# Do Banks Take More Risk In Extended Periods of Expansive Monetary Policy? Evidence from a Natural Experiment[1]

**February 5, 2011**

**Abstract** It has recently been proposed that a prolonged period of low policy interest rates under benign economic conditions tends to produce increased risk-taking in financial markets. This hypothesis implies that expansive monetary policy over an extended period not only encourages an increase in lending activity but also affects financial market participants' risk-taking behavior. It might thus contribute to the build-up of financial imbalances. We provide new evidence in favor of the above hypothesis, exploiting an extensive panel of matched borrowers and lenders recorded at monthly frequency. Based on a conditional difference-in-differences approach, we identify a significant increase in expected default rates within Austrian banks' business-loan portfolios due to the low interest rate period between 2003 and 2005. Our results are robust to a wide range of both aggregate as well as bank-level characteristics. Further, our findings are new and important in at least three respects: First, we construct a measure of ex-ante risk within the entire business-loan portfolio of each bank instead of just the risk attached to an individual loan or borrower. This measure is based on our estimates of each firm's probability of default, using detailed annual balance sheets and income statements as well as observed bankruptcies within our sample. Second, our results indicate that the additional balance-sheet risk was associated with higher firm-level interest rates and thus hints at a "search for yield" motive. Third, we specifically identify the effect of ECB monetary policy in the period 2003-2005, which was characterized by an entirely flat and unprecedentedly low path of policy interest rates, as opposed to the more traditional effects of short-term changes in the monetary stance, usually identified through quarter-on-quarter changes in short-term interest rates.

JEL: E44, E52, E59, G21

Keywords: monetary policy, risk-taking, banking, financial stability

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[1] We are very grateful to the Österreichische Nationalbank (OeNB) for providing the data and generous financial support. In particular, we are greatly indebted to Gerhard Fiam for compiling the dataset and sharing invaluable know-how with respect to the various data sources employed in this paper. Further, we would like to thank Ernest Gnan for arranging generous financial support. Finally, we are grateful to Òscar Jordà, David Marqués Ibañez, Ankur Patel, Katheryn N. Russ, Kevin D. Salyer, and Alan M. Taylor for extremely helpful comments and suggestions. The views and opinions expressed in this paper do not represent the official stance of the OeNB and any mistakes or misprints are entirely our responsibility.

# 1 Introduction

The worldwide financial and economic turmoil of 2007-2008 has highlighted that even the world's most sophisticated financial systems are susceptible to crises and that their malfunctioning can have devastating effects on the real economy. It is now widely agreed upon that the bursting of a series of asset bubbles—mainly in the real estate sectors of few countries like the U.S., Britain, Ireland, and Spain—caused a worldwide panic on financial markets and thereby pushed these markets to the brink of collapse.

There is much less consensus, however, on the forces that made the global financial system so fragile and sensitive to such a disruption. One common theme across the proposed explanations—put forward in a series of recent books, newspaper articles, as well as academic studies—is nicely summarized by the Bank of England's governor, Mervyn King:[2] In the wake of the dot-com bubble, extremely low interest rates throughout the entire western world have "[...] encouraged risk-taking on an extraordinary scale. Banks expanded their balance sheets and new instruments were created to satisfy the search for yield. [...] The build up of risk came to threaten the stability of the entire financial system." (King 2010, p. 4)

Among the most popular starting points for Mr. King's argument are massive flows of capital from the new entrants into western financial markets (Bernanke 2009, King 2010), extremely lax monetary policy for an extended period (Taylor 2007, 2009), or even policies to promote homeownership, which are said to have caused "cheap credit" for risky borrowers in housing markets (Rajan 2010).

However, the various suggested mechanisms are not mutually exclusive. In order to allow for clearcut policy conclusions, it is thus paramount to disentangle their precise effects and gauge their relative importance.

In this paper, we seek to isolate the effect of extremely accommodating monetary policy for an extended period on the degree of (ex-ante) default-risk "allowed" in financial institutions' asset portfolios. This mechanism has recently been dubbed the "risk-taking channel" of monetary policy (Borio & Zhu 2008). If this channel is at work, the argument goes, not only will more firms or projects become creditworthy due to lower interest rates, but banks will also relax their lending standards (Maddaloni & Peydro 2009) and will consequently "allow" more risk in their portfolios.

In light of the aforementioned concerns about the fragility of the worldwide financial system, the existence of the "risk-taking channel" implies potentially important consequences for the design and conduct of future monetary policy. For

[2]See for example Rajan (2010), Taylor (2007, 2009), Bernanke (2009), Obstfeld & Rogoff (2009), Ferguson & Schularick (2009), Obstfeld (2010), King (2010), Schularick (2010), Jordà et al. (2010), and references therein.

instance, Lorenzo Bini Smaghi, a member of the Executive Board of the European Central Bank (ECB), takes this channel seriously and draws the following lesson for monetary policy makers: "[...] ensuring price stability is *not* sufficient for financial stability. [...] Protracted loose monetary conditions can foster excessive risk-taking and, consequentially, produce a build-up of financial imbalances" (Bini Smaghi 2011, original emphasis). In his view, monetary policy and prudential regulation are complements and he thus goes on to propose two alternative ways to accommodate this issue: "The first is through a monetary policy regime that is not centred exclusively on inflation, but leans against the wind of financial imbalances. [...] The second [...] is through macro-prudential supervision, a new perspective of macroeconomic control" (Bini Smaghi 2011).

In fact, European authorities have already taken first steps in that direction by establishing the European Systemic Risk Board (ESRB), on January 20, 2011, whose chair and vice chair are the president of the ECB, Jean-Claude Trichet, and the governor of the Bank of England, Mervyn King, respectively.

To empirically test for the existence of the "risk-taking channel" we analyze an extensive panel of matched Austrian firm-bank pairs operating in the period 2000-2008. The Austrian market for business lending during this period provides an excellent case study for several reasons: First, Austria is a member of the EMU and the ECB kept refinancing rates at an unprecedented low of 2% p.a. from June 6, 2003 through December 6, 2005. Second, the ECB's monetary policy decisions are geared toward stabilizing euro area (EA) averages and, given Austria's small weight in EA aggregates, are thus largely exogenous to the Austrian economy.[3] Third, in the period 2000-2008 Austria was neither experiencing a housing bubble nor was there a huge influx of foreign capital into Austrian bond markets, which could have distorted the yield on long term investments in Austria.

Our empirical strategy is a three-step procedure: First, we utilize detailed information on firms' balance sheets and income statements, together with realized bankruptcy dates, in order to estimate an ex-ante measure of each firm's default risk. Based on these estimates we then construct an estimate of ex-ante expected default rates within each banks business-loan portfolio. In a second step, we identify periods during which ECB monetary policy can be considered exogenous to the Austrian economy. We accomplish this by isolating periods during which the Austrian economy had been performing significantly "worse" than the EA average—as measured by inflation and output gaps—and ones during which it had been doing signif-

[3]While ECB monetary policy is technically exogenous to Austria, given the ECB's mandate, this does not automatically imply statistical exogeneity. However, our empirical approach accommodates for this concern.

icantly "better" than the EA average. Finally, we apply a "conditional difference-in-differences" approach to find robust evidence for a significant increase in expected default rates within Austrian banks' business-loan portfolios as a consequence of the low policy interest rate period 2003-2005.

In particular, our empirical approach allows us to control for the effects of changes in Austrian banks' capital adequacy requirements in preparation for the Basel II accord—which became legally binding for Austrian banks in 2007—, as well as systematic changes in risk-management practices—for instance a switch to internal rating models based on value-at-risk (VaR) analysis. We thus interpret our results as clear evidence for the existence of the "risk-taking channel", in isolation of other mechanisms, that are said to systematically contribute to the deterioration of financial institutions' balance sheets.

The analysis described in this paper is most closely related to work by Altunbas et al. (2009), De Nicoló et al. (2010), as well as Delis & Kouretas (2010). These studies are the first to analyze the effects of monetary policy on banks' overall risk-positions. The first article employs expected default frequencies, as reported by Moody's KMV, while the latter two rely on banks' risk-weighted assets as their measures for banks' portfolio risk. All three papers find that quarter-on-quarter changes in various measures for the stance of monetary policy significantly affect the chosen proxies for banks' risk positions. Furthermore, Altunbas et al. (2009) as well as Maddaloni & Peydro (2009) find that the number of quarters, that short run interest rates stay below the prediction of a Taylor rule, significantly increase banks' portfolio-risk and decrease lending standards, respectively.

Our results are consistent with the evidence found in these studies, yet we provide additional insight, as our analysis specifically identifies the stance of monetary policy over the period from 2003 to 2005 as the principal driver for the increase in risk-taking. This is an important insight, as precisely this specific period is the subject of the ongoing policy debate. Our empirical strategy allows us to conclude that an improvement in economic conditions—as measured by inflation and output gaps—lead to a significant increase in Austrian banks' loan-portfolio-risk during the period 2003-2005 while we do *not* observe such an effect during any other period between 2000 and 2008. In fact, we find that, if anything, an improvement in economic conditions lead to a decrease in the amount of loan-portfolio-risk in periods during which policy interest rates had been adjusted relatively frequently. This result can be attributed to the fact that the years 2003-2005 can be considered an episode during which ECB refinancing rates were "too low for too long"—from an Austrian perspective—, in the sense that the Austrian economy had been performing "worse" than the EA average until the first quarter of 2004 and significantly "better" than the

EA average thereafter.

Furthermore, despite the fact that this particular episode was characterized by unprecedentedly low aggregate *policy* interest rates, our analysis further reveals that firms with higher default rates had been paying higher *firm-level* interest rates. This finding is consistent with standard theory on adverse selection (Stiglitz & Weiss 1981) and therefore hints at a "search for yield" motive, as suggested by Rajan (2006).

Finally, our results are also in line with earlier empirical work investigating the effects of monetary policy on banks' willingness to advance riskier individual loans (Jiménez et al. 2007, Ioannidou et al. 2009). These articles illustrate that banks are more inclined to advance credit to customers with bad credit scores, whenever refinancing conditions become cheaper.

The remainder of this article is organized as follows: Section 2 illustrates the most recent credit cycle in Austria, Section 3 describes data and methodology, Section 4 presents our results, and Section 5 concludes.

## 2 The Most Recent Business-Lending Cycle in Austria

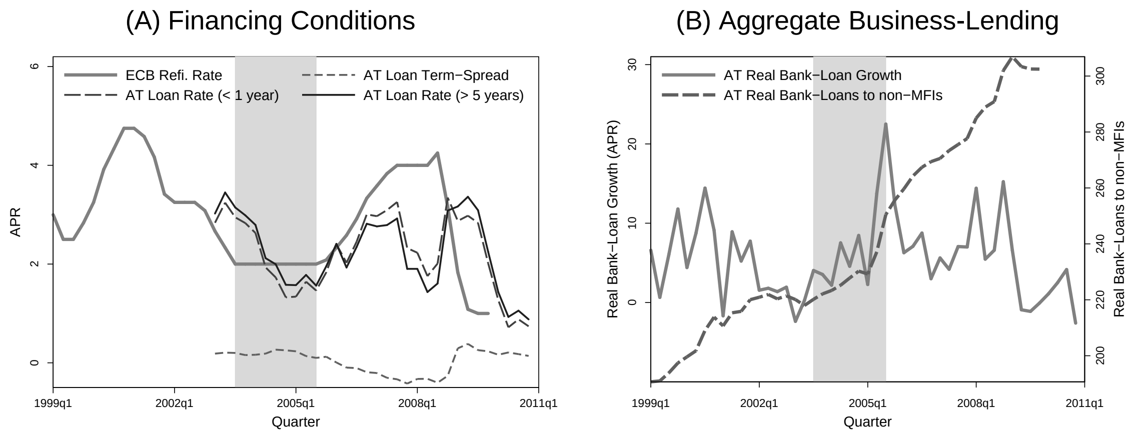
In order to facilitate the international comparability of our findings we briefly discuss the most recent business-lending cycle in Austria and point out several important observations.

First, panel (A) of Figure 1 illustrates a significant decrease in real interest rates on debt of different maturity throughout the period of low and stable policy interest rates between 2003 and 2005. Looking at panel (B) of Figure 1, we observe that this significant drop in real interest rates goes hand in hand with a significant increase in business-lending throughout the same period. These two tendencies point toward traditional interest rate channels as well as the "broad credit channel" (Bernanke & Gertler 1995) of monetary policy.

Second, Figure 1 further hints at a channel recently emphasized by Woodford (2010). He argues that a strong amplification mechanism in the transmission of monetary policy is triggered whenever the spread between long-term and short-term interest rates decreases. This is motivated by the fact that investment decisions—and hence real activity—generally depend mostly on long-term rather than short-term financing conditions. We can see that the biggest spike in business-lending growth, during 2005, precisely coincides with the onset of a decline in the spread between loans of maturity greater than 5 years and loans with maturity less than 1 year.

