomials of order $p_{i,j}$ and $q_{i,j}$, respectively, and $y_{t,i,j}$ is the P&L item i of bank j at time t with mean $\mu_{i,j}$.

[6] *The recent rates were observed over too short a period and are too close to zero to provide a reliable statistical estimate.*

For P&L items that are sensitive to interest rates (see table 3 for an overview)[7] we add the exposure specific to that item[8] times the EURIBOR rate as an exogenous regressor, so that the model becomes

$$\begin{aligned}(1-B)^{d_{i,j}}(y_{t,i,j}-\mu_{i,j}) &= \\ &= \gamma'_{i,j}(Euribor_t Exp_{t,i,j}) + \\ &+ \gamma''_{i,j}(Euribor_{t-1} Exp_{t,i,j}) + \eta_{t,i,j}\end{aligned} \quad (3)$$

$$\varphi(B)\eta_{t,i,j} = \theta(B)\varepsilon_{t,i,j} \quad (4)$$

$\gamma'_{i,j}$ and $\gamma''_{i,j}$ are coefficients measuring the sensitivity of income or expenses to the interest rate level. Economically, these coefficients measure how fast reference rates are passed on to the banks' creditors and debtors. Once again, a subset of these positions, interest expenses on deposits, is floored at zero. To include this legal situation in the model, we replace $y_{t,i,j}$ by max (0, $y_{t,i,j}$) if i is the cost of deposits (table 3). This restriction is important when we use the ARIMA models for forecasting under varying scenarios (see below).

In other words, the approach outlined above models the interest-sensitive P&L items of each bank as a function of the interest rate level times the exposure to that item. For instance, interest income from mortgage loans depends on the size of the mortgage portfolio times the current reference rate (captured above by $\gamma'_{i,j}$ where i would correspond to the P&L item "income from mortgage loans"). As many loan contracts stipulate a slower reaction of rates charged than changes in the reference rate, we also add the lagged reference rate times the (current) exposure to that item (captured above by $\gamma''_{i,j}$). We know that there are numerous other factors which influence revenues and expenses that differ from P&L item to item and from bank to bank. Consequently, we need to model the error term in a flexible function of its own past values (the AR-component, $\varphi(B)$) and recent shocks (the MA-component, $\theta(B)$).

To estimate the effect of negative rates on banks' profits, we proceed as follows: First, we estimate for each bank and P&L item an ARIMA model as described above. The order of the polynomials is chosen by following Hyndman and Khandakar (2008). Second, we use the model for forecasting eight quarters into the future while holding the exposure constant ("constant balance sheet assumption") but varying the reference rates. For the reference rate we use three scenarios. Scenario(–1) assumes a drop in the reference rate to –1%, Scenario(–2) explores the consequences of an extremely negative reference rate of –2%. Scenario(+1), used for comparison purposes, calculates banks' profitability under a reference rate of +1%.[9] Third, we reconstruct the main positions (especially net interest income and earnings before risk costs and taxes) by aggregating over the individual positions and present the results for each banking sector. The sectors we use and key summary statistics are displayed in table 4.

[7] *Actually, the P&L structure we use is much finer, differentiating e.g. between foreign-currency and euro amounts for many items, but table 3 captures the essence.*

[8] *The regulatory reporting system provides for each interest-bearing P&L item the asset or liability value associated with generating this income or expense, a feature that notably distinguishes our database from others.*

[9] *In all three scenarios the reference rate does not vary over the eight-quarter forecast horizon.*

Table 3

P&L items used in the ARIMA approach

P&L item	Separate ARIMA model	Interest rate-sensitive	Floored at zero
1. Interest income			
Interest income from interbank loans	yes	yes	
Interest income from nonbank customer loans	yes	yes	
Interest income from bonds	yes	yes	
Interest income from other	yes	yes	
2. Interest expenses			
Interest expenses from interbank loans	yes	yes	
Interest expenses from nonbank customer deposits	yes	yes	yes
Interest expenses from bonds issued	yes	yes	
Interest expenses from other	yes	yes	
3. Net interest income (1+2)			
4. Income from equity positions	yes	yes	
5. Fee and commission income	yes		
6. Fee and commission expenses	yes		
7. Net income from other financial transactions	yes		
8. Other income	yes		
9. Administrative expenses	yes		
10. Other expenses	yes		
11. Earnings before risk costs and taxes (3+4+5+6+7+8+9+10)			

Source: OeNB.

