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THE IRB APPROACH AND BANK LENDING TO FIRMS

by Raffaele Gallo*

Abstract

This paper examines the impact of the regulatory approach adopted to calculate capital requirements on banks' lending policies. Since the capital absorption of loans to high-risk borrowers is greater under the internal ratings-based (IRB) method than under the standardized approach (SA), IRB banks may raise interest rates and reduce credit to riskier borrowers following their regulatory regime shift. The analysis examines banks' lending policies around each of the shifts that occurred between 2007 and 2017. First, in a context of declining rates and credit growth, banks adopting the IRB approach decreased interest rates (credit) less (more) for riskier than for safer borrowers when compared with SA intermediaries. Second, an existing credit relationship with a high-risk borrower is more likely to end after the shift. Third, the results at the firm level suggest that high-risk borrowers partly compensated the reduction in bank credit by obtaining funds from SA institutions, but that they were not able to offset the rise in their average cost of credit because of the significant costs involved in switching lenders.

JEL Classification: G20, G21, G28, G32.
Keywords: credit risk regulation, interest rates, bank credit, internal rating model.
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Contents

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1. Introduction[1]

The entry into force of Basel II in 2007 has significantly changed the assessment of credit risk. In this framework banks are allowed to choose between the standardized approach (SA), which assigns to each exposure a fixed risk weight, and the internal ratings-based (IRB) approach, which makes capital requirements a function of banks' internal estimates about the riskiness of the borrower.

The adoption of the IRB approach has several and widespread effects on banks' risk management and activities. In general, internal risk models are associated with a high complexity and a certain discretion that make risk estimates comparison difficult across financial institutions (Cannata et al., 2012; Cucinelli et al., 2018; Le Leslé and Avramova, 2012; Mariathasan and Merrouche, 2014; Pérez Montes et al., 2018). These implications are at the core of supervisory scrutiny and the international debate, especially in view of the future implementation of the next regulatory framework (BCBS, 2017).

This work focuses on the impact of these approaches on the sensitivity of bank capital to asset risk: since capital charges are more linked to asset risk when intermediaries adopt internal models, the regulatory capital is more risk-sensitive for IRB banks than for SA ones (Behn et al., 2016b; Kashyap and Stein, 2004; Repullo and Suarez, 2004, 2013).

The IRB approach provides a capital incentive for banks with good risk management. Indeed, this framework would require less capital for less-risky assets than the standardized approach and more capital for riskier assets (Le Leslé and Avramova, 2012). In particular, the two approaches lead to significant differences in the treatment of exposures to unrated firms (Repullo and Suarez, 2004). Under SA, all exposures to unrated borrowers are generally associated with a fixed risk weight (i.e. 100 per cent); under IRB, the risk weights are lower than 100 per cent for safer borrowers, while are higher for riskier ones. Consequently, the capital absorption of loans to low-risk (high-risk) borrowers is lower (greater) for IRB than for SA banks. This asymmetric treatment affects the cost of each exposure for banks (i.e. its capital absorption), and may have a significant impact on their pricing and credit policies. After the adoption of the IRB approach, banks may pass-through the increase in cost by raising interest rates to riskier borrowers. They also have an incentive to reallocate credit from riskier to safer assets to exploit savings in capital charges. Overall, banks adopting the IRB approach may raise interest rates and reduce credit to high-risk borrowers with respect to low-risk ones.

The main goal of this paper is the assessment of the impact of the transition from the standardized approach to the IRB method on Italian banks' lending policies. The sample includes unrated

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borrowers with at least one loan granted by a "treated" bank (i.e. those adopting the IRB approach in t_0) and a "control" bank (i.e. those that have not changed their approach in t_0) between 2007 and 2017. The sample of treated banks consists of the 8 Italian institutions that have adopted the IRB approach in the analyzed period. The share of total bank lending to firms granted by Italian IRB intermediaries reached 65 per cent in 2017. This statistic suggests that, since the regulatory regime shift is associated with substantial administrative and organizational costs, mainly larger banks have started to use internal rating models; nevertheless, a significant share of credit in Italy is still extended by SA banks.

The main identification strategy relies on the examination of borrowers that receive credit immediately before and after the regulatory regime switch of their lender. The analysis focuses on the supply of credit by examining the same firm that receive credit from banks adopting different regulatory approaches in the same period. This setup allows saturating specifications with firm-time and bank-time fixed effects to absorb all time-varying (observed and unobserved) firm and bank heterogeneity (Jiménez et al., 2014). By accounting for loan demand (consistent with Khwaja and Mian, 2008) and time-varying bank heterogeneity, identification resides in comparing changes in the cost and the amount of credit around each bank-specific regulatory regime shift date by the same bank to firms that differ in their riskiness level (measured by relying on an accounting-based credit score).

First, this framework allows verifying the impact of the adoption of the IRB approach on the cost and the amount of bank credit by comparing safer and riskier firms. Second, the analysis focuses on the "extensive margin" of credit, defined as the number of borrowers before and after the shift, by examining whether existing relationships with IRB banks are more likely to end if the loan is granted to a riskier firm. Finally, the paper examines the effect of banks' regulatory approach changes on the ability of riskier firms to access funds, verifying at the firm level whether high-risk borrowers are able to offset the potential negative effects on the cost and the amount of credit associated with the shift of their lender by relying on SA banks.

The results show that, in a period characterized by an average decline in the cost of credit and the credit growth for all borrowers, treated banks decreased interest rates (credit) less (more) for riskier than for safer borrowers when compared with SA intermediaries. The additional effect of the shift on the change in the cost of credit for riskier borrowers is 4 basis points, while the reduction in the credit growth is 1 percentage point larger. For high-risk firms, existing credit relationships are also more likely to end after the regulatory shift of their lenders.

Overall, the analysis at the firm level suggests that riskier firms partly compensated the reduction in bank credit by obtaining funds from SA banks, but they were not able to avoid a relative increase in their average cost of credit. Indeed, riskier borrowers of a treated bank experienced a decrease in

the average interest rates that is 43 bps lower than that faced by safer companies; this effect is 17 bps higher than that observed for borrowers of SA banks in the same period (26 bps).

This work contributes to the literature on the impact of the IRB approach on bank lending (Behn et al., 2016b; Repullo and Suarez, 2004, 2013). To the best of my knowledge, this paper is the first to analyze empirically how the regulatory approach adopted by the bank affects the cost and the amount of credit of their borrowers around the shift.