Furthermore, we can see that these mechanisms were also likely to be at work at the end of 2007, in mid 2008, as well as in the year 2010. Thus, we argue that these channels are important features of the monetary transmission mechanism but

Figure 1: The Most Recent Business-Lending Cycle in Austria (2000 - 2010)




*Notes:* Panel (A) illustrates nominal interest rates on the ECB's main refinancing facility as well as real interest rates for Austrian (AT) bank-credit of different maturity. Real rates are computed by subtracting AT HICP inflation. Further, we report the term-spread between loan rates for the two reported maturities. Panel (B) depicts levels and annualized quarterly growth rates of Austrian real bank-lending to non monetary and financial institutions (non-MFIs). A real series is constructed by dividing nominal bank-lending (in billions of Euros) by the AT GDP deflator (2005q1=100). All data are drawn from the ECB's statistical data warehouse (http://sdw.ecb.europa.eu). The gray areas indicate the period during which ECB refinancing rates were kept at 2%.

do not seem to be phenomena that are restricted to periods of extremely low and stable policy interest rates.

The remainder of this study is devoted specifically to the question of whether the period between 2003 and 2005 featured an additional channel of the monetary transmission mechanism, that is triggered exclusively by stable and extremely low short term refinancing rates over an extended period and causes a deterioration of banks' loan portfolios due to increased bank-risk-taking.

# 3 Data and Methodology

In this section we illustrate our approach to assess whether the period between June 6, 2003 and December 6, 2005, during which the ECB kept refinancing rates at an—at that time—unprecedented low of 2% p.a., significantly affected the amount of risk "allowed" in banks' business-loan portfolios. The section is structured as follows: In Section 3.1 we briefly describe our data sources, Section 3.2 illustrates our measure of banks' loan-portfolio-risk, Section 3.3 outlines how we identify monetary policy regimes, and Section 3.4 presents our empirical test.

## 3.1 The Dataset

Our empirical analysis draws on four main data sources. First, in order to assess individual borrowers' creditworthiness, we utilize annual balance sheets and income statements from an unbalanced panel of 8,653 Austrian firms over the years 1993 to

2009. This data is collected by the Austrian National Bank (OeNB) in the course of its refinancing activities and is stored in a balance sheet register (BILA). The dataset also records various auxiliary characteristics, such as the firms' age, legal form, industry classification, and the number of employees. Furthermore, we observe whether a firm went bankrupt and, if so, on which date it filed for bankruptcy protection. Our sample records a total of 533 bankruptcies, which we employ as our proxy for the event of default.

Table 1: Summary Statistics (GKE, MONSTAT, & ECB)

| | Obs. | Mean | Std. Dev. | Min | $p^{25}$ | $p^{75}$ | Max |
|---|---|---|---|---|---|---|---|
| Bank-Level Information (GKE and MONSTAT): 2000 – 2008 | | | | | | | |
| $EDR_{b,t}$ | 27082 | 0.524 | 0.643 | 0.000 | 0.232 | 0.621 | 18.462 |
| Bank: Capitalization (1-5) | | | | | | | |
| Cap. 1 | 27082 | 0.142 | 0.349 | 0.000 | 0.000 | 0.000 | 1.000 |
| Cap. 2 | 27082 | 0.183 | 0.386 | 0.000 | 0.000 | 0.000 | 1.000 |
| Cap. 3 | 27082 | 0.350 | 0.477 | 0.000 | 0.000 | 1.000 | 1.000 |
| Cap. 4 | 27082 | 0.296 | 0.457 | 0.000 | 0.000 | 1.000 | 1.000 |
| Cap. 5 | 27082 | 0.029 | 0.168 | 0.000 | 0.000 | 0.000 | 1.000 |
| Bank: Cash Ratio (1-3) | | | | | | | |
| Cash Rat. 1 | 27082 | 0.318 | 0.466 | 0.000 | 0.000 | 1.000 | 1.000 |
| Cash Rat. 2 | 27082 | 0.394 | 0.489 | 0.000 | 0.000 | 1.000 | 1.000 |
| Cash Rat. 3 | 27082 | 0.288 | 0.453 | 0.000 | 0.000 | 1.000 | 1.000 |
| Bank: Size by Assets (1-3) | | | | | | | |
| Size 1 | 27082 | 0.661 | 0.473 | 0.000 | 0.000 | 1.000 | 1.000 |
| Size 2 | 27082 | 0.256 | 0.437 | 0.000 | 0.000 | 1.000 | 1.000 |
| Size 3 | 27082 | 0.082 | 0.275 | 0.000 | 0.000 | 0.000 | 1.000 |
| Bank: No. of Loans | 27082 | 26.549 | 102.893 | 1.000 | 3.000 | 12.000 | 1847.000 |
| Aggregate Characteristics (ECB): 2000 – 2008 | | | | | | | |
| $i_q^{ECB}$ | 27082 | 3.094 | 0.911 | 2.000 | 2.000 | 4.000 | 4.750 |
| $gap_q^{TR}$ | 27082 | 0.215 | 0.949 | -1.267 | -0.474 | 0.604 | 2.934 |
| $y_q - y_q^*$ | 27082 | 0.316 | 1.326 | -1.563 | -0.804 | 1.607 | 3.091 |
| $\pi_q^{AT}$ | 27082 | 2.025 | 0.605 | 1.067 | 1.733 | 2.200 | 3.700 |
| $i_q^{10,AT} - i_q^{3,EA}$ | 27082 | 1.039 | 0.795 | -0.410 | 0.330 | 1.653 | 2.263 |
| $i_q^{10,AT} - i_q^{10,EA}$ | 27082 | 0.020 | 0.053 | -0.057 | -0.030 | 0.063 | 0.130 |
| AT Bank-Loans/Total Assets | 27082 | 0.358 | 0.015 | 0.325 | 0.350 | 0.369 | 0.385 |
| GKE Credit/AT Bank-Loans | 27082 | 0.431 | 0.022 | 0.395 | 0.408 | 0.456 | 0.462 |

*Notes:* Our measures for banks' capitalization, cash ratio, and size by assets are indicator variables taking the values 0 and 1. The columns labeled with $p^{25}$ and $p^{75}$ display the $25^{th}$ and $75^{th}$ percentiles, respectively.

Table 2: Summary Statistics (BILA)

| | Obs. | Mean | Std. Dev. | Min | $p^{25}$ | $p^{75}$ | Max |
|---|---|---|---|---|---|---|---|
| Firm-Level Information (BILA): 1993 – 2009 | | | | | | | |
| Accounting Ratios | | | | | | | |
| Liab./Assets | 47673 | 0.659 | 0.227 | 0.000 | 0.519 | 0.835 | 1.000 |
| Bank Liab./Assets | 47661 | 0.260 | 0.240 | 0.000 | 0.030 | 0.426 | 1.000 |
| Liab. Short/Assets | 47661 | 0.296 | 0.213 | 0.000 | 0.135 | 0.421 | 1.000 |
| Liq. Assets/Liab Short | 47153 | 1.732 | 2.037 | 0.000 | 0.895 | 1.868 | 25.729 |
| Acc. Payab./Net Sales | 45581 | 0.089 | 0.124 | 0.000 | 0.029 | 0.103 | 1.531 |
| Gross Profit/Exp. Labor | 42420 | 3.051 | 3.778 | -8.135 | 1.642 | 2.895 | 45.339 |
| Ord. Bus. Inc./Assets | 47652 | 0.059 | 0.115 | -1.479 | 0.005 | 0.098 | 1.412 |
| Exp. Interest/Gross Debt | 47509 | 0.029 | 0.024 | 0.000 | 0.013 | 0.040 | 0.356 |
| Legal Form | | | | | | | |
| AG | 47673 | 0.113 | 0.316 | 0.000 | 0.000 | 0.000 | 1.000 |
| GmbH | 47673 | 0.722 | 0.448 | 0.000 | 0.000 | 1.000 | 1.000 |
| KG | 47673 | 0.127 | 0.333 | 0.000 | 0.000 | 0.000 | 1.000 |
| Other | 47673 | 0.038 | 0.190 | 0.000 | 0.000 | 0.000 | 1.000 |
| Industry | | | | | | | |
| Manufacturing | 47673 | 0.360 | 0.480 | 0.000 | 0.000 | 1.000 | 1.000 |
| Construction | 47673 | 0.056 | 0.231 | 0.000 | 0.000 | 0.000 | 1.000 |
| Wholesale & Trade | 47673 | 0.223 | 0.416 | 0.000 | 0.000 | 0.000 | 1.000 |
| Transportation & Storage | 47673 | 0.041 | 0.199 | 0.000 | 0.000 | 0.000 | 1.000 |
| Prof., Scient., & Tech. | 47673 | 0.080 | 0.271 | 0.000 | 0.000 | 0.000 | 1.000 |
| Admin. & Support | 47673 | 0.014 | 0.119 | 0.000 | 0.000 | 0.000 | 1.000 |
| Other | 47673 | 0.225 | 0.418 | 0.000 | 0.000 | 0.000 | 1.000 |
| Age (years) | 47473 | 18.871 | 17.661 | 0.000 | 7.000 | 26.000 | 140.000 |
| Total Assets (Bill. Euros) | 47673 | 0.071 | 0.374 | 0.000 | 0.005 | 0.037 | 20.149 |
| Insolvent within | | | | | | | |
| 1 year | 47673 | 0.001 | 0.032 | 0.000 | 0.000 | 0.000 | 1.000 |
| 2 years | 47673 | 0.003 | 0.052 | 0.000 | 0.000 | 0.000 | 1.000 |
| 3 years | 47673 | 0.005 | 0.068 | 0.000 | 0.000 | 0.000 | 1.000 |
| 4 years | 47673 | 0.007 | 0.082 | 0.000 | 0.000 | 0.000 | 1.000 |
| 5 years | 47673 | 0.009 | 0.093 | 0.000 | 0.000 | 0.000 | 1.000 |

*Notes:* Our measures for firm's legal form, industry as well as insolvency are indicator variables taking the values 0 and 1. The legal form GmbH represents limited liability companies, AG stands for Aktiengesellschaft (equity firms), and KG refers to Kommanditgesellschaft (limited partnerships with at least one fully liable partner). The insolvency indicators summarized here are defined in equation (1). The columns labeled with $p^{25}$ and $p^{75}$ display the $25^{th}$ and $75^{th}$ percentiles, respectively.

Table 2 displays summary statistics of the firm-level characteristics utilized in this study. One can see that our sample consists of relatively large business whose total assets range from 5 million to 20 billion Euros. Further, 72% of the firms in our sample are limited liability companies (GmbH) and 36% operate in the manufacturing sector. On average, firms' liabilities amount to 66% of total assets while bank-liabilities make up 26% of total assets. Another variable of key importance for our analysis is the ratio of interest expenditure to "gross debt".[4] We interpret this ratio as a proxy for an average firm-level interest rate on firms' debt. In that sense, Austrian businesses in our sample, on average (over time and across different types of debt), paid a real interest rate of 2.9%.[5]

In addition to annual firm specific information, the OeNB collects monthly data on individual loans between Austrian firms and banks in its central credit register (GKE).[6] The sample includes the stocks of credit by Austrian banks to Austrian firms whose total liabilities to Austrian banks exceed EUR 350,000, recorded at monthly frequency. Unfortunately, the OeNB's credit department does not record annual balance sheets and income statements for all of the firms whose financial obligations are in the GKE sample. This is due to the fact that GKE reports are mandated by law while reporting the balance sheet is voluntary. Consequently, our sample of firms is biased toward relatively large and sound businesses and, therefore, any results on risk-taking found in this study must be interpreted as an estimate of a lower bound for the true amount of risk-taking. In particular, we have access to a matched BILA-GKE sample for the years 2000 through 2009 which covers 316 Austrian banks and 6,815 firms whose detailed characteristics are also recorded in BILA.

Table 1 also summarizes the expected default rate within banks' business-loan portfolios ($EDR_{b,t}$) as well as the Austrian Taylor Rule gap ($gap_q^{TR}$) whose construction is outlined in Sections 3.2 and 3.3, respectively.

EMU member states are further required to collect detailed balance sheet infor-

[4]We define "gross debt" as liabilities net of long term reserves as well as provisions for pensions and other social transfers.

[5]In order to reduce the impact of measurement error on our results we drop "implausible" observations, such as negative values for total assets, entries where detailed balance sheet positions don't correctly sum up to reported aggregates, etc. Further, we identify observations that exceed five times the distance between the 5th and 95th percentile of the cross-sectional distribution in either direction as statistical outliers. We run our empirical analyses with and without the identified outliers and find no significant qualitative differences, yet we believe the "clean" dataset to be more representative of the average firm's characteristics.