Table 4

Key statistics by banking sector

Sector	Total assets (EUR million)	Deposit share (% of total assets)	Loans to customers (% of total assets)	Net interest income (% of total earnings)	Net interest margin (% of total assets)
Car finance banks	708.75	63.79	78.37	59.04	2.32
Branches	494.48	50.37	31.60	30.12	0.88
Building and loan associations and housing banks	3,300.88	33.86	41.45	96.42	0.72
Large banks	33,009.89	34.63	34.43	32.88	0.72
Medium universal banks	5,802.67	52.19	70.62	66.96	1.65
Private stock banks	697.91	70.81	27.22	17.84	0.78
Raiffeisen credit cooperatives	258.18	79.30	58.92	64.57	1.80
Savings banks	1,349.13	72.18	67.82	60.84	1.69
Special purpose financial institutions	2,487.84	26.37	52.88	42.77	1.07
Volksbank credit cooperatives	705.71	79.07	68.33	60.98	1.86

Source: OeNB.

Note: Mean figures across banks and the last eight quarters.

2.3 The results

Table 5 depicts the NIM for banks under the scenarios considered. Looking at the last two columns of the table, $\Delta(-1)$ and $\Delta(-2)$, we see that negative reference rates would have a profound impact on banks' profitability. Under a reference rate of –1% this impact ranges from (a median of) –43.4 basis points for Volksbank credit cooperatives to –5.8 basis points for large banks. Under the extreme assumption of a reference rate of –2%, the impact is generally scaled by a factor larger than

2, ranging from –90.6 basis points to –11.6 basis points. Looking at the last row, "all banks," we see that in case of a reference rate of –2%, the median NIM is 98.6 basis points or –66.7 below current levels. While this is a substantial decline, the NIM remains fairly positive under this extreme reference rate and the assumption (which the model automatically makes) that there is little adaptation from the banks' side.

Let us compare the model outcome with that of section 2, which estimated a 16.4 basis point rise in the NIM when reference rates increase by 100 basis points (at current levels). The model employed here comes to a very similar estimate (+19.2 basis points for an increase of 119 basis points,[10] see the last row of table 5). However, the panel model of section 2 did not take the nonlinear floor on deposits into consideration – which is irrelevant in a normal interest rate environment. The panel model's estimate was a symmetrical one: It also predicted a 16.4 basis point drop in the NIM when reference rates decrease by 100 basis points. This is where the models disagree. The ARIMA approach employed in this section, which takes the floor on deposits into account, paints a more meager picture of the profitability of banks under a scenario of negative rates. It predicts a decline of –29.8 basis points in the NIM if reference rates drop to –1% and of –66.7 basis points if they drop to –2%, substantially more than predicted without taking the floor on deposits into account.

Concerning banking sectors, there are two clusters in the results: Large banks, building and loan associations and housing banks, and private stock banks are hit less hard, while in all other banking sectors the NIM decreases more substantially. Large banks hold a lower share of deposits, are more strongly financed through interbank liabilities and issued bonds and are better hedged against interest rate movements. Also, the share of equity positions on the asset

Table 5

Net interest margin by banking sector across scenarios

Sector	Realized	Scen.(+1)	Scen.(–1)	Scen.(–2)	Δ (+1)	Δ (–1)	Δ (–2)
	Basis points						
Volksbank credit cooperatives	176.9	194.3	133.5	86.3	17.4	–43.4	–90.6
Car finance banks	244.9	247.1	212.3	173.9	2.3	–32.6	–71.0
Raiffeisen credit cooperatives	170.8	189.6	141.0	104.8	18.8	–29.8	–66.0
Savings banks	161.8	184.8	137.4	99.2	23.0	–24.4	–62.5
Medium universal banks	153.5	151.8	122.2	95.4	–1.7	–31.4	–58.2
Special purpose financial institutions	110.1	103.7	76.5	53.5	–6.4	–33.6	–56.6
Branches	64.5	65.2	26.1	10.7	0.8	–38.4	–53.7
Private stock banks	59.6	110.3	43.4	27.5	50.8	–16.1	–32.0
Building and loan associations and housing banks	58.8	54.7	44.5	38.8	–4.1	–14.4	–20.0
Large banks	79.2	113.1	73.4	67.6	33.9	–5.8	–11.6
All banks	165.3	184.5	135.5	98.6	19.2	–29.8	–66.7

Source: OeNB.