In particular, this work is closely related to the theoretical contribution of Repullo and Suarez (2004). The empirical evidence presented in this work is in line with their prediction on the reduction in the cost of credit for low-risk borrowers of banks adopting the IRB approach. In contrast, the results related to the relative increase in rates for high-risk borrowers are not consistent with their expectations, which indicate that, in a perfectly competitive market for business loans, riskier firms may avoid increases in their rates by borrowing from lenders that adopt the less risk-sensitive SA. This difference may be due to the costs for borrowers involved in switching to different lenders (Rajan, 1992; Sharpe, 1990), which may be particularly significant for riskier firms. Indeed, the results obtained at the firm level suggest that riskier borrowers that switched from an IRB to a SA bank after the shift have obtained credit at higher rates from the latter lender, consistent with the presence of significant switching costs.

Other related works focus on how banks adopting different regulatory approaches react to an exogenous shock on the demand side, e.g. an economic downturn or a worsening of financial market conditions (Behn et al., 2016b; Bruno et al., 2017; Cucinelli et al., 2018; Gallo, 2020). These studies do not explore the effect on bank lending directly associated with the regulatory regime switch (i.e. they do not compare lending policies of the same bank before and after its regulatory shift). Moreover, the main analysis in this paper is at the bank-firm level to exploit the information advantage of granular data, while other studies focus on more aggregate measures, such as banks' risk-weighted assets (Bruno et al., 2017) or the NPL ratio (Cucinelli et al., 2018) as a proxy of the level of risk borne by a bank.

The remainder of this paper is organized as follows. Section 2 reviews the related literature and outlines the regulatory background. Section 3 presents the research hypotheses. Section 4 describes the dataset. Section 5 discusses the methodology and presents a preliminary evidence relying on data aggregated at the bank level. The main results are reported in Section 6. Section 7 presents additional tests. Section 8 concludes.

2. Review of regulatory background and related research

After the introduction of Basel II, the required bank capital is calculated as a fraction of risk-weighted assets (RWA), which are estimated by multiplying the value of each bank asset by a corresponding risk weight. Under the standardized approach, fixed risk weights are defined for each bucket of assets, similarly to the Basel I framework. Under this method, uncollateralized loans granted to unrated firms have a risk weight of 100 per cent.[2] Therefore, the assigned risk weight is not sensitive to the riskiness of the borrower.

In contrast, the risk weight of each asset under the IRB approach depends on banks' internal risk models. Internal estimates rely on four parameters: the probability of default (PD), the loss given default (LGD), the exposure at default (EAD), and the effective maturity of the loan.[3] Each model has to be approved and validated at least once a year by regulators. The estimates under IRB have to be periodically updated. Consequently, risk weights and related capital charges for each exposure may change over time.[4]

The literature has discussed the incentives stemming from the adoption of the IRB approach. First, a high responsiveness of capital requirements to a change in the borrower's riskiness may create incentives for banks to deleverage after a shock, amplifying business cycle fluctuations (Behn et al., 2016b; Kashyap and Stein, 2004; Repullo and Suarez, 2013) and financial instability (EBA, 2013). On the other hand, the reduction in the loan portfolio riskiness after a deterioration of credit conditions may strengthen the solvency of the banking system in the long-term (Repullo and Suarez, 2013).

In addition, the adoption of internal models allows banks to exert greater discretion in the assessment of the borrower's riskiness. Some evidence suggests that the adoption of the IRB approach may provide intermediaries some incentives to underestimate the riskiness of their assets to reduce capital requirements (Behn et al., 2016a; Plosser and Santos, 2014).

The literature on the impact of the IRB approach on credit supply shows that IRB banks adopt different lending policies than SA intermediaries. After a shock to the average riskiness of borrowers (e.g. economic downturns), IRB banks reallocated credit from riskier to safer borrowers more than SA intermediaries. Behn et al. (2016b) find that the amount of IRB loans granted by German banks decreased more than that of SA loans in response to an exogenous shock to credit risk (i.e. the collapse

[2] In contrast, the risk weight assigned to assets rated by a specialized agency can change after a downgrade or an upgrade of the external credit rating. Moreover, the risk weight may be lower than 100 per cent for specific exposures, such as SMEs.

[3] Banks estimate all four parameters under the advanced IRB (AIRB) approach, while they estimate only the PD in the foundation IRB (FIRB) approach and assume fixed standard values for the other parameters. This distinction does not affect the main findings because the treatment for riskier and safer borrowers is equal under both methods.

[4] The differences in capital absorption between IRB and SA for each bucket of assets are significant but, at the bank level, they can be partly smoothed by Pillar 2 requirements.

of Lehman Brothers in September 2008). Bruno et al. (2017) find that IRB banks have reduced more their corporate loan portfolio than SA ones between 2008 and 2014, both in absolute terms and as a share of total credit exposures. Cucinelli et al. (2018) show that, in the aftermath of the financial and economic crisis (2008-2015), European IRB banks adopted more conservative lending policies by granting new loans to safer customers. Finally, Gallo (2020) finds that the adoption of the IRB approach made loan rates applied to listed firms significantly more market-oriented: a worsening of financial market conditions is associated with a rise in interest rates applied to listed borrowers greater on loans granted by IRB banks than on those extended by SA intermediaries.

3. The research hypotheses

Since the capital absorption of loans to high-risk borrowers is greater for IRB banks than for SA ones, banks adopting internal rating models may pass-through the rise in cost to riskier borrowers and may reallocate credit from riskier to safer assets to save capital after their shift. This main prediction leads to three different testable hypotheses.

First, a shift in the regulatory approach adopted by the lender may affect the cost and the amount of bank credit for safer and riskier firms differently. Holding all else equal, banks adopting the IRB approach may apply higher interest rates and grant less credit to high-risk firms. Therefore, the first testable hypothesis is:

H1. *After the adoption of the IRB method, banks raise interest rates and reduce credit more for high-risk firms than for low-risk ones.*

Second, a shift in the regulatory approach may have an impact on the probability of ending for existing credit relationships. Indeed the impact of the regulatory regime shift may not be limited to the "intensive margin" of credit (the amount granted to the same borrower before and after the shift) but it also affects the "extensive margin" (the number of borrowers before and after the shift). Consequently, the second hypothesis is that:

H2. *After the adoption of the IRB method, an existing credit relationship is more likely to end if the loan is granted to a riskier firm with respect to a safer one.*

Finally, the third hypothesis focuses on the overall impact on bank credit of the IRB approach adoption. Indeed, a riskier borrower may be able to offset the increase in the cost and the reduction in the amount of credit assumed in *H1* and *H2* by relying on other banks that have not changed their regulatory approach. If the borrower obtains more credit at a lower interest rate from other banks, the overall impact of the regulatory shift would be negligible at the firm level.