[6]Details on the data collection criteria can be found in the official standards for reporting to the central credit register, which are publicly available at http://www.oenb.at/de/img/gke-richtlinie-20080729-e-1_tcm14-88442.pdf. Due to Austrian information privacy legislation the individual data on both firms and banks are strictly confidential and available to us only in anonymized form. Further the data have to be aggregated for any publication. Access to the anonymized individual data is granted by the OeNB's credit department on a case-by-case basis. Contact information can be found at www.oenb.at.

mation on their monetary and financial institutions (MONSTAT).[7] Unfortunately, due to Austrian data confidentiality restrictions, we were not allowed to match this detailed bank-level information to our sample of matched firm-bank pairs. Instead, we were able to merge very crude categories of key bank-level characteristics that vary on an annual frequency. The top panel of Table 1 illustrates our measures for banks' capitalization, liquidity, and size for the matched BILA-GKE sample.[8]

Finally, all aggregate data are drawn from the ECB's statistical data warehouse.[9] The bottom panel of Table 1 reports summary statistics on these aggregate variables. An important statistic for the purpose of this study is the average proportion of business loans within banks' balance sheets, which was 36%, on average, and was ranging between 33% and 39% between 2000 and 2008. The remaining aggregate variables are discussed in detail throughout sections 3.2 to 3.4. In particular, Figures 1 and 3 illustrates the time paths of selected aggregate characteristics employed in this study.

## 3.2 Banks' Loan-Portfolio Risk

A key building block of our empirical test is a single-index measure of each bank's ex-ante portfolio-risk position at any given point in time.

As a first step, we use the borrowers' annual balance sheets and income statements to estimate a probability of default (PD) for each of the firms in our sample.[10] We proxy the event of default, using the 533 bankruptcies observed within our unbalanced panel of 8,653 Austrian firms observed between 1993 and 2009. The low number of bankruptcies within our sample of firms is not surprising since only relatively large and sound businesses are willing to report balance sheet and income statement data to the OeNB's credit department. Nevertheless, loans to those enterprises make up a significant fraction of Austrian business lending and are therefore a relevant sample for the question at hand.[11] Furthermore, realized bankruptcies are a very conservative proxy for the event of default on a firm's financial obligations. It would be preferable, in principle, to use a less stringent measure, like late or insufficient payments on a loan-by-loan basis. Unfortunately, we do not have access to

[7]For details see http://europa.eu/legislation_summaries/economic_and_monetary_affairs/institutional_and_economic_framework/l25044_en.htm.

[8]The matching of the two datasets was conducted by the OeNB's credit department and the matched version was delivered to us in completely anonymized form.

[9]See http://sdw.ecb.europa.eu/.

[10]In principle it would be preferable to use firms' PDs as assessed within banks' internal rating models (which Austrian banks are mandated to construct due to the Basel II accord). Unfortunately, the OeNB only collects these bank-internal ratings starting with 2008. We, therefore, construct our own estimates based on firms' balance sheets and income statements in order to have a consistent measure of observable ex-ante default-risk throughout the sample period from 2000 through 2008.

[11]See Table 1.

such a measure, and thus consider our estimates as a lower bound for the true PD of a given borrower.

More precisely, we define

$$INS^h_{f,y} = \begin{cases} 1 & \text{if firm } f \text{ declares bankruptcy} \\ & \text{in any of the years } \tilde{y} \in \{y, y+1, ..., y+h\} \\ 0 & \text{otherwise,} \end{cases} \tag{1}$$

to indicate the event that a firm declares insolvency within $h$ years from year $y$. Further, we construct

$$LO_{f,y} = \gamma_0 + \gamma_1' \cdot AR_{f,y} + \gamma_2' \cdot LF_{f,y} + \gamma_3' \cdot IND_{f,y} + \gamma_4' \cdot Z_{f,y}, \tag{2}$$

where $AR_{f,y}$ is a $k_1 \times 1$ vector of accounting ratios derived from firms' annual balance sheets and income statements, $LF_{f,y}$ is a $k_2 \times 1$ vector of dummies for the firm's legal form, $IND_{f,y}$ is a $k_3 \times 1$ vector of industry dummies, and $Z_{f,y}$ represents a $k_4 \times 1$ vector of additional firm specific characteristics including the firm's age. The vector $\gamma = (\gamma_0, \gamma_1', ..., \gamma_4')' \in \mathbb{R}^K$ is a vector of coefficients with $K = 1 + \sum_{i=1}^4 k_i$. The particular choice of accounting ratios in $AR_{f,y}$ is guided by results in Hayden's (2003) earlier work on predicting Austrian firms' PDs. Thus, based on the above definitions we estimate the logit models

$$p^h_{f,y^*} \equiv \Pr\left[ \tilde{INS}^{h,y^*}_{f,y} = 1 \middle| AR_{f,y}, LF_{f,y}, IND_{f,y}, Z_{f,y}, y \leq y^* \right] = \frac{\exp(LO_{f,y})}{1 + \exp(LO_{f,y})}, \tag{3}$$

for the years $y^* \in \{2000, ..., 2009\}$, where

$$\tilde{INS}^{h,y^*}_{f,y} = \begin{cases} INS^h_{f,y} & \text{if firm } f \text{ declares bankruptcy before } y^*+1 \\ \text{undefined} & \text{otherwise.} \end{cases}$$

This means that, for example, our estimates for the probability of firm $f$'s default within $h$ years from the year 2000, $\hat{p}^h_{f,2000}$, employ balance sheet information from 1993 up until 2000. The estimates for 2001 use data from 1993 through 2001, etc. Table 6 in Appendix C reports the estimates of the coefficient vector $\gamma$ in equation (2) for each year between 2000 and 2009.

These estimates are not the particular focus of this study, yet they inform us about the relative importance of the various firm specific characteristics' ability to predict bankruptcy. We find that, consistently across time periods, the relative magnitudes and signs of our coefficient estimates are consistent with the results found by Hayden (2003), who fits a similar model to a sample of Austrian firms between 1987 and

1997. In particular, our estimates indicate that the degree of leverage as well as activity ratios, such as the ratio of accounts payable to net sales, have a significantly positive impact on firms' default risk.[12] On the other hand, the ratio of gross profits to expenditures on labor, measuring productivity, as well as ordinary business income as a fraction of assets, capturing firms' profitability, are significantly negatively related to the probability of default.

One outstanding result of our logit estimates is a highly significant and sizable positive relation between default risk and average firm-level real interest rates, as measured by the ratio of interest expenditures to gross debt. This finding is consistent with the classic adverse selection results, like advocated by Stiglitz & Weiss (1981), stating that high risk borrowers are more inclined to accept high interest rates. It is thus important to keep in mind that all the results found in this study take into account firm-level pricing of the credit extended to individual firms that is in line with standard theory.

Most important for the purpose of this study, however, is the ability of our estimates to accurately predict the events of default and non-default. In order to assess the predictive ability of our estimates we employ the area under the receiver operating characteristic curve (AUC).[13] Table 6 reports two versions of this statistic for each year. The AUC for in-sample (ex-post) predictions varies between 0.806 and 0.842 while our out-of-sample (ex-ante) predictions result in AUC values between 0.756 and 0.873. These numbers reveal that our predictions are fairly accurate, both in terms of ex-ante as well as ex-post predictions. Hence, we use the coefficient estimates discussed above, together with logit models (3), in order to compute ex-ante probabilities of default for every firm, $f$, and year between 2000 and 2009, $\left\{\hat{p}^h_{f,y}\right\}_{y=2000}^{2009}$. In what follows, we employ these estimates as our core measure of each firm's creditworthiness.

In practice, however, when banks and other investors take decisions on where to invest their money, they use ordinal rating scales—such as those published by Standard & Poor's (S&P) or Moody's—rather than direct estimates of each borrower's PD. Partially, this is because rating scales are easier to interpret than a specific estimate of the PD, but also because rating scales additionally take into account information about firms that is not directly observable from balance sheets or income

[12]The ratio of accounts payable to net sales captures a firm's "payment habits". Firms with a lot of outstanding payments to customers relative to their own sales tend to be financially more fragile.

[13]The AUC is the area under the receiver operating characteristic curve (ROC), which exploits the trade-off between failing to predict bankruptcy vs. failing to predict "non-bankruptcy". This is a good evaluation criterion for our particular purposes since we care about both "spotting a good investment opportunity" and, probably even more importantly, "avoiding a bad investment". The AUC is a statistic that varies between 0 and 1, where 0.5 is equivalent to a coin flip while an AUC of 1 indicates a perfect predictor.

statements. For this reason the OeNB has developed a rating scale that maps firms' PDs into 21 rating classes in order to assess individual banks' refinancing eligibility. This rating scale is designed in such a way that the OeNB can map PDs, as reported by banks on the basis of their individual internal rating models, into a unified rating scheme. Furthermore, each of these risk classes can be mapped into an S&P (or Moody's) equivalent rating.[14]

In order to illustrate the distribution of Austrian banks' business lending across the risk classes used in practice, we thus employ the OeNB rating scale to map our estimates of each borrower's PD into a risk rating, $\hat{r}_{f,y} = g(\hat{p}^{3}_{f,y-1}) \in \mathcal{R} = \{0, 1, ..., 21\}$, where $g(\cdot)$ indicates the OeNB's mapping between PDs and rating classes, and we focus on a horizon of bankruptcy within $h = 3$ years.[15]

A simple way to illustrate the composition of risk in a bank's business-loan portfolio is, therefore, to compute the fraction of credit advanced to borrowers within each risk class at any given point in time. We denote this fraction as

$$RF^{r}_{b,y,m} = \frac{\sum_{f \in \mathcal{F}^{r}_{b,y,m}} c_{f,b,y,m}}{\sum_{f \in \mathcal{F}_{b,y,m}} c_{f,b,y,m}} \quad \text{for all } r \in \mathcal{R}, \tag{4}$$

where $c_{f,b,m,y}$ denotes credit advanced from bank $b$ to firm $f$, $\mathcal{F}_{b,y,m}$ is the set of firms being serviced by bank $b$ in month $(y, m)$, and $\mathcal{F}^{r}_{b,y,m} = \{f \in \mathcal{F}_{b,y,m} | \hat{r}_{f,y} = r\}$ is the subset of firms that fall into risk class $r$ in year $y$. We compute these fractions for every Austrian bank in our sample of matched bank-firm pairs operating during the years 2000 through 2008.

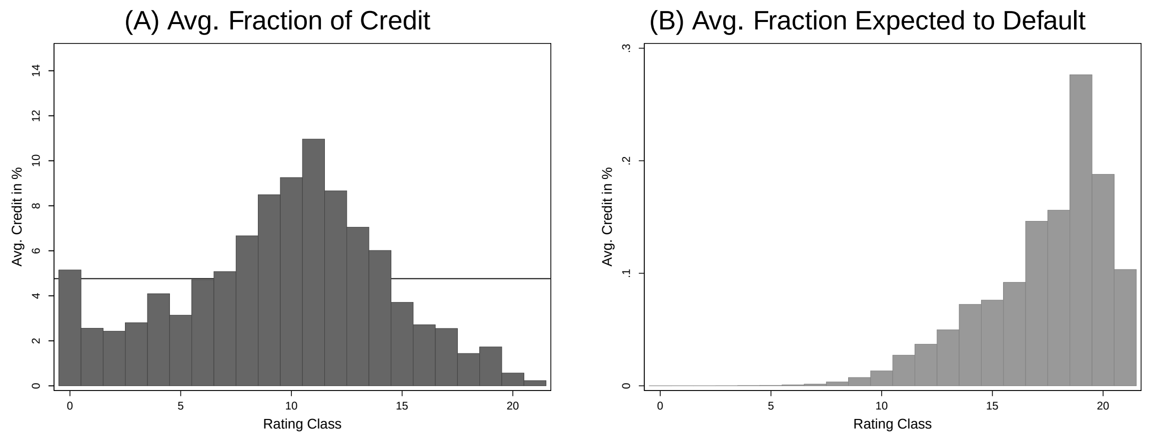
Panel (A) of Figure 2 plots the fractions of lending to each risk class, as defined in equation (4), for the average Austrian bank within the period from January 2000 through August 2008. As a reference, the horizontal line in panel (A) of Figure 2 indicates a uniform distribution across risk-classes. One can see that the bulk of business lending by the average Austrian bank was going to risk classes between 6 and 14. Nevertheless, there is also a non-negligible fraction of lending within risk classes 15 or higher.

While panel (A) of Figure 2 illustrates the composition of risk within the average Austrian bank's business-loan portfolio relative to the OeNB's rating scale, we argue

[14] A description of the OeNB's rating scale and its use can be found on page 49 in http://www.oenb.at/en/img/offsiteanalysis_internet_tcm16-33280.pdf.

[15] The precise specification of $g(\cdot)$ is confidential and we are not allowed to present it here. However, as we explain at the end of this section, our central measure of banks' portfolio-risk is constructed in a way such that it does not depend on the particular design of the OeNB's rating scheme. Nevertheless, we illustrate the banks loan composition relative to the OeNB rating scale in order to illustrate the potential pitfalls when constructing a risk measure dependent on a risk-rating whose precise construction is unknown. We also perform robustness checks of all results with respect to the bankruptcy horizon, $h$, and find no qualitative difference when varying the horizon between one and five years.