Note: "Realized" is the average of the last four quarters, "Scen." denotes the three scenarios and Δ denotes differences between scenario and realized values. Medians for each sector. The sectors are listed in ascending order according to the values provided in the last column.

[10] *The last EURIBOR rate used in the model is –0.19% for Q1 2016.*

side is considerably larger. For building and loan associations and housing banks, their main asset class – building loans – benefits from a contractual interest rate floor of 3%, rendering this sector only slightly sensitive to negative rates.[11] Private stock banks have a stronger focus on private wealth management and are therefore less dependent on deposit financing. As a result, they are less exposed to the asymmetric dilemma. For all the other sectors these arguments are not valid. Thus, the impact on these sectors is much stronger.[12]

Smaller banks focusing on the regional retail banking business, such as Volksbank credit cooperatives, savings banks and Raiffeisen credit cooperatives, are hit hardest. Somewhat surprisingly, the car finance sector also appears among those sectors that are strongly impacted by negative rates. Looking at the data we see that this sector's asset side reacts more to changes in the reference rate implying a strong contractual link between the reference rate and the interest charged. If we compare the ranking of sectors in the last two columns, we see some differences, but the two clusters (the bottom three sectors and the rest) are still very distinct.

As a consequence, the effects driving the results for any single bank are a combination of (1) how responsive the asset side is to changes in the reference rate and (2) how much of the liability side is floored at zero. Both factors can be influenced in a number of ways, e.g. by whether the asset side structure has a higher share of equities or other assets like real estate, whether interest rate hedges like swaps or interest rate floors (e.g. as for building societies) are in place etc. Given the distance between current reference rates (–0.19% for Q1 2016) and the extreme (–2%) simulated above, banks will have time to adapt as conditions change. Of course it is difficult to simulate such adaptive behavior on the banks' side. This is why the "constant

Table 6

Return on assets before risk costs and taxes by banking sector

Sector	Realized	Scen.(+1)	Scen.(–1)	Scen.(–2)	Δ (+1)	Δ (–1)	Δ (–2)
	Basis points						
Volksbank credit cooperatives	31.6	23.0	–40.1	–88.3	–8.6	–71.8	–119.9
Branches	54.4	48.5	–6.5	–27.0	–5.9	–61.0	–81.5
Raiffeisen credit cooperatives	69.5	86.3	36.1	–2.5	16.8	–33.4	–71.9
Savings banks	78.0	102.0	52.4	13.5	24.1	–25.5	–64.5
Medium universal banks	75.3	90.7	42.6	16.3	15.4	–32.7	–59.0
Private stock banks	15.1	64.1	12.7	–34.2	49.0	–2.4	–49.4
Special purpose financial institutions	106.6	137.3	83.9	69.5	30.7	–22.7	–37.1
Car finance banks	69.6	136.5	76.3	34.1	66.9	6.7	–35.5
Building and loan associations and housing banks	15.6	9.7	9.4	5.2	–5.9	–6.2	–10.3
Large banks	72.6	115.4	91.0	62.6	42.8	18.4	–10.0
All banks	65.6	86.6	36.8	–0.6	21.1	–28.8	–66.2

Source: OeNB.

Note: "Realized" is the average of the last four quarters, "Scen." denotes the three scenarios and Δ denotes differences between scenario and realized values. Medians for each sector. The sectors are listed in ascending order according to the values provided in the last column.

[11] *However, the floor, together with low or negative reference rates, is likely to trigger a reduction in volume as the product becomes less competitive. Due to the constant balance sheet assumption employed here, this effect is not captured.*

[12] *The special purpose financial institutions sector is a zoo of very different animals, including bad banks, credit card companies and factoring banks, which is why we do not discuss this catch basin in detail.*

balance sheet assumption" is applied (see section 2.2), which ignores banks' adaptation behavior. As a consequence, the results presented here can be understood as a particularly severe case, that is an extreme reference rate and without adaptive behavior.