However, switching lenders may lead to substantial costs for borrowers. Indeed, prolonged credit relationships mitigate the significant information asymmetries in the credit market by allowing banks

to accumulate information about borrowers' creditworthiness over time (Boot, 2000). Since this knowledge is bank-specific, firms that want to change their lenders may incur substantial switching costs, which may significantly decrease the access to alternative source of funds. These costs may be higher for more opaque borrowers (Rajan, 1992; Sharpe, 1990) such as riskier firms. As a result, after the regulatory shift of the lender, riskier borrowers might not be able to mitigate the increase in the cost of funding as well as the reduction in the total amount of credit by relying on other banks. Given these premises, the third hypothesis is that:

H3. *Riskier borrowers of a lender adopting the IRB method experience an increase in the average cost of credit and a reduction in the total bank credit growth after the regulatory regime shift.*

4. Data and sample

The sample consists of quarterly data on credit to Italian non-financial firms from the Italian Credit Register ("Centrale dei Rischi", CR) from 2007 to 2017. This database is handled by the Bank of Italy and covers the population of individual borrowers' outstanding exposure of over €30,000 with a single intermediary.[5] CR provides information on lenders and borrowers, while data on interest rates are obtained from a section of the CR, TAXIA. This latter database contains information on the interest rate charged on all loans granted by a representative sample of Italian banks, which accounts for more than 80 per cent of total bank lending in Italy.[6]

Credit is aggregated at the banking group level because lending policies are typically decided at this level. To ensure the comparability of results, the empirical analysis focuses on the amount of granted credit lines (i.e. the sum of outstanding and loan commitments) at the end of the fourth quarter of each year. This type of credit is the most comparable because it is highly standardized across banks (Sette and Gobbi, 2015), has no specified maturity, is granted for no specific purpose, and is typically not backed by collateral. In addition, since the usage of available credit lines is strongly seasonal (Jiménez et al., 2009; Sette and Gobbi, 2015), the analysis compares the same period of subsequent years.

The change in the net interest rate on revolving credit lines and the growth rate of the granted amount are retrieved for each bank-firm relationship. The interest rate for each credit line is estimated by dividing the amount due by the product between the loan amount and the days this amount was outstanding. To avoid outliers affecting the results, the change in the interest rate and the credit growth are winsorized at the 5th and 95th percentiles and at the 1st and 99th percentiles, respectively.[7]

[5] For CR, the reporting threshold was €75,000 before 2009.
[6] For TAXIA, the reporting threshold is €75,000.
[7] Consistent with Sette and Gobbi (2015), an higher threshold is adopted for the cost of credit to address the greater risk of outliers deriving from the construction of this variable.

Firm accounting data are taken from the database of Cerved group, which is a leading provider in Italy for information on limited companies. For each firm Cerved computes annually a credit score, which is an indicator of the probability of default based on the Z-score methodology (Altman et al., 1994). The Z-score varies from 1 (safest) to 9 (riskiest). Firms with a credit score equal or above six are considered as high-risk borrowers. Data on banks' consolidated balance sheets are obtained from the supervisory reports.

Loans to firms with no balance sheet information in the Cerved database, nonperforming loans, and those extended to borrowers with a rating assigned by a credit rating agency[8] are excluded from the final sample.

The regulatory approach adopted by each Italian bank is singled out by relying on confidential supervisory information and publicly available banks' Pillar 3 reports. Figure 1 shows the number of IRB banks by year in the examined period. The intermediaries that have adopted the IRB approach in year t_0 (8) represent the sample of "treated" banks. The other lenders (553) are included in the sample of "control" banks. Figure 2 presents the share of total bank lending to non-financial firms granted by Italian IRB intermediaries. The share of credit granted by IRB banks ranged from about 40 to 65 per cent over the analyzed period.

The main sample includes firms with at least one loan granted by a treated and a control bank both before and after the shift. For each t_0 (i.e. a year in which at least one bank has adopted the IRB approach), the analysis compares the credit granted to the same borrower in the fourth quarter of t_{-1} (the year before the shift) and t_{+1} (the year after the shift). This allows comparing how treated and control lenders evaluate the same borrower, overcoming potential identification issues.

Overall, the sample employed in the following analyses at the bank-firm level includes 599,418 bank-firm relationships (117,348 firms), of which 301,255 are relationships between banks and high-risk borrowers (68,795 firms).

For the exercises at the firm level, the sample consists of companies with at least one loan outstanding both before and after the shift. Therefore, these analyses consider also borrowers with a single credit relationship to assess the overall impact of the regulatory regime shift on the Italian credit market. For these exercises, the sample includes 1,048,032 borrower-time observations (437,820 firms), of which 553,427 are related to high-risk borrowers (296,114 firms).

[8] These loans are excluded because the standardized approach prescribes specific risk weights for exposures to rated firms. Therefore, differences in loan contract terms between rated borrowers of SA and IRB banks should be due to a different treatment in the current regulatory framework.

5. Methodology and descriptive statistics

5.1 Methodology

To test the impact of the adoption of the IRB approach on the cost and the amount of granted credit to safer and riskier firms (*H1*), first, the baseline models described in Eqs. (1) and (2) are estimated by employing the sample at the bank-firm level described in Section 4.

$$\Delta Rate_{ijt+1} = \beta_1 HighRisk_{it} + \beta_2 IRBshift_{jt} + \beta_3 HighRisk_{it} \cdot IRBshift_{jt} + \gamma Controls_{ijt} + \theta_{t+1} + \varepsilon_{ijt+1} \quad (1)$$

$$\Delta Credit_{ijt+1} = \beta_1 HighRisk_{it} + \beta_2 IRBshift_{jt} + \beta_3 HighRisk_{it} \cdot IRBshift_{ijt} + \gamma Controls_{ijt} + \theta_{t+1} + \varepsilon_{ijt+1} \quad (2)$$

The dependent variables of Eqs. (1) and (2) are Δ*Rate*, which is the difference between the annualized interest rate on granted credit lines in t_{+1} and t_{-1} by bank *j* to firm *i*, and Δ*Credit*, which is the difference between the log amount of granted credit lines in t_{+1} and t_{-1} by bank *j* to firm *i*, respectively.

HighRisk is a dummy variable equal to 1 if the firm's credit score in t_0 is greater than 5 and 0 otherwise, while *IRBshift* is a dummy variable equal to 1 if the bank *j* has adopted the IRB approach in t_0 and 0 otherwise. The variable of interest is the interaction between *HighRisk* and *IRBshift*.

The model also includes a vector of control variables (*Controls*). First, the potential effects of bank-firm relationships are taken into account by introducing *Share*, the share of total credit (revolving credit lines, term loans, and loans backed by accounts receivables) granted by bank *j* to firm *i* in t_{+1}. A higher value of this variable indicates stronger bank-firm relationships because holding a large share of the overall credit granted to the firm generally allows having better access to significant information (Elsas, 2005).

Second, the borrower's characteristics are controlled by adding firms' accounting data (*Size*, *Leverage*, *Fixed Assets*, *EBITDA*, *IntCovRatio*), *Industry* (indicator variables for the industry of firm *i* based on 2-digit ATECO), as well as *Area* (indicator variables for geographical area of the country).