Figure 2: The Average Bank's Loan Portfolio and Expected Default Rate (2000 - 2008)




*Notes:* Panel (A) illustrates the average fractions of lending to each risk class, defined as $\overline{RF}^r = \left(\sum_{f\in\mathcal{F}^r}\bar{c}_f\right)/\left(\sum_{f\in\mathcal{F}}\bar{c}_f\right)$ for all risk classes, $r \in \mathcal{R}$, where $\bar{c}_f$ represents the pooled average of lending to firm $f$, $\mathcal{F}$ is the set of all firms, and $\mathcal{F}^r$ is the set of firms in risk class $r$ during the period 2000m1 through 2008m8. As a reference, the horizontal solid line represents a uniform distribution across risk classes. In panel (B) the fractions from panel (A) are weighted by the pooled average (across firms and years) of the estimated PD within each risk class.

that the displayed distribution does not provide a convenient tool to assess the average bank's overall portfolio risk. This is because the illustrated distribution does not inform us about the relative riskiness of individual risk classes. We know, for instance, that borrowers in risk class 15 have a worse credit rating than those in risk class 14. However, this information does not inform us about the precise underlying difference in creditworthiness. In other words, risk classes $r \in \mathcal{R}$, are an ordinal measure of risk, which are a practical tool for an investor who wants to allocate a set amount of resources to potential investment projects with different degrees of risk. In order to construct a measure of overall portfolio-risk, on the other hand, we need a cardinal measure of each borrower's riskiness that allows us to quantify the relative tradeoffs between the different risk classes. De Nicoló et al. (2010), who assess US banks' portfolio-risk, address this issue by applying a weighting scheme that assigns a weight of 0 to the lowest risk class and a weight of 1 to the highest risk class.[16] The resulting measure is dependent on the precise choice of rating scale as well as weighting-scheme and is, consequently, difficult to interpret independently.

Therefore, to avoid this implicit dependency, we choose to utilize the average estimated probability of default, $\bar{p}^r_{b,y,m} = \left(1/N^r_{b,y,m}\right)\sum_{f\in\mathcal{F}^r_{b,y,m}}\hat{p}^3_{f,y-1}$, where $N^r_{b,y,m}$ is the number of firms in risk class $r$, serviced by bank $b$ in month $(y, m)$, as the weight

[16] In De Nicoló et al.'s (2010) analysis, "[r]isk-weighted assets are defined as the weighted average of different bank assets, where the weights denote increasing riskiness that is guided by bank regulation. For instance, highly rated government securities, such as U.S. treasuries, command a risk weight of zero, whereas most unsecured household loans command a risk weight of 100 percent."

for each risk class. This weighting scheme is easy to interpret and, more importantly, produces a cardinal measure that is independent of the underlying design of the rating scale.

Panel (B) of Figure 2 depicts the resulting distribution of the PD weighted fractions of credit within each risk class, $\bar{p}^r_{b,y,m} \cdot RF^r_{b,y,m}$, for the average Austrian bank within the period of January 2000 through August 2008. Since our risk weights are the estimated probabilities of default we interpret this measure as the expected default rate within each risk class. Thus, this alternative illustration of the average bank's composition of portfolio-risk highlights that only loans to the highest risk-classes are effectively resulting in significant expected loss rates.

Furthermore, summing these default rates across all risk-classes produces a measure of the expected default rate within each bank's business loan portfolio, which we denote as

$$EDR_{b,t} = \sum_{r \in \mathcal{R}} \bar{p}^r_{b,t} \cdot RF^r_{b,t}, \tag{5}$$

for each bank $b$ in month $t = (y, m)$. Within our sample of Austrian bank-firm pairs between January 2000 and August 2008 the average expected default rate is 0.5242%. To put this number into perspective, Table 3 reports publicly available expected default frequencies for a 5-year horizon for selected major Austrian banks. In the analysis presented throughout this paper, we focus on a 3-year horizon as we believe that our sample of firms' balance sheets from 1993 through 2009 is too short to convincingly analyze a horizon as long as five years. Nevertheless, in order to facilitate the comparison of our measure to the numbers in Table 3, we compute the average expected default rate for horizon $h = 5$, which yields an unconditional average of 0.9596%.[17]

The default frequencies in Table 3, derived from ratings by Moody's Financial Services and conversion tables by Tabakis & Vinci (2002), are a measure of banks' overall portfolio risk. It is, thus, not surprising that the default rates reported in Table 3 are slightly lower than the average default rate, $EDR_{b,t}$, as constructed in equation (5). First, $EDR_{b,t}$ only captures the default risk within banks' loan portfolio, which is presumably hedged, to some extent, by other assets on banks' books. Second, the default rates reported in Table 3 are only for the 6 largest Austrian banks while the measure constructed in this study incorporates 316 Austrian banks. Given the methodological differences and the different sample we conclude that our measures of expected default risk within Austrian banks' business-loan portfolios are broadly

[17]As mentioned earlier we perform our entire analysis for horizons $h = 1, 2, 3, 4, 5$ and find no notable qualitative differences in the main results. Regression tables akin to Tables 5 and 6 in Appendix C for the alternative horizons are available upon request.

Table 3: Expected Default Frequencies of Selected Major Austrian Banks

| | Oct. 31 2005 | Sep. 30 2006 | May 14 2007 | Nov-13 2008 | Oct. 23 2009 | May 25 2010 |
|---|---|---|---|---|---|---|
| BA-CA | 0.66 | 0.66 | 0.50 | 0.50 | 0.75 | 0.75 |
| BAWAG P.S.K. | 0.66 | 0.45 | 0.45 | 1.45 | 1.45 | 1.45 |
| Erste Bank | 0.75 | 0.75 | 0.45 | 0.45 | 0.45 | 0.45 |
| Hypo | 0.50 | 0.50 | 0.66 | 0.66 | 1.45 | 1.29 |
| VAG | 0.66 | 0.66 | 0.45 | 0.45 | 1.45 | 1.45 |
| RZB | 0.75 | 0.75 | 0.50 | 0.50 | 0.75 | 0.75 |
| Avg. | 0.66 | 0.63 | 0.50 | 0.67 | 1.05 | 1.02 |

*Notes:* The table reports expected default rates in percent based on ratings by Moody's Investor Services. These ratings are drawn from various issues of the official OeNB financial stability report, which are publicly available at www.oenb.at. The ratings by Moody's are translated into expected default rates for a horizon of 5 years based on tables provided by Tabakis & Vinci (2002). When comparing the ratings for 2005 and 2006 to later years one has to take into account a change in Moody's rating methodology as of 2007. For details see the OeNB's Financial Stability Report in June 2007, p. 70.

consistent with publicly available measures for overall risk in banks' portfolios.

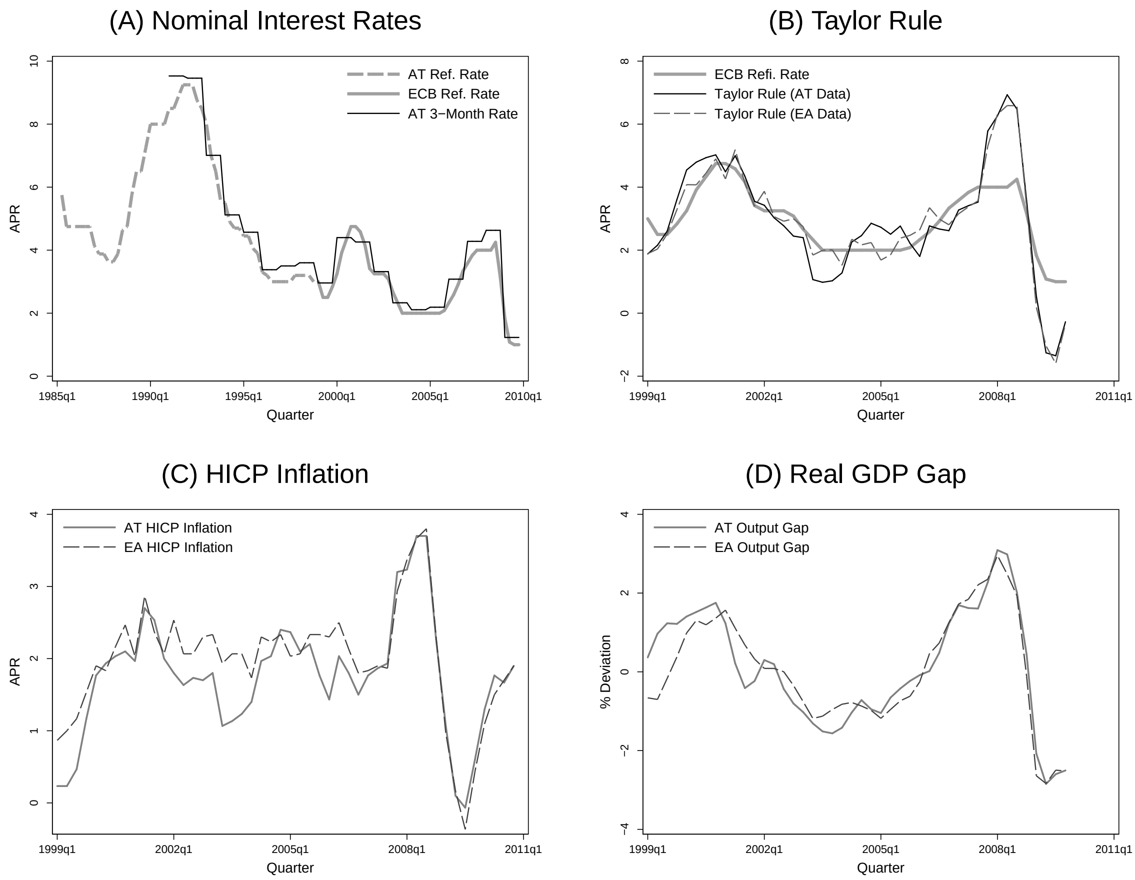
Therefore, in what follows, we will employ banks' expected default rates, $EDR_{b,t}$, defined in equation (5), as our measure of banks' loan-portfolio risk.

## 3.3 The Stance of Monetary Policy

Analyzing the effect of extended periods of extremely accommodating monetary policy requires an appropriate measure for the stance of monetary policy. Using interest rates for the ECB's main refinancing facility, it is easy to identify a unique period of unprecedentedly low policy interest rates between June 6, 2003 and December 6, 2005. This period can be considered a unique "policy regime" since up until that point refinancing rates had never been as low and also had never remained unchanged for such an extended period of time. Panel (A) of Figure 3 plots the ECB refinancing rate in comparison to the Austrian refinancing rate prior to the establishment of the EMU as well as Austrian 3-month interest rates starting in 1990. As one can clearly see, the Austrian short term interest rate closely follows the ECB policy rate. This illustrates that the policy rate set by the ECB has a direct effect on short term rates relevant for Austrian market participants.

While the aforementioned period between 2003 and 2005 is a natural candidate for a case study of a "low interest rate" policy regime it is not trivial to identify a causal effect on bank risk-taking induced by a switch to that regime. Since the Austrian economy generally has a very low weight in the ECB's objective function one can argue that any change in policy rates is not directly caused by events happening

Figure 3: The Stance of Monetary Policy




*Notes:* The Taylor rules in panel (B) are computed using equation (12) based on Austrian as well as euro area quarterly HICP inflation and real GDP. We assume equal weights on output and inflation stabilization, i.e. $\phi_\pi = \phi_y = 0.5$, and we do not consider interest rate smoothing, i.e. $\phi_i = 0$. All equilibrium values are approximated with a Hodrick-Prescott trend using a smoothing parameter $\lambda = 1600$. All aggregate data are drawn from the ECB's statistical data warehouse (http://sdw.ecb.europa.eu/).

in the Austrian economy. However, it is still possible that Austrian economic activity is very highly correlated with other European countries—first and foremost Germany. Therefore, in times during which the Austrian economy moves in lock-step with the German economy one must interpret ECB policy actions *as if* they were geared toward stabilizing the Austrian economy. In such a scenario, any estimate of the correlation between a switch in monetary policy regimes and the change in a measure of bank risk-taking does, consequently, not necessarily identify a causal link. It is in fact possible that a change in risk-taking within the Austrian banking sector—together with simultaneous changes of the same nature in other countries—is causing the ECB to change its stance of monetary policy and not the other way around.