The asymmetric dilemma responsible for squeezing the NIM is also depicted in chart 2, which shows that while deposit costs have reached a level close to zero (long-term deposits keep the costs above zero) and would not fall if the reference rate were to drop further into negative territory, the yield on customer loans would follow the reference rate and decrease further. Although the yield on customer loans would remain positive it would not be sufficient to cover costs for the majority of banks.

This is also shown in table 6, which depicts the return on assets (before risk costs and taxes)[13] in basis points for all sectors and across scenarios.[14] The major difference between this indicator and the NIM shown in table 5 is that income from equity exposure, net fee and commission income, administrative expenses and other income and expenses are considered. In total (last row of table 6) the impact in all three considered scenarios is very similar to that for the NIM with a deviation of only a few basis points. Individual sectors are hit harder, e.g. branches, or less hard, e.g. the car finance sector. However, as the additional P&L items that are considered in the calculation of return on assets are prone to one-off effects that make forecasting difficult, we focus on the NIM result.

3 Summary and conclusions

In this paper we analyze the effects of low and negative rates on the profitability of Austrian banks. We found that a bank's NIM is linked to the interest rate environment. The link is strong when reference rates are close to zero (at around 16 basis points per 100 basis points) but – due to nonlinearities – subdued in normal times. Smaller, regional banks are affected more, but this does not trigger a considerable economic impact.

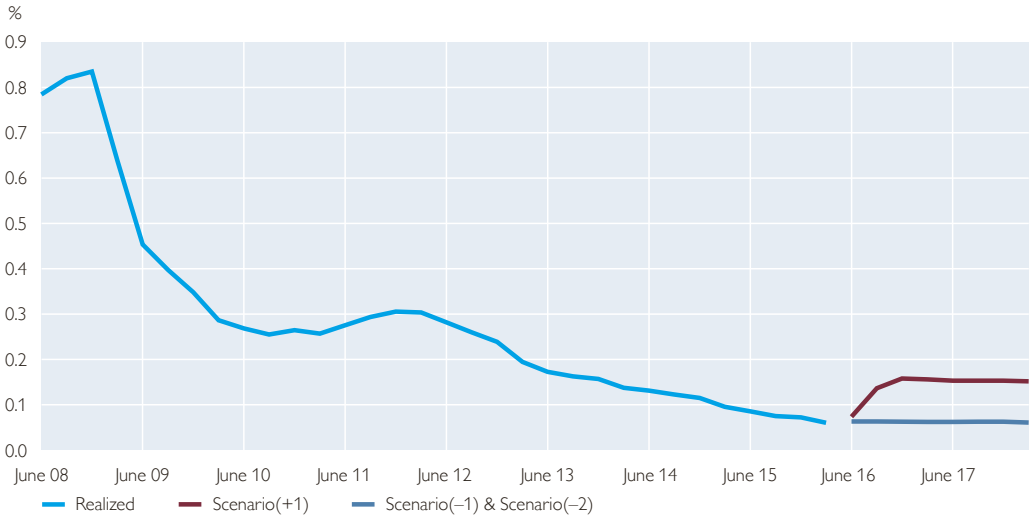
While the above is expected in an environment of low and zero rates, we are skeptical of extrapolating these findings to negative rates. To better investigate negative rates we employ an ARIMA simulations approach that takes into account the asymmetric dilemma that deposit rates are legally floored at zero while loan rates directly track reference rates. Using such an approach, we find that negative rates can create a substantial burden on the profitability of banks and that smaller deposit-financed banks, in particular, are hit hardest. This finding is important as these banks often do not participate in empirical studies due to a shortage of data. Simulations of reference rates of –2% show that under such extreme conditions and assumptions, the profits of a large part of the banking system would be eroded, but median NIM would remain in positive territory.