Third, this vector also includes a set of bank characteristics to take into account lenders' heterogeneity in terms of size (*BankSize*), business model (*Loans* and *Deposits*), capital (*CapRatio*), and profitability (*ROE*). Finally, both models include year fixed effects (θ). Table A.1 in the Appendix presents the complete list of variables with their relative sources.

Afterwards, the equations are estimated by including bank-time (δ) and firm-time (η) fixed effects, as described in Eqs. (3) and (4). In these equations, fixed effects absorb all time-varying (observed and unobserved) firm and bank heterogeneity. Therefore, both models focus on the differential impact

of a shift in the regulatory approach on changes in the cost and the amount of credit between safer and riskier firms that are contemporaneously borrowers of treated and control banks. Consistent with *H1*, the coefficient of the interaction between *HighRisk* and *IRBshift* should be significant and positive (negative) in the cost (the amount) of credit model.

$$\Delta Rate_{ijt+1} = \beta_1 HighRisk_{it} \cdot IRBshift_{ijt} + \delta_{jt+1} + \eta_{it+1} + \varepsilon_{ijt+1} \quad (3)$$

$$\Delta Credit_{ijt+1} = \beta_1 HighRisk_{it} \cdot IRBshift_{ijt} + \delta_{jt+1} + \eta_{it+1} + \varepsilon_{ijt+1} \quad (4)$$

The second analysis focuses on the extensive margin of credit (*H2*). In this case the sample includes firms with at least one loan granted by a treated and a control bank in t_{-1}. Eqs. (5) and (6) are estimated by adopting *Exit*, which is a dummy variable equal to 1 for loans that existed in t_{-1} and ceased to exist after the shift, as the dependent variable. A linear probability model is estimated to include bank-time and firm-time fixed effects. Consistent with *H2*, the coefficient of the interaction between *HighRisk* and *IRBshift* should be significant and positive, implying a greater probability that a credit relationship with a treated bank is terminated for riskier firms.

$$Exit_{ijt+1} = \beta_1 HighRisk_{it} + \beta_2 IRBshift_{jt} + \beta_3 HighRisk_{it} \cdot IRBshift_{ijt} + \gamma Controls_{ijt} + \theta_{t+1} + \varepsilon_{ijt+1} \quad (5)$$

$$Exit_{ijt+1} = \beta_1 HighRisk_{it} \cdot IRBshift_{ijt} + \delta_{jt+1} + \eta_{it+1} + \varepsilon_{ijt+1} \quad (6)$$

Both models are estimated by excluding credit relationships that existed in 2007: since numerous relationships were terminated after the global financial crisis, this event may affect the results of the shifts occurred in 2008.[9]

Finally, an analysis at the firm level is employed to verify *H3*. Eqs. (7) and (8) adopt $\Delta AvgRate$, which is the difference between the average annualized rate on granted credit lines in t_{+1} and t_{-1} to firm *i*, and $\Delta TotCredit$, which is the difference between the log amount of total granted credit lines in t_{+1} and t_{-1} to firm *i*, as dependent variables, respectively.

$$\Delta AvgRate_{it+1} = \beta_1 HighRisk_{it} + \beta_2 IRBexp_{it} + \beta_3 HighRisk_{it} \cdot IRBexp_{it} + \gamma Controls_{it} + \theta_{t+1} + \varepsilon_{it+1} \quad (7)$$

[9] Unreported robustness checks show that the main findings are robust to estimating also the other presented models by separating crisis and "normal" periods.

$$\Delta TotCredit_{it+1} = \beta_1 HighRisk_{it} + \beta_2 IRBexp_{it} + \beta_3 HighRisk_{it} \cdot IRBexp_{it} \quad (8)$$
$$+ \gamma Controls_{it} + \theta_{t+1} + \varepsilon_{it+1}$$

To assess the overall impact of the adoption of the IRB approach, both models adopt a sample that includes also firms with a single credit relationship, as described in Section 4. In both equations the vector *Controls* includes the variable *ShareHHI*, which is calculated as the Herfindahl-Hirschman index (HHI) of share of total credit.[10] The variable of interest is the interaction between *HighRisk* and *IRBexp*, a dummy variable equal to 1 for firms that in t_{-1} had a share of credit granted by a treated bank falling in the top quartile of the distribution and 0 otherwise.[11] This variable identifies the firms that had a significant credit relationship with a treated bank before its shift, and consequently they should be more "exposed" to the shock represented by the adoption of the IRB approach. Consistent with *H3*, β_3 should be significant and positive (negative) in the average cost (the total amount) of credit model.

5.2 Descriptive statistics

Table 1 shows a set of descriptive statistics on credit relationships by comparing treated and control banks. During the period analyzed, the cost and the amount of credit decreased on average both for the low and high-risk firms included in the sample. However, the cost (amount) of credit decreased at a lower (higher) rate for riskier firms, mainly for loans granted by treated intermediaries. In addition credit relationships between riskier firms and treated banks have also a slightly higher probability of ending.

Table 2 presents the summary statistics by comparing low and high-risk firms. Statistics for the sample at the bank-firm level (panel A) show that less-risky borrowers have greater size, interest coverage ratio, fixed assets and EBITDA as well as lower leverage compared with riskier firms. The strength of bank-firm relationships (i.e. the share of credit) is approximately equal for both groups. Statistics for the sample at the firm level (panel B) confirm that riskier borrowers experienced a lower decrease in the average cost of credit and a larger reduction in the total amount of bank loans. The share of low and high-risk firms exposed to the adoption of the IRB approach by one of their lenders is about equal, as indicated by the mean values of the variable *IRBexp* for the two groups of borrowers.

Finally, Table 3 shows the set of bank characteristics included in the analysis by comparing control and treated intermediaries. Before the shift, with respect to former lenders, treated banks were on

[10] HHI is calculated as the sum of squared share of total credit granted by each bank to firm *i* in t_{+1}.
[11] The results are robust to considering this dummy equal to 1 for all firms that in t_{-1} had a relationship with a bank that has adopted the IRB approach in t_0 and 0 otherwise.

average larger, relied less on retail deposits, had lower loan and capital ratios, and were more profitable. These differences motivate the inclusion of bank-time fixed effects in the main models to absorb all time-varying heterogeneity between the two groups of lenders.

5.3 Preliminary evidence: share of high-risk loans

Before presenting the analyses at the bank-firm level, this section shows a preliminary evidence by examining data aggregated at the bank level. This exercise verifies whether treated banks have partly reallocated credit from riskier to safer borrowers after the regulatory regime shift. Therefore the share of credit to riskier borrowers granted by treated intermediaries is compared with that extended by the control group.