To accommodate this inherent endogeneity problem we identify sub-periods within each policy regime for which we can confidently argue that ECB monetary policy was exogenous to Austria. We accomplish this by comparing the actual ECB refinancing rate to a given "reference policy rate" for Austria, in order to gauge whether, from an Austrian perspective, policy had potentially been "too tight" or "too loose". If the chosen reference policy represents the policy actions that the ECB would have taken if it had been concerned exclusively with the Austrian economy, then any deviation from that reference policy represents an ECB intervention that must have been exogenous to the Austrian economy. Thus, for this identification strategy to be valid, it is crucial to identify a reference rule that is a good predictor for observed ECB policy rates, when applied to euro area data. A natural choice for such a reference policy is a Taylor (1993) rule. The resulting deviations from the realized ECB refinancing rates for both the euro area (EA) and Austria (AT), which we will refer to as Taylor rule "gaps", $gap_q^{j,TR}$, can be written as

$$gap_q^{j,TR} = \left[\bar{r}_q^j + \phi_\pi(\pi_q^j - \bar{\pi}_q^j) + \phi_y(y_q^j - \bar{y}_q^j)\right] - \left[i_q^{ECB} - \pi_q\right], \quad (6)$$

where $i_q^{ECB}$ is the ECB refinancing rate, $\pi_q^j$ and $y_q^j$ represent HICP inflation and real GDP in geographic region $j \in \{AT, EA\}$ in quarter $q$, respectively. $\bar{r}_q^j$, $\bar{y}_q^j$, and $\bar{\pi}_q^j$ denote equilibrium (or *target*) levels of real interest rates, real GDP, and inflation in regions $j$. Finally, $\phi_\pi$ and $\phi_y$ represent policy weights on inflation and output stabilization, respectively.

In our empirical analysis, we use Taylor's (1993) original suggestion of equal weights on output and inflation stabilization, i.e. $\phi_\pi = \phi_y = 0.5$. Further, we approximate all equilibrium values for each region $j$ using a Hodrick-Prescott (HP) filter with a smoothing parameter of $\lambda = 1600$, i.e. $\bar{r}_q^j = \hat{\bar{r}}_q^{j,HP}$, $\bar{y}_q^j = \hat{\bar{y}}_q^{j,HP}$, and $\bar{\pi}_q^j = \hat{\bar{r}}_q^{j,HP}$.

Panel (B) of Figure 3 illustrates the Taylor rules for both regions, AT and EA, as well as the actual ECB refinancing rates. One can see that the reference policy performs significantly better when applied to EA data as opposed to AT data. Appendix B shows that this feature is robust to five alternative specifications, including the one employed by Altunbas et al. (2009).[18] We choose the specification where all equilibrium variables are estimated with an HP trend, as it is the most agnostic specification and allows for changes in the ECB's implicit inflation target. One can clearly see that during the period from 2000 trough 2008 there are several sub periods during which the Taylor rule predicts monetary policy that should have been more accommodating as well as sub-periods during which monetary policy should have been more restrictive, from an Austrian point of view.

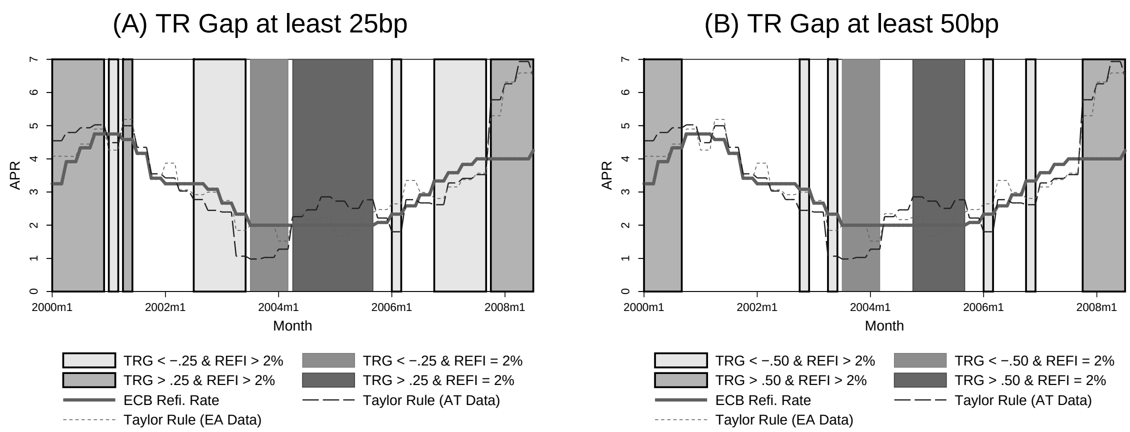
Since, historically, the minimum change in policy rates considered by the ECB

[18] In particular, we run all our empirical tests for the 6 specifications reported in Appendix B, and find no notable qualitative differences.

is 25 basis points, we argue that, as a baseline case, any period during which the Taylor rule gap, as defined in equation (6), exceeds 25 basis points in absolute value is one in which monetary policy was exogenous to the Austrian economy. Panel (A) of Figure 4 illustrates the resulting division of our sample into sub-periods during which we consider ECB policy to be exogenous to Austria. The figure also depicts the Taylor rule predictions for both Austria and the euro area. One can clearly see that the Austrian Taylor rule predicts a larger deviation than the euro area Taylor rule in almost all of the highlighted periods.

To ensure that our analysis is not contaminated by the few selected periods during which the euro area Taylor rule is a worse predictor for observed ECB policy than the Austrian Taylor rule, we select an alternative set of sub-periods in which the Austrian Taylor rule gap is larger than 50 basis points in absolute value. Panel (B) of Figure 4 illustrates that, for this alternative specification, there is no case where the euro area Taylor rule gap exceeds the Austrian Taylor rule gap in the same direction. Hence, we argue that during the selected sub-periods, the ECB refinancing rate was not geared either directly or indirectly—for instance, through the tight link between Austria and Germany—toward the Austrian economy.

Figure 4: Design of the Natural Experiment




*Notes:* The Taylor rules are computed using equation (12) based on Austrian as well as euro area quarterly HICP inflation and real GDP. We assume equal weights on output and inflation stabilization, i.e. $\phi_\pi = \phi_y = 0.5$, and we do not consider interest rate smoothing, i.e. $\phi_i = 0$. All equilibrium values are approximated with a Hodrick-Prescott trend using a smoothing parameter $\lambda = 1600$. All aggregate data are drawn from the ECB's statistical data warehouse (http://sdw.ecb.europa.eu/).

The next section outlines how we employ these periods, together with our measure of banks' loan-portfolio risk, to estimate a causal effect of the monetary policy regime between 2003 and 2005 on risk-taking in Austrian business lending.

### 3.4 Assessing the Effect of “Too Low Interest Rates for Too Long”: A Natural Experiment

In order to test whether interest rates that were “too low for too long” lead to a deterioration in Austrian banks’ risk positions, we adapt an empirical strategy called “difference in differences“, which enjoys great popularity in applied empirical microeconomics due to the seminal work by Card & Krueger (1994). This empirical strategy is useful whenever one seeks to analyze a discrete policy change and the policy measure under review does not vary at the level of the individuals affected. In our case, the individuals are banks, and the ECB refinancing rate is a policy instrument that is the same for every bank within the euro area.

The basic idea behind this method is best explained within the context of a randomized medical experiment. Suppose we wanted to assess the effectiveness of Aspirin in reducing fever for a group of patients showing up at a doctor’s office. We would randomly select two groups of patients and take their temperature. In the next step, we would give one group an actual Aspirin and prescribe a sugar pill to the other group.[19] After an hour we would take everybody’s temperature for a second time and compute the difference in average temperatures of the treatment group as well as the difference in average temperature of the control group (i.e. the sugar pill recipients). The difference between the two differences would tell us the effectiveness of Aspirin in reducing fever. The difficulty with applying this method to economics is the construction of pseudo-randomized groups, which is usually referred to as the design of a “natural experiment.”

Within the context of this study, we seek to analyze the effect of a certain monetary policy regime (Aspirin in the example given above) on the risk-taking behavior of banks (the changes in patients’ temperature in the aforementioned example). To accomplish this, we start with defining

$$MPR_t = \begin{cases} 1 & \text{if} \quad i_t^{ECB} = 2\% \\ 0 & \text{if} \quad i_t^{ECB} > 2\% \end{cases} \quad \text{and} \quad TRG_t^{\mu} = \begin{cases} 1 & \text{if} \quad gap_t^{TR} > \mu \\ 0 & \text{if} \quad gap_t^{TR} < -\mu \end{cases}, \tag{7}$$

where $MPR_t$ indicates the monetary policy regime in period $t = (y, m)$.[20] We consider the period between 2003 and 2005 ($MPR_t = 1$) as the “treatment” period and all the remaining periods between 2000 and 2008 ($MPR_t = 0$) as the “control” periods. The indicator $TRG_t^{\mu}$ serves two purposes in the design of our natural experiment:

[19]It is important to note that the group of patients that visit the doctor’s office is not a random selection (they are all sick). However, who receives the actual drug and who receives the placebo is random, i.e., the doctor flips a coin to assign each patient to one of the two groups.

[20]Notice that, since we restrict our sample to the period 2000-2008, this indicator unambiguously identifies the low interest rate period of 2003-2005.

First, it acts as a "pseudo-randomization" tool since it isolates periods during which monetary policy was exogenous—or, statistically speaking, "random"—to the Austrian economy. As we argued in Section 3.3 we choose two alternative thresholds, $\mu \in \{0.25, 0.5\}$, in order to ensure exogeneity of the monetary policy instrument. Second, $TRG_t^{\mu}$ allows us to measure the effect of a switch from "worse than EA average" ($TRG_t^{\mu} = 0$) to "better than EA average" ($TRG_t^{\mu} = 1$) economic performance—or in other words, a switch to benign economic conditions. This interpretation is motivated by the fact that a Taylor (1993) rule prescribes high interest rates when economic performance is promising and inflation is high, while it advocates low interest rates when the economy is in need of stimulus and there is little fear of inflationary pressure.

Using the above definitions, we denote the expected change in banks' expected default rate due to a switch in economic conditions—from "worse than the EA" to "better than the EA"—relative to threshold $\mu$ and within a given policy regime $i \in \{0, 1\}$ as

$$\left.\frac{\Delta EDR}{\Delta TRG^{\mu}}\right|_{MPR=i} \equiv \mathrm{E}\left[EDR_{b,t}\left|TRG_t^{\mu} = 1, MPR_t = i\right.\right] - \mathrm{E}\left[EDR_{b,t}\left|TRG_t^{\mu} = 0, MPR = i\right.\right]. \tag{8}$$

The changes defined in equation (8) are akin to the changes in temperature over time within the "treatment group" ($MPR_t = 1$) as well as the "control" group ($MPR_t = 0$) in the example of the medical experiment. Therefore, we formally define the null hypothesis

$$H_0 : DD^{\mu} \equiv \left.\frac{\Delta EDR}{\Delta TRG^{\mu}}\right|_{MPR_t=1} - \left.\frac{\Delta EDR}{\Delta TRG^{\mu}}\right|_{MPR_t=0} = 0. \tag{9}$$

in order to test it against the alternative $H_1 : DD^{\mu} \neq 0$. In words, we are testing whether the period of extremely accommodating monetary policy between 2003 and 2005 ($TRG_t^{\mu} = 1$) changes the response of banks' loan-portfolio risk to a relative improvement in economic conditions.[21] We interpret this as a way to assess whether "too low interest rates for too long" have an effect on bank risk-taking. The Austrian banking sector between 2003 and 2005 provides a case study for evaluating this claim, as we identify that, during the "treatment" period, Austrian economic activity starts out below the EA average and switches to above EA average as early as the second quarter of 2004. Thereafter, as illustrated in Figure 4, ECB refinancing rates re-

[21]In fact, as one can see in panels (C) and (D) of Figure 3 as well as Figure 4, it turns out that all the relative improvements in Austrian economic activity considered by this test are also absolute improvements.

mained constant—and, hence, "too low" form an Austrian perspective—throughout the rest of the "low interest rate" regime ending during the fourth quarter of 2005.

Since the hypothesis in equation (9) only involves simple conditional expectations it is easy to construct estimates $\hat{DD}^{\mu}$ based on conditional sample averages. However, the conditional expectations in equation (8) assume that all banks are equal and all aggregate economic conditions, that might also be influencing the amount of banks' risk-taking, stay unchanged throughout the entire sample period. As this assumption is likely to be violated, we are potentially reporting inconsistent estimates due to the omission of observed and unobserved bank heterogeneity as well as aggregate characteristics. We can easily accommodate this concern by casting the above exercise into the following regression framework:

$$EDR_{b,t} = \alpha_0^{\mu} + \alpha_1^{\mu} \cdot MPR_t + \alpha_2^{\mu} \cdot TRG_t^{\mu} + DD^{\mu} \cdot [MPR_t \times TRG_t^{\mu}] + \beta^{\mu\prime} X_{b,t} + \epsilon_{b,t}^{\mu}, \quad (10)$$

where $(\alpha_0^{\mu}, \alpha_1^{\mu}, \alpha_2^{\mu}, DD^{\mu}, \beta^{\mu\prime})' \in \mathbb{R}^{4+\ell}$ is a coefficient vector, $X_{b,t}$ represents an $\ell \times 1$ vector of observable bank-specific and aggregate characteristics as well as a set of bank indicator variables, $\epsilon_{b,t}^{\mu}$ is a disturbance term with $E[\epsilon_{b,t}^{\mu}] = 0$, and $\mu \in \{0.25, 0.5\}$.[22]

It is straightforward to show that $DD^{\mu}$ in regression model (10) is equivalent to the definition in equation (9) if and only if $\beta^{\mu\prime} = 0$.[23] Hence, if indeed there is no relevant systematic relation between individual bank characteristics and banks' expected default rates, then the OLS estimate $\hat{DD}^{\mu}$ is equivalent to taking simple conditional sample averages. If, on the other hand, bank and aggregate characteristics, $X_{b,t}$, influence expected default rates, the baseline estimates are inconsistent estimates of $DD^{\mu}$.