[13] *Position 11 in table 3 divided by total assets.*

[14] *Risk costs in the P&L statements are not available on a quarterly basis.*

Chart 2a

Deposit costs

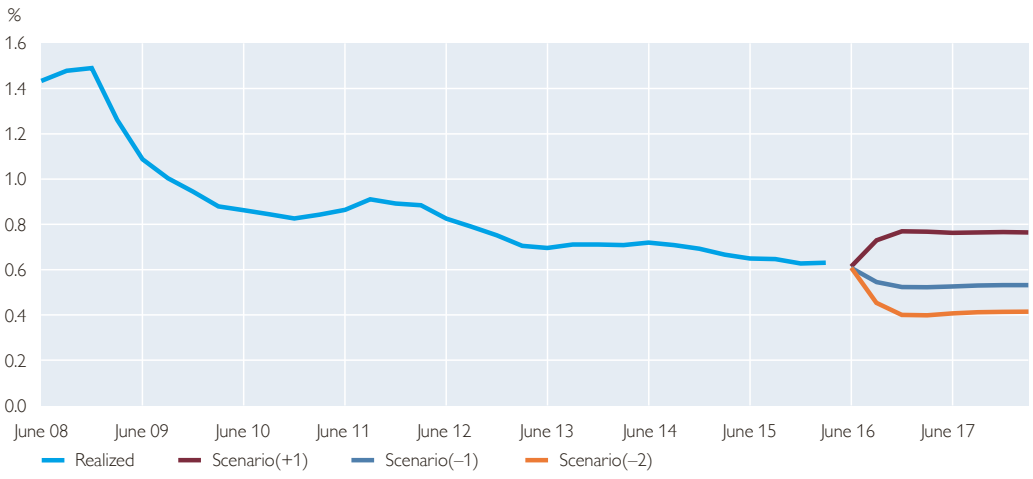


Source: OeNB.

Note: Values in % of volumes over time. Median across all banks.

Chart 2b

Yields on customer loans



Source: OeNB.

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Annex A
Summary statistics

Table A1

Descriptive statistics

	Min.	Q1	Median	Mean	Q3	Max.	StD	Data C.
NIM	–3.04	1.64	2.08	2.11	2.59	13.84	0.79	80%
EURIBOR	–0.19	0.72	2.15	2.29	3.59	5.03	1.60	100%
EURIBOR^2	–0.03	0.52	4.62	7.83	12.89	25.3	7.77	100%
Term spread	–0.41	0.77	1.41	1.33	1.99	2.99	0.83	100%
Interaction: EURIBOR x RBD	–0.19	0.00	0.00	0.47	0.00	5.03	1.20	99%
RBD	0.00	0.00	0.00	0.18	0.00	1.00	0.39	99%
Total assets	5.64	10.77	11.56	11.74	12.41	18.87	1.48	80%
Euro loans to domestic customers	0.00	0.39	0.49	0.48	0.59	1.00	0.17	80%
FX loans to domestic nonbanks	0.00	0.01	0.04	0.07	0.09	0.65	0.08	79%
Loans to foreign customers	0.00	0.00	0.01	0.03	0.02	1.00	0.09	78%
Interbank loans	0.00	0.14	0.20	0.23	0.29	1.00	0.14	80%
Interest-bearing securities	0.00	0.02	0.07	0.09	0.14	1.00	0.09	79%
Nonbank deposits	0.00	0.70	0.79	0.74	0.85	1.00	0.19	80%
Bank deposits	0.00	0.03	0.07	0.11	0.15	1.00	0.13	78%
Securitized debt	0.00	0.00	0.00	0.02	0.00	1.00	0.08	79%
Net fee income	–9.61	0.50	0.65	0.88	0.80	85.03	2.69	80%
Staff expenses	0.00	1.00	1.00	0.94	1.00	1.00	0.17	80%
Other administrative expenses	0.00	0.55	0.70	0.70	0.87	1.00	0.21	80%
RWAs to total assets	0.00	0.48	0.57	0.57	0.67	7.34	0.18	80%
LLP ratio	0.00	0.03	0.04	0.05	0.06	0.71	0.03	79%
GDP growth	–4.71	0.70	1.84	1.68	3.08	4.10	1.78	100%
Unemployment growth rate	–24.18	–8.13	3.10	1.84	7.74	39.34	12.49	100%

Source: OeNB.