Table 4 presents the results of a regression model estimated by adopting $\Delta ShareHighRisk$, which is the difference between the ratio of loans to high-risk borrowers to total loans in t_{+1} and t_{-1}, as the dependent variable. *IRBshift* is the variable of interest. The sample consists of the amount of credit aggregated at the bank level granted by SA intermediaries and those that have adopted the IRB approach in t_0. The model is a repeated cross-section: it is estimated for each bank-specific regulatory shift date and it includes bank and year fixed effects. This table as well as the following ones report robust standard errors.

The estimates show that treated banks reduced by about 6 percentage points the share of loans to riskier borrowers after the shift, 3.5 percentage points more than control lenders. This finding are consistent with the hypothesis that the adoption of the IRB approach is associated with a reduction in the exposure to risker borrowers.

6. Results

6.1 The impact of the regulatory regime shift on the cost and the amount of credit

Table 5 shows the results obtained from the estimation of Eqs. (1) and (3).[12] Taking into account that interest rates declined on average for all borrowers in the analyzed periods (as shown in Table 1), the estimates in column (1) show that the interest rates applied to less-risky firms by treated banks decreased by 18 bps more than those charged by control institutions to the same companies (-75 and -57 bps, respectively).[13] In the same period, treated intermediaries reduced interest rates by 50 bps less for riskier borrowers than for safer ones (-25 bps); whiles SA intermediaries reduced rates by 41

[12] The number of observations in the cost of credit models is lower because TAXIA does not contain information on all loans included in CR, as discussed in Section 4. An unreported robustness check shows that the results are robust to adopting a constant sample in all models.

[13] Using the estimates in column (1) of Table 5, for low-risk borrowers, the average decrease in rates on credit by control banks is equal to the constant (-0.566), while that on credit by treated banks is (-0.566-0.183).

bps less for the same borrowers (-16 bps).[14] As a result, the additional effect of the shift on riskier firms (9 bps)[15] is sizable: it is about 18 per cent of the lower reduction in interest rates borne by riskier borrowers with respect to safer ones.[16]

As regards the firm control variables, banks reduced rates more for larger firms, those with greater interest coverage ratio, EBITDA and lower leverage. In addition the negative sign of *Share* suggests that interest rates decreased more for firms with a greater share of total credit held by the lender bank, consistent with the literature on relationship banking.

Columns (2), (3) and (4) confirm that treated banks reduced interest rates to high-risk borrowers less than control intermediaries also after including bank control variables, firm-time fixed effects, and bank-time fixed effects, respectively. However, the magnitude of the effect declines after saturating the specification (from 9 to 4 bps; column 4). Overall, these results are consistent with *H1*, implying that a shift in the regulatory approach adopted by the lender had an asymmetric impact on the cost of credit for high and low-risk firms.

Table 6 reports the results obtained from the estimation of Eqs. (2) and (4). The first column indicates that the credit growth of treated intermediaries was 9 percentage points lower than that of control banks both for low and high-risk borrowers in the considered period, as the interaction between *HighRisk* and *IRBshift* is negative but not significant. In contrast, the estimates in columns (2), (3), and (4) show that the coefficient of the interaction is significant when controlling for supply-side factors. In particular, the results in column (4) indicate that, in the year after the shift, treated banks reduced credit by 1 percentage point more for riskier borrowers than for safer ones when compared with SA intermediaries, consistent with *H1*.

6.2 The impact of the regulatory regime shift on the extensive margin of credit

This section focuses on the impact of the IRB adoption on the number of borrowers before and after the shift (the extensive margin of credit, *H2*), comparing the probability of ending for credit relationships between treated or control lenders and low or high-risk borrowers.

Table 7 shows the results of Eqs. (5) and (6) estimated by adopting *Exit* as the dependent variable, as described in Section 5. The estimates in column (1) show that the probability of ending for relationships between treated lenders and less-risky borrowers in the year after the shift was about 2 percentage points lower than that for relationships with control intermediaries. In contrast, the probability of ending for relationships with treated banks was 4.4 percentage points higher for riskier

[14] Using the estimates in column (1), for high-risk borrowers, the average decrease in rates on credit by control banks is equal to (0.411-0.566), while that on credit by treated banks is (-0.566+0.411+0.088).
[15] Using the abovementioned changes in the interest rates: (-75+25)-(-57+16) = -9.
[16] It is calculated as: 9/50.

firms than for safer ones when compared with that for relationships with control intermediaries, consistent with *H2*. Columns (2), (3), and (4) confirm that the results are robust to including bank control variables as well as firm-time and bank-time fixed effects.

Overall, these findings suggest that the adoption of the IRB approach had a significant impact on the extensive margin of credit, which imply that existing relationships with treated banks are more likely to end if the loan was granted to a riskier borrower (*H2*).

6.3 The impact of the regulatory regime shift at the firm level

The framework employed in previous sections does not allow taking into account the overall impact at the firm level. Indeed, riskier borrowers may offset the negative effects on the cost and the amount of credit associated with the regulatory shift of their lenders by relying on control banks. The exercise presented in this section allows verifying this hypothesis.

Columns (1) and (2) of Table 8 report the results of Eqs. (7) and (8), respectively. For borrowers more exposed to a treated bank before its shift (i.e. a share of credit granted by a treated bank above the 75^{th} percentile of the distribution), the estimates presented in column (1) document that high-risk firms experienced a decrease in the average interest rates that is about 43 bps lower than that faced by safer companies.[17] This is 17 bps higher than that observed for borrowers of SA banks in the same period (26 bps). As indicated in column (2), riskier borrowers of a treated intermediary also experienced a statistically significant greater reduction in the total bank credit growth, but the differential effect is economically negligible (about 0.5 percentage points).

These findings are consistent with hypothesis *H3*, although evidence is weaker for loan amounts. Interestingly, the firm-level effect on loan rates for riskier borrowers (17 bps) is larger than the impact previously shown at the bank-firm level (4 bps). This result may be due to the costs incurred by those borrowers that switched from treated to control banks after the shift. Indeed, since the decrease in total credit is negligible (as shown in column (2) of Table 8), the estimates suggest that riskier borrowers that experienced a reduction in credit growth or a relationship ending by a treated intermediary were able to obtain funds from SA banks; however, new lenders charged higher rates. This additional spread payed by high-risk firms is consistent with the evidence on the significant switching costs for riskier borrowers documented in the literature (Rajan, 1992; Sharpe, 1990).

To verify whether the increase in loan rates is connected with higher switching costs for riskier borrowers, Eq. (5) is estimated by interacting *ShareHHI* with *HighRisk* and *IRBexp*. Indeed, since *ShareHHI* indicates how the credit is concentrated for each firm, this variable can be employed as a

[17] Using the estimates in column (1): (0.263-0.074+0.171)-(-0.074) = 0.434.

proxy of the hold-up power of lenders (Ioannidou and Ongena, 2010). Column (3) of Table 8 presents the results of this exercise. The positive sign of the *HighRisk·IRBexp·ShareHHI* coefficient suggests that the decrease in the average interest rates was lower mainly for riskier borrowers of treated banks that had a highly concentrated credit (i.e. high concentration index). This evidence implies that the costs for firms involved in switching lenders may strengthen the negative impact of the IRB adoption on interest rates.