Therefore, we alternatively estimate regression model (10) controlling for various bank-level characteristics as well as aggregate variables, that are likely to be influencing expected default rates. Section 4 shows our empirical results and discusses the various characteristics included in $X_{b,t}$.

# 4 Empirical Results

Using the dataset described in Section 3.1 we perform the empirical tests outlined in Section 3.4. Table 4 summarizes the resulting estimates for the "difference in differences", $\hat{DD}^{\mu}$, as well as the associated standard errors in parentheses below each estimate. We find that, for both versions of the pseudo-randomization, $\mu \in \{0.25, 0.5\}$, the effect of the low interest rate regime on banks' risk positions is

[22]Note that the vector of control variables combines both bank-specific and aggregate variables, i.e. $X_{b,t} = (\tilde{X}_{b,t}', Z_t')'$, where $\tilde{X}_{b,t}$ is an $\ell_1 \times 1$ vector of bank-specific variables (including fixed effects) and $Z_t$ represents an $\ell_2 \times 1$ vector of aggregate variables, with $\ell = \ell_1 + \ell_2$.

[23]See Appendix A for details of the relation between equations (9) and (10).

positive and highly significant. In particular, as summarized in rows A.1 and B.1 of Table 4, using simple conditional sample averages, we estimate the average expected default rate to increase by about 11 to 17 basis points, depending on the value of threshold $\mu$, relative to an overall sample average of 0.5242%. This is a sizable effect, especially considering the conservative estimates of PDs and our sample of relatively large and sound businesses.

Further, our analysis indicates that expected default rates during the "counterfactual" periods were slightly decreasing in response to an improvement in economic conditions—both relative to the EA as well as in absolute terms. This finding reveals that temporary deviations of ECB refinancing rates from those predicted by the AT Taylor rule do not necessarily imply a deterioration in banks' balance sheets. Thus, we can conclude that it takes an extended period of low and stable policy interest rates for risk-taking incentives to kick in.

However, as argued in the previous section, we have reason to believe that these baseline estimates might be inconsistent due to the omission of bank-level and aggregate characteristics, that also influence the amount of risk in banks' loan portfolios. Therefore, rows A.2 and B.2 in Table 4 summarize estimates of "conditional differences in differences", based on OLS estimates of regression model (10). As one can clearly see, controlling for various aggregate and bank-level characteristics does not change the qualitative result. The detailed regression results are displayed in Table 5 of Appendix C and we will briefly discuss the additional control variables in the following paragraphs.

As one can see in panels (C) and (D) of Figure 3, Austrian output gaps as well as inflation differ substantially between the "control" and "treatment" periods. Thus, to ensure that our results are not driven by these changes we include the levels of Austrian output gaps, $y_q^{AT} - \bar{y}_q^{AT}$, and inflation, $\pi_q^{AT}$, as our first set of control variables. Our regression results indicate that the influence of Austrian output gaps on banks' expected default rates is significant and, as expected, negative.

Further, we presume that both term and country-risk-premia might have a significant influence on the degree of risk in banks' portfolios. We accommodate this concern by including the spread between Austrian 10-year bond yields and 3-month EA money market rates, $i_q^{10,AT} - i_q^{3,EA}$, to proxy term-spreads, and the spread between the yields of Austrian 10-year and EA 10-year bonds, $i_q^{10,AT} - i_q^{10,EA}$, to control for country-risk premia. We find that, for a threshold $\mu = 0.5$, country risk spreads have a significantly positive influence on banks' risk position.

As we pointed out in our discussion of the most recent credit cycle in Austria, there was a tremendous increase in real business-lending activity toward the end of the "treatment period". To make sure that the measured increase in expected default

Table 4: The Effect of "Too Low Interest Rates for Too Long"

| | $i_q^{ECB} > 2\%$ | $i_q^{ECB} = 2\%$ | Diff. |
|---|---|---|---|
| *(A) TR Gap at least 25bp in absolute value ($\mu = 0.25$)* | | | |
| TR Gap $< -.25$ | .4968 | .5554 | .0586 |
| | (.0056) | (.0153) | (.032) |
| TR Gap $> .25$ | .4408 | .6149 | .174 |
| | (.0063) | (.0126) | (.0392) |
| **A.1 Difference** | -.0559 | .0595 | **.1154** |
| | (.0175) | (.019) | (.0243) |
| **A.2 Conditional Difference** | -.0243 | .0891 | **.1134** |
| | (.0318) | (.022) | (.0261) |
| *(B) TR Gap at least 50bp in absolute value ($\mu = 0.5$)* | | | |
| TR Gap $< -.5$ | .5309 | .5554 | .0244 |
| | (.0092) | (.0153) | (.0316) |
| TR Gap $> .5$ | .4236 | .6236 | .2 |
| | (.0071) | (.0132) | (.0328) |
| **B.1 Difference** | -.1074 | .0682 | **.1756** |
| | (.0213) | (.0294) | (.0338) |
| **B.2 Conditional Difference** | -.1585 | .0961 | **.2546** |
| | (.0653) | (.0353) | (.0534) |

Average expected default rate: 0.5242%

*Notes:* The table reports average expected default rates in percent (across banks and months) within each group. Standard errors of the averages are reported in parentheses below each average. Standard errors of the differences are adjusted for serial correlation and clustered on bank. Details on the conditional differences are reported in Table 5 of Appendix C. As a reference, the unconditional sample average of expected default rates across all banks from 2000 through 2008 is reported in the last line.

rates is not entirely driven by this significant credit expansion during the year 2005, we also include real Austrian business-loan growth, as depicted in panel (B) of Figure 1.

Another concern is the restriction of our analysis to business-lending only. While business lending in Austria amounts to roughly 40% of all lending, alternative sources of external funding became significantly more popular throughout our sample period from 2000 through 2008. Thus, we include the aggregate fraction of Austrian business lending in banks' total assets to accommodate this concern. Our regression results indicate that this control variable is not statistically significant.

Apart from concerns about aggregate changes in the Austrian economy we are also worried about changes in the aggregate representativeness of our unbalanced panel of firm-bank pairs. For that reason we include the ratio of aggregate lending within our GKE sample as a fraction of overall Austrian business lending. We find that this variable, indeed, is significantly correlated with expected default rates for a threshold of $\mu = 0.5$.

Finally, after controlling for the relevant aggregate characteristics, we are further concerned about bank-level heterogeneity, that might be driving our results. Hence, we include control variables for banks' degree of capitalization, cash ratio, size by total assets, as well as the number of customers serviced at any given point in time. On top of that, we add a complete set of bank fixed effects to additionally accommodate for unobserved bank heterogeneity. Our regressions indicate that, on top of what is already captured by bank fixed-effects, none of the specific bank-level control variables significantly affect expected default rates in banks' business-loan portfolios. This is an important observation, as these bank-level variables capture the effects of changes in financial regulation that were going on during this period—first and foremost the structural changes due to (the preparation for) the Basel II accord, which became legally binding in Austria as of January 1, 2007.

Given this rich set of control variables, we are confident, that the effect identified by our analysis, as illustrated in rows A.2 and B.2 in Table 4, is indeed capturing a causal effect of extremely low and constant policy interest rates during the years 2003 through 2005 on Austrian banks' risk-taking behavior.

## 4.1 Robustness Checks

Despite the many aggregate control variables, discussed in the previous section, one might raise the concern that the period between 2000 and 2002 was quite different from the period between 2006 and 2008, along other dimensions, not controlled for here. Thus, we investigate whether there is a difference in the measured effect, if we restrict our control periods to either "before" (2000-2002) or "after" (2006-2008) the "treatment" period, respectively. Table 5 of Appendix C illustrates the results of the two alternative thought experiments and reveals a significantly positive effect on bank-risk-taking for both of them.

These alternative experiments have an important consequence: They rule out financial innovation, systematic changes in risk-management practices, as well as more restrictive capital adequacy requirements—in preparation for the Basel II accord—as the main drivers for the increase in loan-portfolio-risk. All these structural changes took place during the "treatment" period. Thus, if they were driving the results, then we should see a significant "difference in differences" for the "before" comparison but not for the "after" comparison—a hypothesis that we can confidently reject.

Furthermore, all results presented in this article are conditional on a bankruptcy prediction horizon $h = 3$. This particular choice is mainly driven by the fact that we only observe a very low number of bankruptcies within our sample of firms and, more importantly, as firms' balance sheets are reported on a voluntary basis, we do not observe very many firms' balance sheets for the year of their bankruptcy. Thus, using a longer forecasting horizon allows us to also utilize information about firms whose balance sheet we do not observe in the year of bankruptcy. The longer the forecasting horizon, however, the more observations we give up at the end of our sample, for the purpose of our bankruptcy prediction exercise. Keeping this tradeoff in mind, we perform our entire empirical exercise for horizons $h = 1, 2, 3, 4, 5$ but do not find any significant qualitative differences in our main results. Thus, we chose to report detailed results for a horizon $h = 3$, as it represents the "middle ground" in terms of the trade-off described above.

# 5 Concluding Remarks

Our empirical findings point to a channel of the transmission mechanism of monetary policy which is exclusively triggered by a stance of monetary policy, that is characterized by an extended period of extremely cheap short-term refinancing conditions. This channel works on top of the traditional interest rate channels, the "broad credit channel", as well as mechanisms that are driven by the spread between long-term and short-term financing costs (Woodford 2010), as illustrated in Figure 1.

However, in contrast to the traditional transmission channels, this so-called "risk-taking channel" of monetary policy has the property that its consequences for real activity need not materialize within a short period of time.[24] In fact, as the direct effect of this mechanism is a deterioration of financial institutions' risk-positions, it might not result in any significant implications for the real economy under "normal" circumstances. However, in the unlikely event of a significant disruption of financial markets—like the failure of Lehman Brothers in the fall of 2008, which resulted in a global panic among investors, that occurred only 3 years after the deterioration of banks' balance sheets had taken place—more "fragile" bank balance sheets might significantly amplify the repercussions of a "shock" to the financial system. It is thus not surprising that Nouriel Roubini and Stephen Mihm compare the mechanisms that lead to the 2007/2008 financial turmoil to the fault lines that eventually lead to

[24]See for instance Christiano et al. (1996) or Christiano et al. (2007), who find that real activity tends to respond within about a year to temporary movements in short term policy interest rates. Furthermore, the latter study also finds extremely quick responses of borrowers' net worth and risk spreads.

an earthquake (Roubini & Mihm 2010, p. 62):

> [...] [T]he pressures build for many years, and when the shock finally comes, it can be staggering. [...] The collapse revealed a frightening truth: the homes of subprime borrowers were not the only structures standing on the proverbial fault line; countless towers of leverage and debt had been built there too.

Moreover, the deterioration of banks' balance sheets during the period 2003 through 2005 was likely to be significantly amplified by the tremendous increase in the quantity of lending, that is consistent with traditional channels of monetary policy transmission and illustrated in Figure 1. This amplification is likely to have happened, as the outstanding boom in lending activity significantly increased the size of the financial sector, and hence, made any sudden failure of this market even more detrimental to the overall economy.

Thus, the existence of the "risk-taking channel" suggests that future monetary policy should take into account its effects on financial stability due to its influence on risk-taking behavior of financial institutions. Whether this calls for a policy of "leaning against the wind of financial imbalances" (Bini Smaghi 2011) or whether tighter coordination with prudential regulation is the appropriate route for future policy goes beyond the scope of this paper.

Nevertheless, our results are useful in guiding the design of future policy as they shed some new light on the potential mechanisms through which this channel might work. The most prominent proposal for the incentive that triggers such a change in risk-taking behavior is the so-called "search for yield" (Rajan 2006, Borio & Zhu 2008). The idea behind this motive is a lack of high yield investment opportunities, during periods in which extremely low policy interest rates exercise downward pressure on real long-term yields. Our results are consistent with such a mechanism, as our logit regressions point to a significant positive relation between firm-level real interest rates and firms' probabilities of default throughout the entire sample period of 2000 through 2008 (see Table 6 in Appendix C). Thus, the measured increase in banks' portfolio risk between 2003 and 2005 must have been compensated by higher yields, in a period during which returns on business-loans were constantly falling (see panel (A) of Figure 1).