Note: Data C. defines the percentage of available data (sample period Q1 1998 to Q1 2016 using data from 946 banks). The other columns refer to sample statistics. EURIBOR, long-term interest rates (part of the term spread), the NIM and net fee income are annualized rates. Staff expenses and other administrative expenses are expressed as yearly costs divided by total assets. Euro loans to domestic nonbanks, FX loans to domestic nonbanks, interbank loans, interest-bearing securities, bank deposits, nonbank deposits, securitized debt, risk-weighted assets (RWAs), the leverage ratio and the LLP ratio are defined as annual rates. GDP growth and unemployment growth rate are defined as the year-on-year growth rate of real GDP and of the unemployment rate, respectively. See also table 1.

Annex B
Econometric considerations for choosing the panel model approach

The Breusch-Pagan Lagrangian multiplier test for random effects supports the use of a panel estimator as it rejects the null of poolability at the 1% level, thereby underlining the importance of taking the presence of any type of bank-specific effect into account. Moreover, the Wooldridge test for autocorrelation in panel data rejects the null of no first-order autocorrelation in the idiosyncratic error terms at the 1% level (see Wooldridge, 2002; Drukker, 2003). A modified Wald test for groupwise heteroskedasticity likewise rejects the null of homoskedasticity of the idiosyncratic error variances at the 1% level. When autocorrelation and heteroskedasticity appear in panels, we have to make a more general assumption about the distribution of the error term and thus employ robust estimators of the variance-covariance matrix.

To make a decision on whether to use fixed or random effects we proceeded as follows: As we are confronted with heteroskedasticity in the error variance, we need a variant of the Hausman test that is robust against heteroskedasticity. We therefore employ the Hansen (1982) *J* test of overidentifying restrictions, which tests whether the additional moment condition of the explanatory variables being uncorrelated with the panel-specific effects (as imposed by random effects estimation) holds (see Arellano, 1993). As the null of the test of validity of this particular overidentifying restriction is rejected at the 1% level, we conclude that a model with fixed effects better describes the underlying data-generating process.

We chose a static model, i.e. we chose not to include a lagged dependent variable due to (i) the potentially large consequential bias documented by Achen (2001) and Keele and Kelly (2006) and (ii) the bias documented by Nickell (1981). In addition, it is not clear why the lagged NIM should have a causal relationship to the current one. Ignoring these arguments and including a lagged dependent variable would reduce all estimated coefficients reported in table 2 by around a third to a half. Significance levels are maintained and the only sign switch is EURIBOR[2]. We think that these consequences perfectly fit the symptoms of a substantial bias (Achen, 2001) and therefore do not consider these results further.

Annex C
Interpretation of regression coefficients

Here we discuss in more detail those results of the regression presented in table 2 that do not have a direct connection to the interest rate level. In general, the results are in line with expectations. Banks engaging in riskier lending as indicated by the RWA density tend to have a higher NIM, as do smaller banks and banks with higher nonstaff administrative costs. When risks materialize, banks have to book loan loss provisions and also face non-performing loans, which, in consequence, lowers the NIM. Several regressors describe the composition of the asset or liability side and some explanation is required here: To understand why the fraction of interbank loans on the asset side has a positive contribution to the NIM when these positions are generally considered to yield lower interest than other asset side positions, note that this is the case here too. Interbank loans show a positive contribution to the NIM but their contribution is less than the one from loans to customers. The reason why the coefficient is positive (and not negative) is that interbank

loans contribute (little but positively) to the net interest income while other asset side positions yield even less or no interest (e.g. exposure to sovereigns, buildings, intangible assets). The same holds true for the liability side where deposits – while being less expensive[15] than e.g. securitized debt – still reduce the NIM of a bank compared to liability positions not included in the regression e.g. equity. Staff expenses show a negative sign, which we think is caused by banks engaging in fee, commission and wealth management activities or trading that tend to have high staff expenses but a low NIM. The only surprising sign is the one on the unemployment growth rate, implying a higher NIM when unemployment grows. We think that this must be understood in connection with the coefficient on GDP growth, which shows a higher NIM in times of growth. Why – controlling for GDP growth and loan loss provisions – unemployment growth is positively associated with the NIM is not clear. However, while the coefficient is statistically significant, it is not so economically.

[15] *Note that this comparison takes only the interest expenses into account and not other costs e.g. branch networks.*