7. Additional tests

The following sections present additional estimates to strengthen the validity of the main findings. In the first set of tests, the variable *HighRisk* is replaced with different borrower-level variables. The second robustness check presents a falsification test. For space considerations, the following tests focus on the cost of credit model (Eq. 3), but the results are also robust to adopting Eq. (4).

Moreover, unreported robustness checks show that the results are robust to examining the yearly granted credit, considering the overall credit extended by each bank (the sum of credit lines, term loans, and loans backed by accounts receivable), and focusing only on the shifts occurred after the global financial crisis.

7.1. Borrowers' characteristics

The main models presented in previous sections are based on an accounting credit score to identify riskier borrowers. This section focuses on different borrowers' characteristics to explore the categories of firms that are more affected by a regulatory regime shift.

First, the level of debt may represent a proxy of the borrower's riskiness: highly leveraged firms are generally more financially constrained and may not be able to repay their obligations. Column (1) of Table 9 shows the results of Eq. (3) estimated by replacing *HighRisk* with *HighLev*, which is a dummy variable equal to 1 if the firm's leverage is greater than the median in t_0 and 0 otherwise. The results document that highly leveraged firms experienced a lower decrease in rates on credit granted by treated banks.

The second test focuses on the borrower size. Smaller firms are considered as riskier than larger ones because they are on average financially weaker and less transparent (Petersen and Rajan, 1994; Rajan and Zingales, 1995). Column (2) of Table 9 shows the results of Eq. (3) estimated by replacing *HighRisk* with *Smaller*, which is a dummy variable equal to 1 if the firm' total assets are lower than the median in t_0 and 0 otherwise. The estimates indicate that treated banks decreased interest rates less for smaller borrowers.

Overall, these tests suggest that the main findings are robust to adopting different measures to identify riskier borrowers.

7.2. Falsification test

This section presents a falsification test to address potential concerns about structural differences in lending policies among treated and control banks that might exist before the regulatory regime shift.

To employ this test, Eq. (3) is estimated by considering the year before the real shift date as t_0. Therefore, this test is equivalent to assume that the shift date has occurred in t_{-1} for each treated bank. Table 10 shows the results of this falsification exercise. The interaction coefficient between *HighRisk* and *IRBshift* is not significant, suggesting that the change in interest rates for high-risk borrowers with respect to less-risky ones is not significantly different between treated and control banks before the shift date.

8. Conclusions

This paper analyses whether the adoption of internal rating models affects banks' lending policies for low and high-risk borrowers. The main hypothesis is that the relatively disadvantageous treatment that loans for riskier firms receives under the IRB approach may lead banks adopting this method to raise interest rates and reduce credit to high-risk borrowers compared with low-risk ones.

The empirical evidence indicates that, in the year after the regulatory regime shift, banks adopting the IRB approach reduce interest rates (credit) to riskier borrowers compared with less-risky ones less (more) than SA institutions. Second, an existing relationship with a bank adopting the IRB method is more likely to end if the loan is granted to a high-risk borrower. Third, after the regulatory regime shift, the results obtained at the firm-level suggest that riskier firms were able to compensate partly the reduction in bank credit by obtaining funds from SA banks, but they could not offset the negative effect on the average cost of credit because of the significant costs associated with switching lenders.

The results are robust to adopting the firm's level of debt or size to identify riskier borrowers and employing a falsification test.

These findings are associated with several policy implications. The results suggest that an increase in the number of intermediaries adopting the IRB method may incentivize a safer allocation of credit. Indeed, as shown by the bank-level analysis in Section 5.3, a regulatory shift is associated with a greater reduction in the share of loans to riskier borrowers. A side effect of this process is that the access to credit for riskier firms may be hampered by an increase in the average cost of credit, which may reach an unsustainable level for already financially constrained borrowers.

Overall, it should be noted that the presented analysis does not provide a comprehensive assessment of the effects of risk-based capital requirements for the whole financial system, while it focuses only on the impact of the IRB adoption on bank lending policies for high and low-risk firms. Therefore, further research on this topic is required to a more accurate assessment of the overall costs and benefits of this regulatory framework.

Appendix

Table A.1

Variables description.

Variable	Description	Source
Dependent Variable		
Δ*Rate*	Difference between the annualized rate on granted credit lines in t_{+1} and t_{-1} by bank *j* to firm *i*.	CR
Δ*Credit*	Difference between the log amount of granted credit lines in t_{+1} and t_{-1} by bank *j* to firm *i*.	CR
Exit	Dummy variable equal to 1 for loans that existed in t_{-1} and ceased to exist after the shift.	CR
Δ*AvgRate*	Difference between the average annualized rate on granted credit lines in t_{+1} and t_{-1} to firm *i*.	CR
Δ*TotCredit*	Difference between the log amount of total granted credit lines in t_{+1} and t_{-1} to firm *i*.	CR
Δ*ShareHighRisk*	Difference between the ratio of loans to high-risk borrowers to total loans in t_{+1} and t_{-1}.	CR
Key Explanatory Variables		
HighRisk	Dummy variable equal to 1 if the firm's credit score in t_0 is greater than 5 and 0 otherwise.	Cerved
IRBshift	Dummy variable equal to 1 if the bank *j* has adopted the IRB approach in t_0 and 0 otherwise.	Supervisory and Pillar 3 information
IRBexp	Dummy variable equal to 1 for firms that in t_{-1} had a share of credit granted by a treated bank falling in the top quartile of the distribution and 0 otherwise.	Supervisory and Pillar 3 information
HighLev	Dummy variable equal to 1 if the firm's leverage is greater than the median in t_0 and 0 otherwise.	Cerved
Smaller	Dummy variable equal to 1 if the firm's total assets are lower than the median in t_0 and 0 otherwise.	Cerved
Control Variables		
Share	The share of total credit (revolving credit lines, term loans, loans backed by accounts receivables) granted by bank *j* to firm *i* in t_{+1}.	CR
ShareHHI	The Herfindahl-Hirschman index (HHI) of share of total credit granted to firm *i* in t_{+1}.	CR
BankSize	Logarithm of the total assets of bank *j* in t_{-1}.	Supervisory reports
Loans	Ratio of total loans to total assets of bank *j* in t_{-1}.	Supervisory reports
Deposits	Ratio of deposits to total liabilities of bank *j* in t_{-1}.	Supervisory reports
CapRatio	Ratio of total equity to total assets of bank *j* in t_{-1}.	Supervisory reports
ROE	Return on equity (pre-tax income over total equity) of bank *j* in t_{-1}.	Supervisory reports
Size	Logarithm of the total assets of firm *i* in t_0.	Cerved
IntCovRatio	Ratio of EBITDA to interest expense of firm *i* in t_0.	Cerved
Leverage	Ratio of total debt to the book value of assets of firm *i* in t_0.	Cerved
Fixed Assets	Ratio of fixed assets to total assets of firm *i* in t_0.	Cerved
EBITDA	Ratio of EBITDA to total assets of firm *i* in t_0.	Cerved
Industry	Indicator variables for the industry of firm *i* based on 2-digit ATECO.	Cerved
Area	Indicator variables for area of the country: north-west, north-east, center, south.	Cerved

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Figures and tables

Figure 1

Number of IRB banks by year (2008-17).