A second possibility, consistent with our results, is an incentive that stems from the expectation of cheap future refinancing conditions. If a bank is expecting that refinancing rates will remain cheap for a long period of time, then more risky investment projects are less dangerous, as potential short term losses can easily be overcome by extremely cheap short term refinancing. Thus, the longer refinancing rates stay constant at extremely low rates, the more banks might start to expect this tendency to continue, and in turn, engage in more risky lending activities.

Thus, our evidence highlights a channel of the monetary transmission mechanism that should not be ignored in the design of future monetary policy. However, the precise mechanisms through which this channel operates are not yet well explored. This makes the case for explicit theoretical models, that imply precise testable hypotheses in order to disentangle alternative mechanisms, like the "search for yield" and "cost of funds" motives mentioned above.

# Appendices

## A Relation Between Equation (9) and Equation (10)

For any given set of individual bank and aggregate characteristics characteristics, $X_{b,t}$, regression model (10) directly implies the following conditional expectations:

$$\begin{aligned}
\mathrm{E}\left[EDR_{b,t}\,|TRG_t^{\mu}=1, MPR_t=0, X_{b,t}\right] &= \alpha_0^{\mu}+\alpha_2^{\mu}+\beta^{\mu\prime}X_{b,t}\\
\mathrm{E}\left[EDR_{b,t}\,|TRG_t^{\mu}=0, MPR_t=0, X_{b,t}\right] &= \alpha_0^{\mu}+\beta^{\mu\prime}X_{b,t}\\
\mathrm{E}\left[EDR_{b,t}\,|TRG_t^{\mu}=1, MPR_t=1, X_{b,t}\right] &= \alpha_0^{\mu}+\alpha_1^{\mu}+\alpha_2^{\mu}+DD^{\mu}+\beta^{\mu\prime}X_{b,t}\\
\mathrm{E}\left[EDR_{b,t}\,|TRG_t^{\mu}=0, MPR_t=1, X_{b,t}\right] &= \alpha_0^{\mu}+\alpha_1^{\mu}+\beta^{\mu\prime}X_{b,t}.
\end{aligned}$$

Therefore, given regression model (10), the differences defined in equation (8) can be written as

$$\begin{aligned}
\left.\frac{\Delta EDR}{\Delta TRG^{\mu}}\right|_{MPR_t=1,X_{b,t}} &= \alpha_2^{\mu}\\
\left.\frac{\Delta EDR}{\Delta TRG^{\mu}}\right|_{MPR_t=0,X_{b,t}} &= \alpha_2^{\mu}+DD^{\mu},
\end{aligned}$$

which directly imply the definition in equation (9). Note further that the third conditioning argument in all the above expectations, $X_{b,t}$, is irrelevant if $\beta^{\mu\prime}=0$. Therefore, taking simple conditional averages, as reported in lines A.1 and B.1 of Table 4 is equivalent to estimating the special case of model (10) where $\beta^{\mu\prime}=0$.

## B Robustness of Exogenous ECB Policy

The Taylor rule (TR) gaps, used to identify exogenous monetary policy in this study, are based on monetary policy rules of the following form:

$$i_q^{j,TR}-\pi_q^j=\bar{r}_q^j+\phi_\pi(\pi_q^j-\bar{\pi}_q^j)+\phi_y(y_q^j-\bar{y}_q^j)+\phi_i(i_q^{ECB}-i_{q-1}^{ECB}), \tag{11}$$

where $i_q^{ECB}$ is the ECB refinancing rate, $\pi_q^j$ and $y_q^j$ represents HICP inflation and real GDP in region $j \in \{AT, EA\}$ in quarter $q$, respectively. $\bar{r}_q^j$, $\bar{y}_q^j$, and $\bar{\pi}_q^j$ denote equilibrium (or *target*) levels of real interest rates, real GDP, and inflation in regions $j$, respectively. Finally, $\phi_\pi$, $\phi_y$, and $\phi_i$ represent policy weights on inflation stabilization, output stabilization, and interest rate smoothing, respectively.

We consider six alternative specifications for each region in order to identify periods during which ECB monetary policy was likely to be exogenous to the Austrian economy. For each of these specifications we use Taylor's original suggestion of equal weights on on output and inflation stabilization, i.e. $\phi_\pi = \phi_y = 0.5$. Further, we approximate the equilibrium real interest rate as well as the natural level for each region $j$ using the Hodrick-Prescott filter with a smoothing parameter of $\lambda = 1600$, i.e. $\bar{r}_q^j = \hat{\bar{r}}_q^{j,HP}$ and $\bar{y}_q^j = \hat{\bar{y}}_q^{j,HP}$. For the remaining parameters we choose the following six alternative specifications:

(A.1) We proxy the target inflation with average HICP inflation in Austria and the Euro area, $\bar{\pi}_q^{AT} = 2.23125$ and $\bar{\pi}_q^{EA} = 2.6086905$, taken over the pre EMU period 1991-1998. Further, we assume the ECB does not care about interest rate smoothing, i.e. $\phi_i = 0$

(A.2) $\bar{\pi}_q^{AT} = 2.23125$, $\bar{\pi}_q^{EA} = 2.6086905$, and $\phi_i = 0.9$

(B.1) We set target inflation to 2%, i.e. $\bar{\pi}_q^{AT} = \bar{\pi}_q^{EA} = 2$, and $\phi_i = 0$

(B.2) $\bar{\pi}_q^{AT} = \bar{\pi}_q^{EA} = 2$, and $\phi_i = 0.9$

(C.1) We proxy equilibrium inflation in each region with an HP trend, i.e. $\bar{\pi}_q^j = \hat{\bar{r}}_q^{j,HP}$, and $\phi_i = 0$

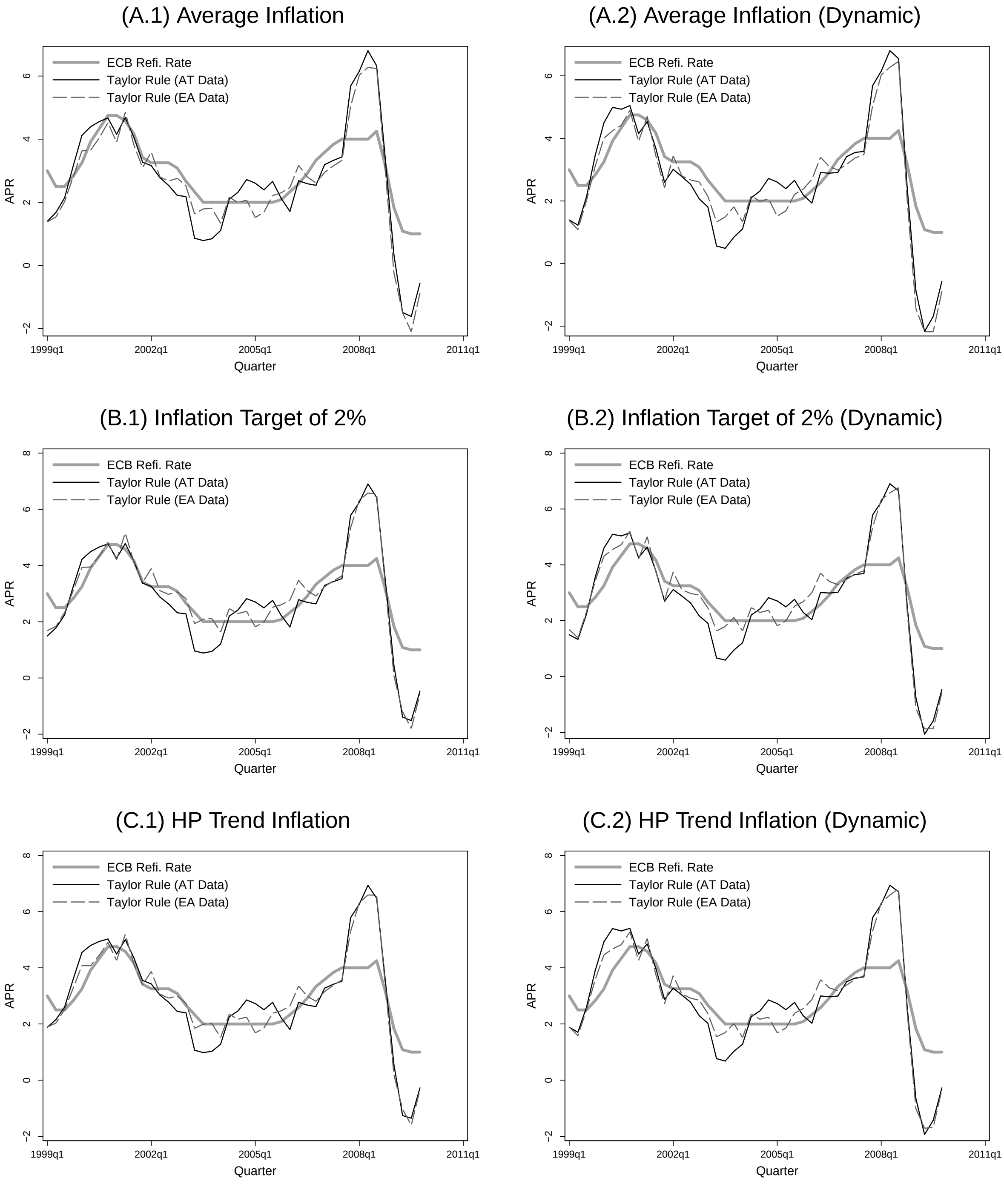
(C.2) $\bar{\pi}_q^j = \hat{\bar{r}}_q^{j,HP}$, and $\phi_i = 0.9$

All six specifications yield very similar results and are illustrated in Figure 5. In particular, each graph depicts the predictions $i_q^{j,TR}$, which can also be written as

$$i_q^{j,TR} = \bar{r}_q^j + \bar{\pi}_q^j + (1+\phi_\pi)(\pi_q^j - \bar{\pi}_q^j) + \phi_y(y_q^j - \bar{y}_q^j) + \phi_i(i_q^{ECB} - i_{q-1}^{ECB}). \quad (12)$$

The alternative specifications highlight several important phenomena. First, Taylor's basic specification of $\phi_\pi = \phi_y = 0.5$ does fairly well in predicting ECB refinancing rates between 1999 and 2008. Second, interest smoothing motives, i.e. specifications with $\phi_i > 0$, do not seem to play a significant role for the purpose of our thought experiment. Third, and most importantly, in periods during which the Austrian TR predicts policy rates that are notably different from the actual ECB refinancing rate, the predictions for the Euro area always deviate in the same direction and by less, if at all. Hence, we can confidently argue that such periods represent times during which ECB monetary policy was neither directly nor indirectly driven by Austrian economic activity.

Figure 5: The Stance of Monetary Policy



# C Regression Tables

## Table 5: Difference in Differences Regression Results

Dependent Variable: Monthly Expected Default Rate ($EDR_{b,t}$, $h = 3$)