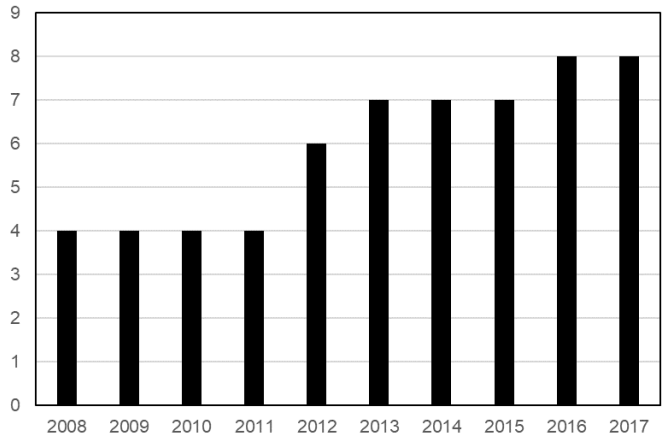

Figure 2

Share of the overall granted credit to non-financial firms by regulatory approach in the examined period.

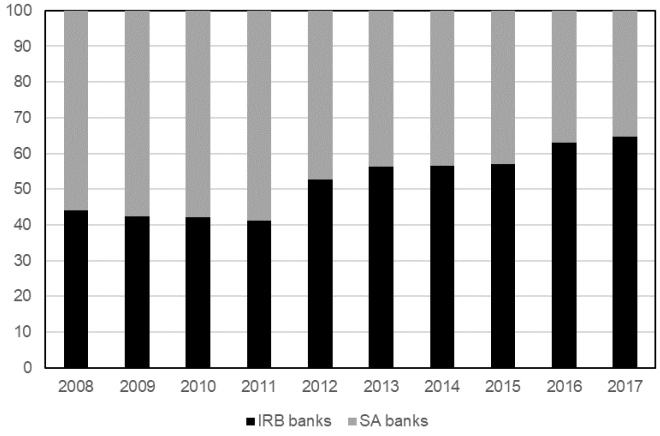

Table 1

Summary statistics on credit relationships comparing treated and control banks

		Control Banks			Treated Banks		
		Mean	**Median**	**Std. Dev.**	**Mean**	**Median**	**Std. Dev.**
ΔRate	LR	-0.72	-0.33	2.37	-1.44	-1.30	2.44
	HR	-0.18	0.01	2.46	-0.81	-0.54	2.40
ΔCredit	LR	-0.37	0.00	58.51	-6.39	0.00	66.60
(*p.p.*)	HR	-2.77	0.00	60.94	-9.07	0.00	68.44
Exit	LR	0.15	0.00	0.36	0.13	0.00	0.34
	HR	0.25	0.00	0.43	0.27	0.00	0.44

Table 2

Summary statistics comparing low and high-risk firms.

Variable	LR Firms			HR Firms		
	Mean	**Median**	**Std. Dev.**	**Mean**	**Median**	**Std. Dev.**
A: Bank-Firm Level						
ΔRate	-1.00	-0.67	2.44	-0.44	-0.15	2.46
ΔCredit (*p.p.*)	-2.41	0.00	61.44	-5.02	0.00	63.80
IRBshift	0.34	0.00	0.47	0.36	0.00	0.48
Share	0.21	0.16	0.17	0.21	0.16	0.18
Size	9.00	8.90	1.55	8.48	8.36	1.41
IntCovRatio	10.43	5.65	11.73	2.01	1.82	3.16
Leverage	0.69	0.72	0.22	0.87	0.89	0.18
Fixed Assets	0.24	0.18	0.22	0.20	0.12	0.21
EBITDA	0.10	0.08	0.12	0.05	0.05	0.11
B: Firm level						
ΔAvgRate	-0.75	-0.51	2.05	-0.29	-0.10	2.07
ΔTotCredit (*p.p.*)	-2.01	0.00	44.06	-8.12	0.00	50.03
IRBexp	0.26	0.00	0.44	0.24	0.00	0.43
ShareHHI	0.61	0.53	0.30	0.63	0.55	0.29

Table 3

Summary statistics comparing treated and control banks.

Variable	Treated Banks			Control Banks		
	Mean	**Median**	**Std. Dev.**	**Mean**	**Median**	**Std. Dev.**
BankSize (*€bn*)	504.11	538.99	373.58	225.93	90.66	299.46
Loans (*%*)	73.09	71.26	5.74	73.98	74.20	6.57
Deposits (*%*)	34.43	38.51	10.53	44.70	44.27	12.64
CapRatio (*%*)	7.31	6.17	1.78	8.00	8.24	2.11
ROE (*%*)	3.85	6.73	13.19	-1.30	4.85	17.59

Table 4

The share of credit granted to high-risk firms.

	(1) Δ*ShareHighRisk*
IRBshift	-0.035***
	(0.010)
Constant	-0.022***
	(0.000)
Bank FE	*Yes*
Year FE	*Yes*
Observations	1,956
Adj R-squared	0.216

The table shows the results of a regression model estimated by examining the amount of credit aggregated at the bank level granted by SA intermediaries and those that have adopted the IRB approach in t_0. The dependent variable is Δ*ShareHighRisk*, the difference between the ratio of loans to high-risk borrowers to total loans in t_{+1} and t_{-1}. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 5

The impact of the IRB adoption on the cost of credit.

	(1) *ΔRate*	*(2)* *ΔRate*	*(3)* *ΔRate*	*(4)* *ΔRate*
HighRisk	0.411***	0.444***	0.396***	-
	(0.000)	(0.000)	(0.000)	
IRBshift	-0.183***	-0.377***	-	-
	(0.000)	(0.000)		
HighRisk·IRBshift	0.088***	0.133***	0.114***	0.039**
	(0.000)	(0.000)	(0.000)	(0.031)
Share	-0.469***	-0.453***	-0.514***	-
	(0.000)	(0.000)	(0.000)	
Size	-0.026***	-0.032***	-0.032***	-
	(0.000)	(0.000)	(0.000)	
IntCovRat	-0.016***	-0.012***	-0.015***	-
	(0.000)	(0.000)	(0.000)	
Leverage	0.200***	0.004	0.208***	-
	(0.000)	(0.325)	(0.000)	
FixedAsset	-0.016	-0.023	-0.011	-
	(0.484)	(0.282)	(0.648)	
EBITDA	-0.848***	-0.987***	-0.871***	-
	(0.000)	(0.000)	(0.000)	
BankSize	-	0.141***	-	-
		(0.000)		
Loans	-	0.351***	-	-
		(0.001)		
Deposits	-	0.361***	-	-
		(0.000)		
CapRatio	-	1.452***	-	-
		(0.000)		
ROE	-	-0.512***	-	-
		(0.000)		
Constant	-0.566***	-1.380***	-0.577***	-0.619***
	(0.000)	(0.000)	(0.000)	(0.000)
Year, Industry, Area FE	*Yes*	*Yes*	*Yes*	*No*
Firm-Time FE	*No*	*No*	*No*	*Yes*
Bank-Time FE	*No*	*No*	*Yes*	*Yes*
Observations	341,370	341,370	341,370	341,370
Adj R-squared	0.164	0.168	0.187	0.293

Columns (1), (2) and (3) show the results obtained from the estimation of Eq. (1) by adding firm controls, bank controls, and bank-time FE, respectively. Column 4 presents the results of Eq. (3). The dependent variable is *ΔRate*, the difference between the annualized rate on granted credit lines in t_{+1} and t_{-1} by bank *j* to firm *i*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 6

The impact of the IRB adoption on the amount of credit.

	(1) *ΔCredit*	*(2)* *ΔCredit*	*(3)* *ΔCredit*	*(4)* *ΔCredit*
HighRisk	-0.026***	-0.023***	-0.026***	-
	(0.000)	(0.000)	(0.000)	
IRBshift	-0.087***	-0.042***	-	-
	(0.000)	(0.000)		
HighRisk·IRBshift	-0.004	-0.007*	-0.007*	-0.010***
	(0.265)	(0.057)	(0.091)	(0.010)
Constant	-0.048***	-0.055**	-0.164***	-0.035***
	(0.000)	(0.010)	(0.000)	(0.000)
Firm Controls	*Yes*	*Yes*	*Yes*	*No*
Bank Controls	*No*	*Yes*	*No*	*No*
Firm-Time FE	*No*	*No*	*No*	*Yes*
Bank-Time FE	*No*	*No*	*Yes*	*Yes*
Observations	599,418	599,418	599,418	599,418
Adj R-squared	0.011	0.014	0.033	0.055

Columns (1), (2) and (3) show the results obtained from the estimation of Eq. (2) by adding firm controls, bank controls, and bank-time FE, respectively. Column 4 presents the results of Eq. (4). The dependent variable is *ΔCredit*, difference between the log amount of total granted credit lines in t_{+1} and t_{-1} to firm *i*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7

The impact of the IRB adoption on the "extensive margin" of credit.

	(1) *Exit*	*(2)* *Exit*	*(3)* *Exit*	*(4)* *Exit*
HighRisk	0.054***	0.051***	0.054***	-
	(0.000)	(0.000)	(0.000)	
IRBshift	-0.021***	-0.018***	-	-
	(0.000)	(0.000)		
HighRisk·IRBshift	0.044***	0.044***	0.036***	0.045***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.523***	1.167***	0.514***	0.198***
	(0.000)	(0.000)	(0.000)	(0.000)
Firm Controls	*Yes*	*Yes*	*Yes*	*No*
Bank Controls	*No*	*Yes*	*No*	*No*
Firm-Time FE	*No*	*No*	*No*	*Yes*
Bank-Time FE	*No*	*No*	*Yes*	*Yes*
Observations	459,345	459,345	459,345	459,345
Adj R-squared	0.053	0.064	0.152	0.345

Columns (1), (2) and (3) show the results obtained from the estimation of Eq. (5) by adding firm controls, bank controls, and bank-time FE, respectively. Column 4 presents the results of Eq. (6). The sample includes firms with at least one loan granted by a treated and a control bank in t_{-1}. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 8

The impact of the IRB adoption on the cost and the amount of credit at the firm level.

	(1) Δ*AvgRate*	*(2)* Δ*TotCredit*	*(3)* Δ*AvgRate*
HighRisk	0.263***	-0.061***	0.358***
	(0.000)	(0.000)	(0.000)
IRBexp	-0.074***	-0.024***	-0.064***
	(0.000)	(0.000)	(0.001)
HighRisk·IRBexp	0.171***	-0.005*	0.046*
	(0.000)	(0.051)	(0.063)
HighRisk·ShareHHI	-	-	-0.167***
			(0.000)
IRBexp·ShareHHI	-	-	-0.009
			(0.804)
HighRisk·IRBexp·ShareHHI	-	-	0.224***
			(0.000)
ShareHHI	0.207***	-0.270***	0.288***
	(0.000)	(0.000)	(0.000)
Constant	-0.726***	0.525***	-0.780***
	(0.000)	(0.000)	(0.000)
Firm Controls	*Yes*	*Yes*	*Yes*
Observations	640,320	1,048,032	640,320
Adj R-squared	0.145	0.046	0.145

Column (1) presents the results of Eq. (7). The dependent variable of this model is Δ*AvgRate*, the difference between the average annualized rate on granted credit lines in t_{+1} and t_{-1} to firm *i*. Column (2) presents the results of Eq. (8). The dependent variable of this model is Δ*TotCredit*, the difference between the log amount of total granted credit lines in t_{+1} and t_{-1} to firm *i*. In Column (3), Eq. (7) is estimated by interacting *ShareHHI* with *HighRisk* and *IRBexp*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 9

The impact of the IRB adoption on the cost of credit by exploring borrowers' characteristics.

	(1) *Leverage*	*(2)* *Size*
HighLev·IRBshift	0.048***	-
	(0.006)	
Smaller·IRBshift	-	0.045**
		(0.011)
Constant	-0.618***	-0.618***
	(0.000)	(0.000)
Firm-Time FE	*Yes*	*Yes*
Bank-Time FE	*Yes*	*Yes*
Observations	341,370	341,370
Adj R-squared	0.293	0.293

Columns (1) and (2) present the results of Eq. (3) estimated by replacing *HighRisk* with *HighLev* and *Smaller*, respectively. The dependent variable is *ΔRate*, the difference between the annualized rate on granted credit lines in t_{+1} and t_{-1} by bank *j* to firm *i*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 10

Falsification test.

	(1) *ΔRate*
HighRisk·IRBshift	0.020
	(0.164)
Constant	0.648***
	(0.000)
Firm-Time FE	*Yes*
Bank-Time FE	*Yes*
Observations	267,619
Adj R-squared	0.381

The table shows the results of the falsification test. The dependent variable is *ΔRate*, the difference between the annualized rate on granted credit lines in t_{+1} and t_{-1} by bank *j* to firm *i*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

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