| | $\mu = 0.25$ | | | | $\mu = 0.5$ | | | |
|---|---|---|---|---|---|---|---|---|
| | 2000-2008 | | 2000-2005 | 2003-2008 | 2000-2008 | | 2000-2005 | 2003-2008 |
| Constant | 0.4968*** | 0.2349 | 0.8420 | -0.2216 | 0.5309*** | 1.8457** | 2.5180** | 2.3010 |
| | (0.0190) | (0.3598) | (0.7114) | (1.1413) | (0.0213) | (0.9028) | (1.0613) | (1.9498) |
| $MPR_t$ | 0.0586* | -0.0132 | -0.0286 | -0.1080 | 0.0244 | -0.0537* | -0.0220 | -0.0080 |
| | (0.0320) | (0.0222) | (0.0226) | (0.1132) | (0.0316) | (0.0290) | (0.0431) | (0.1338) |
| $TRG_t^{25}$ | -0.0559*** | -0.0243 | -0.0860*** | -0.0114 | | | | |
| | (0.0175) | (0.0318) | (0.0279) | (0.0641) | | | | |
| $TRG_t^{25} \times MPR_t$ | 0.1154*** | 0.1134*** | 0.1009** | 0.1628** | | | | |
| | (0.0243) | (0.0261) | (0.0466) | (0.0772) | | | | |
| $TRG_t^{50}$ | | | | | -0.1074*** | -0.1585** | -0.3698** | -0.1777 |
| | | | | | (0.0213) | (0.0653) | (0.1477) | (0.1256) |
| $TRG_t^{50} \times MPR_t$ | | | | | 0.1756*** | 0.2546*** | 0.3211*** | 0.2502** |
| | | | | | (0.0338) | (0.0534) | (0.0821) | (0.1008) |
| Aggregate Characteristics | | | | | | | | |
| $y_q^{AT} - \bar{y}_q^{AT}$ | | -0.0463*** | -0.0212 | -0.1109*** | | -0.0467** | 0.0611 | -0.0600 |
| | | (0.0111) | (0.0170) | (0.0263) | | (0.0186) | (0.0766) | (0.0374) |
| $\pi_q^{AT}$ | | 0.0204 | 0.0477* | 0.0190 | | 0.0372 | 0.0551 | 0.0279 |
| | | (0.0251) | (0.0264) | (0.0578) | | (0.0369) | (0.0383) | (0.0863) |
| $i_q^{10,AT} - i_q^{3,EA}$ | | -0.0098 | 0.0115 | -0.1111*** | | 0.0167 | 0.0304 | -0.0211 |
| | | (0.0227) | (0.0264) | (0.0393) | | (0.0253) | (0.0296) | (0.0405) |
| $i_q^{10,AT} - i_q^{10,EA}$ | | 0.2510 | 0.0528 | 1.4761** | | 0.6726*** | -0.1315 | 0.8259 |
| | | (0.1787) | (0.5020) | (0.6370) | | (0.2567) | (0.7754) | (0.9472) |
| AT Bank-Loan Growth | | 0.0005 | 0.0056 | -0.0059** | | -0.0028 | -0.0006 | -0.0021 |
| | | (0.0024) | (0.0034) | (0.0026) | | (0.0022) | (0.0028) | (0.0018) |
| AT Bank-Loans/Total Assets | | 0.0126** | -0.0086 | 0.0313 | | -0.0140 | -0.0365** | -0.0253 |
| | | (0.0060) | (0.0142) | (0.0196) | | (0.0160) | (0.0179) | (0.0386) |
| GKE Credit/AT Bank-Loans | | -0.4464 | -0.0277 | -0.7293 | | -1.9395** | -1.3156 | -2.0086 |
| | | (0.5269) | (0.4244) | (1.0499) | | (0.9630) | (0.8257) | (1.3512) |
| Bank: Capitalization (1-5) | | | | | | | | |
| Cap. 2 | | 0.0199 | -0.0021 | 0.0907** | | 0.0380 | 0.0325 | 0.0582 |
| | | (0.0368) | (0.0409) | (0.0381) | | (0.0365) | (0.0434) | (0.0381) |
| Cap. 3 | | -0.0258 | -0.0984 | 0.0702 | | -0.0247 | -0.0808 | 0.0225 |
| | | (0.0445) | (0.0695) | (0.0492) | | (0.0436) | (0.0642) | (0.0482) |
| Cap. 4 | | 0.0256 | 0.0565 | 0.1436 | | 0.0216 | 0.0164 | 0.0868 |
| | | (0.0586) | (0.0801) | (0.0903) | | (0.0547) | (0.0743) | (0.0774) |
| Cap. 5 | | -0.3507 | -0.4896 | -0.4932 | | -0.3442 | -0.5088 | -0.4681 |
| | | (0.2758) | (0.3234) | (0.4646) | | (0.2483) | (0.3389) | (0.3578) |
| Bank: Cash Ratio (1-3) | | | | | | | | |
| Cash Rat. 2 | | 0.0006 | 0.0307 | -0.0166 | | 0.0010 | 0.0360 | -0.0358 |
| | | (0.0318) | (0.0492) | (0.0353) | | (0.0382) | (0.0531) | (0.0443) |
| Cash Rat. 3 | | -0.0052 | -0.0237 | -0.0075 | | -0.0091 | -0.0190 | -0.0325 |
| | | (0.0484) | (0.0822) | (0.0490) | | (0.0530) | (0.0878) | (0.0550) |
| Bank: Size by Assets (1-3) | | | | | | | | |
| Size 2 | | 0.0116 | -0.0527 | 0.0363 | | 0.0041 | -0.0469 | -0.0069 |
| | | (0.0498) | (0.0787) | (0.0490) | | (0.0525) | (0.0762) | (0.0589) |
| Size 3 | | 0.0247 | -0.0374 | 0.1120 | | 0.0139 | -0.0482 | 0.0549 |
| | | (0.0657) | (0.1126) | (0.0883) | | (0.0672) | (0.1164) | (0.0850) |
| Bank: No. of Loans | | -0.0001 | -0.0002 | -0.0000 | | -0.0002 | -0.0003 | -0.0001 |
| | | (0.0001) | (0.0002) | (0.0001) | | (0.0001) | (0.0002) | (0.0001) |
| Bank FEs | no | yes | yes | yes | no | yes | yes | yes |
| No. Banks | 316 | 316 | 297 | 312 | 316 | 316 | 296 | 312 |
| Obs. | 21584 | 21584 | 14182 | 14589 | 13807 | 13807 | 9058 | 10369 |
| Model p-value | 0.0000 | 0.0000 | 0.0418 | 0.0000 | 0.0000 | 0.0000 | 0.0525 | 0.0000 |
| Mean EDF | 0.5242 | 0.5242 | 0.5242 | 0.5242 | 0.5242 | 0.5242 | 0.5242 | 0.5242 |
| D-in-D/Mean EDF | 0.2202 | 0.2164 | 0.1925 | 0.3106 | 0.3350 | 0.4857 | 0.6126 | 0.4773 |

*Notes:* The table reports coefficient estimates of regression models (10). Standard errors, reported in parentheses below each coefficient estimate, are corrected for serial correlation and clustered on bank. Coefficients that are significantly different from zero are indicated with $^{***}$ for a p-value $p < 0.01$, $^{**}$ for $p < 0.05$, and $^{*}$ for $p < 0.1$.

## Table 6: Logit Regressions for Predicting the Probability of Default

Dependent Variable: Insolvency within the next 3 years

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Accounting Ratios | | | | | | | | | | |
| Liab./Assets | 4.392*** | 3.697*** | 3.683*** | 3.405*** | 2.966*** | 3.280*** | 3.390*** | 3.545*** | 3.619*** | 3.697*** |
| | (1.363) | (1.172) | (1.060) | (1.087) | (0.995) | (1.007) | (1.000) | (0.987) | (0.977) | (0.980) |
| Bank Liab./Assets | 1.469 | 1.753 | 1.735* | 1.472 | 1.701* | 1.351 | 1.355* | 1.306* | 1.281* | 1.275* |
| | (1.363) | (1.136) | (1.022) | (0.934) | (0.868) | (0.839) | (0.823) | (0.791) | (0.777) | (0.772) |
| Liab. Short/Assets | 0.778 | 1.004 | 0.874 | 0.759 | 1.112 | 0.820 | 0.821 | 0.676 | 0.634 | 0.621 |
| | (1.523) | (1.273) | (1.162) | (1.076) | (0.985) | (0.942) | (0.926) | (0.898) | (0.879) | (0.874) |
| Liq. Assets/Liab Short | 0.051 | 0.038 | 0.053 | 0.048 | 0.079* | 0.070 | 0.068 | 0.056 | 0.052 | 0.055 |
| | (0.093) | (0.072) | (0.061) | (0.060) | (0.046) | (0.049) | (0.046) | (0.045) | (0.044) | (0.043) |
| Acc. Payab./Net Sales | 1.988*** | 1.738*** | 2.136*** | 2.095*** | 2.084*** | 2.061*** | 2.058*** | 1.980*** | 2.015*** | 2.043*** |
| | (0.569) | (0.551) | (0.487) | (0.433) | (0.385) | (0.372) | (0.354) | (0.348) | (0.340) | (0.336) |
| Gross Profit/Exp. Labor | -0.322** | -0.108 | -0.139 | -0.125 | -0.126 | -0.142 | -0.155 | -0.140 | -0.149* | -0.150* |
| | (0.136) | (0.107) | (0.117) | (0.101) | (0.089) | (0.093) | (0.097) | (0.086) | (0.088) | (0.087) |
| Ord. Bus. Inc./Assets | -1.906 | -3.091*** | -3.015*** | -3.023*** | -3.113*** | -3.090*** | -2.997*** | -2.943*** | -2.883*** | -2.790*** |
| | (1.288) | (0.944) | (0.839) | (0.760) | (0.683) | (0.669) | (0.639) | (0.629) | (0.604) | (0.606) |
| Exp. Interest/Gross Debt | 16.559*** | 14.346*** | 13.666*** | 14.596*** | 14.099*** | 14.583*** | 15.372*** | 14.936*** | 14.696*** | 14.359*** |
| | (3.206) | (2.960) | (2.901) | (2.486) | (2.306) | (2.236) | (2.035) | (1.959) | (1.902) | (1.921) |
| Legal Form (relative to GmbH) | | | | | | | | | | |
| AG | 0.466 | 0.641* | 0.620* | 0.623* | 0.534* | 0.505 | 0.552* | 0.609* | 0.635** | 0.618* |
| | (0.450) | (0.385) | (0.365) | (0.333) | (0.319) | (0.321) | (0.322) | (0.321) | (0.320) | (0.322) |
| KG | 0.571* | 0.485 | 0.520* | 0.435 | 0.290 | 0.273 | 0.285 | 0.303 | 0.321 | 0.319 |
| | (0.313) | (0.297) | (0.284) | (0.279) | (0.269) | (0.267) | (0.267) | (0.267) | (0.267) | (0.267) |
| Other | -0.040 | -0.152 | 0.266 | 0.083 | 0.003 | 0.009 | 0.058 | 0.276 | 0.301 | 0.304 |
| | (0.736) | (0.731) | (0.609) | (0.613) | (0.609) | (0.609) | (0.609) | (0.551) | (0.556) | (0.554) |
| Industry (relative to Manufacturing) | | | | | | | | | | |
| Construction | -0.121 | -0.110 | -0.186 | -0.223 | -0.170 | -0.254 | -0.285 | -0.286 | -0.302 | -0.314 |
| | (0.553) | (0.528) | (0.527) | (0.513) | (0.442) | (0.441) | (0.435) | (0.429) | (0.427) | (0.427) |
| Wholesale & Trade | -0.509 | -0.462 | -0.234 | -0.264 | -0.386 | -0.408 | -0.414 | -0.423 | -0.434 | -0.431 |
| | (0.342) | (0.328) | (0.303) | (0.296) | (0.278) | (0.275) | (0.273) | (0.272) | (0.272) | (0.272) |
| Prof., Scient., & Tech. | 0.108 | -0.082 | 0.011 | -0.141 | -0.394 | -0.518 | -0.587 | -0.721 | -0.751* | -0.740* |
| | (0.487) | (0.476) | (0.429) | (0.421) | (0.417) | (0.424) | (0.427) | (0.445) | (0.441) | (0.438) |
| Admin. & Support | 1.561* | 1.518** | 1.481** | 1.306** | 1.061* | 0.902 | 0.812 | 0.672 | 0.630 | 0.642 |
| | (0.821) | (0.621) | (0.625) | (0.619) | (0.596) | (0.587) | (0.584) | (0.590) | (0.585) | (0.582) |
| Other | 0.035 | 0.064 | 0.067 | 0.040 | -0.112 | -0.174 | -0.209 | -0.254 | -0.290 | -0.287 |
| | (0.339) | (0.307) | (0.299) | (0.285) | (0.274) | (0.272) | (0.271) | (0.270) | (0.271) | (0.271) |
| Transportation & Storage | | -1.102 | -1.185 | -1.286 | -1.504 | -1.585 | -1.631 | -1.707* | -1.753* | -1.751* |
| | | (1.029) | (1.030) | (1.027) | (1.019) | (1.020) | (1.019) | (1.021) | (1.021) | (1.021) |
| Age | -0.014 | -0.011 | -0.004 | -0.025 | -0.020 | -0.025 | -0.025 | -0.025 | -0.027 | -0.029* |
| | (0.025) | (0.024) | (0.024) | (0.018) | (0.017) | (0.016) | (0.016) | (0.017) | (0.017) | (0.017) |
| $Age^2$ | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | -8.936*** | -8.775*** | -8.802*** | -8.327*** | -8.101*** | -8.101*** | -8.288*** | -8.427*** | -8.485*** | -8.540*** |
| | (0.937) | (0.897) | (0.846) | (0.796) | (0.715) | (0.717) | (0.724) | (0.726) | (0.731) | (0.737) |
| Obs. | 15261 | 17692 | 19608 | 21794 | 24582 | 28027 | 32093 | 36294 | 40063 | 41380 |
| Model p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AUC Ex-Ante | 0.757 | 0.756 | 0.774 | 0.768 | 0.756 | 0.832 | 0.797 | 0.873 | . | . |
| AUC Ex-Post | 0.806 | 0.809 | 0.809 | 0.818 | 0.823 | 0.828 | 0.834 | 0.838 | 0.841 | 0.842 |

*Notes:* The table reports the maximum likelihood estimates of coefficient vector $\gamma$ in equation (2) based on logit models (3). Standard errors, reported in parentheses below each coefficient estimate, are corrected for serial correlation and clustered on firm. Coefficients that are significantly different from zero are indicated with $^{***}$ for a p-value $p < 0.01$, $^{**}$ for $p < 0.05$, and $^{*}$ for $p < 0.1$. The omitted legal form are limited liability companies (GmbH), AG stands for Aktiengesellschaft (equity firms), and KG refers to Kommanditgesellschaft (limited partnerships with at least one fully liable partner). The omitted industry is the manufacturing sector. Ex-ante AUC values for the years 2008 through 2009 could not be computed since we observe too few bankruptcies for those years within our sample of firms.

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