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THE IMPACT OF THE IRB APPROACH ON THE RELATIONSHIP BETWEEN THE COST OF CREDIT FOR PUBLIC COMPANIES AND FINANCIAL MARKET CONDITIONS

by Raffaele Gallo[*]

Abstract

This paper examines whether the regulatory approach adopted by banks to calculate capital requirements has a different impact on the loan rates for public and private companies when financial market conditions change. Using Italian data for the period 2008-18, the analysis documents that the adoption of the internal ratings-based (IRB) approach has led to a significantly greater sensitivity of the loan rates applied to public companies to financial market conditions, proxied by the VSTOXX index. For credit granted by IRB banks, being public is associated with a significant loan cost advantage when the level of financial instability is low. However, when VSTOXX rises, public companies experience a greater increase in loan rates than private firms; the effect is determined mostly by less capitalized IRB banks. In contrast, for credit granted by banks that adopt the standardized approach (SA), public borrowers do not benefit from a significant loan cost advantage compared with private ones, and a change in financial market conditions has a similar impact on loan rates for both types of companies.

JEL Classification: G01, G20, G21, G32.
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Contents

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1. Introduction[1]

After the introduction of the Basel II framework in 2007, banks are allowed to choose between two main regulatory approaches to calculate capital charges for credit risk. Under the standardized approach (SA), risk weights associated with each exposure are fixed and constant over time. Under the internal ratings-based approach (IRB), risk weights depend on banks' internal risk models validated by the supervisors. When using the latter method, therefore, banks calculate capital charges relying on their own estimate of the risk associated with each exposure in their portfolio.

The use of internal models has represented a major change in the regulatory assessment of credit risk. The implications associated with the adoption of the IRB approach are at the core of supervisory scrutiny and of the debate on the next regulatory framework (BCBS, 2017).

Since capital charges are linked to asset risk under the IRB approach while they are fixed over time under SA, the literature has underlined that the regulatory capital is more risk-sensitive for IRB than for SA banks (Behn et al., 2016b; Kashyap and Stein, 2004; Repullo and Suarez, 2004, 2013). Consequently, capital requirements for IRB financial institutions may significantly change over time, rising after a negative shock to borrower's riskiness.

In addition, the IRB approach allows exerting greater discretion in the assessment of the borrower's creditworthiness because IRB banks can estimate the risk of each exposure with their own models. However, the literature has documented that the discretion is lower when there is an external benchmark that can be compared with banks' internal evaluations (Behn et al., 2016a; Firestone and Rezende, 2016; Plosser and Santos, 2014).

The abovementioned characteristics of the IRB approach, i.e. sensitivity to risk and reliance on external benchmarks, may have an asymmetric impact on the cost of loans granted to public and private borrowers. For a public borrower, the market price of the firm's share is a benchmark for IRB banks' evaluations; in contrast, for a private firm, IRB lenders' internal estimates cannot be compared with an external benchmark specifically related to the same borrower. Since changes in the market-based benchmark value affect IRB banks' evaluations for public firms, the cost of IRB loans may be more sensitive to financial market conditions for public borrowers than for private ones. Therefore, after a rise in financial instability, public firms may experience an increase in IRB loan rates greater than that faced by private companies. Instead, for SA loans, changes in financial market conditions may not affect loan rates for public and private borrowers differently.

[1] I thank F. Ciocchetta, S. De Mitri, R. Felici, and M. Moscatelli for their support in data collection. The work benefited from the useful comments of N. Branzoli, L. Carpinelli, G. Cascarino, F. Columba, D. Drago, G. Gobbi, G. Guazzarotti, A. Ilari, D. Loschiavo, S. Magri, and F. Palazzo. I also thank several colleagues in the Bank of Italy's Directorate General for Economics, Statistics and Research and seminar participants at the Bank of Italy's Workshop "Banking Research Network" (Rome, September 2019) for their useful suggestions.

This effect is relevant for the literature on the cost and benefits of going public. Several studies have documented that public firms benefit from a significant loan cost advantage with respect to private companies because they can rely on lower costs of information production and greater bargaining power (Pagano et al., 1998; Saunders and Steffen, 2011). The adoption of the IRB approach may reduce the loan cost advantage of listing in periods of financial market instability.

The aim of this paper is to evaluate whether the regulatory approach adopted by Italian banks to calculate capital requirements for credit risk affects the sensitivity of public and private firms' borrowing costs to changes in financial market conditions.

The sample analyzed is made of public and private borrowers with at least one loan granted respectively by a SA bank and an IRB bank in the same quarter, between 2008 and 2018. This identification strategy allows examining the loan rate applied to the same firm by at least two banks that adopt a different regulatory approach.

The empirical analysis indicates that public firms benefit on average from a loan cost advantage of 73 basis points (bps) with respect to private companies for credit granted by IRB banks. However, the adoption of the IRB approach leads to a greater sensitivity of the loan rates applied to public firms to financial market conditions, measured by the VSTOXX index. After a rise in VSTOXX of one standard deviation (about 8 units), public firms experience an increase in loan rates 31 bps greater than that faced by private companies. In contrast, for credit granted by SA banks, being listed is not associated with a significant loan cost advantage and a change in financial market conditions affects interest rates for public and private borrowers in a similar way.

The evidence concerning IRB banks may depend on the level of their capital ratios: greater capital buffers may reduce the loan rate sensitivity to financial market conditions. Even if IRB banks with different capital ratios assign the same riskiness to a public borrower, less capitalized IRB financial institutions may have a stronger reaction to a credit risk shock because they find it more problematic to comply with an increase in regulatory capital requirements (Behn et al., 2016b). Consequently, they may raise loan rates for public firms more than other IRB banks in reaction to an increase in financial instability. The results confirm that the reduction in the loan cost advantage of public firms associated with a deterioration in financial market conditions is more pronounced if the IRB bank has less capital.

The main findings hold also after considering lender bank and firm heterogeneity and using a matched sample that allows comparing borrowers with statistically similar characteristics.

This work contributes to two main strands of the extant literature. First, this paper expands the analysis of the impact of the IRB approach on bank lending (Behn et al., 2016a, 2016b; Berg and Koziol, 2017; Plosser and Santos, 2014; Repullo and Suarez, 2004, 2013). Second, it is related to

the literature on the loan cost advantage of public firms (Pagano et al., 1998; Saunders and Steffen, 2011) and on the effect of exogenous shocks on this benefit (Gallo, 2019; Santos and Winton, 2008). To the best of my knowledge, this paper is the first to assess the impact of the IRB approach on the relationship between the loan cost advantage of being public and the financial market climate.

The remaining part 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 used in the analysis. The main results are reported in Section 6. Section 7 contains robustness checks, while Section 8 concludes.

2. Review of the regulatory background and related research

2.1. The introduction of the model-based regulation

The entry into force of the Basel II framework in 2007 has significantly modified the credit risk assessment of financial institutions. The regime of Basel I classifies each bank asset in a list of pre-determined buckets and assigns a fixed risk weight to each category. In contrast, the Basel II framework allows establishing a stronger link between capital charges and the actual risk of assets (Behn et al., 2016b). This framework allows banks to choose between the standardized approach (SA) and the internal ratings-based approach (IRB) for calculating capital requirements. In both methods capital requirements are determined in terms of risk-weighted assets (RWA), which are estimated by multiplying each risk weight with the value of the corresponding asset. The Basel III framework has confirmed this distinction.

The standardized approach is substantially similar to that prescribed under the Basel I framework (i.e. fixed risk weights assigned to each bucket of assets). For assets rated by a specialized agency, the risk weight can change after a downgrade or an upgrade of the external credit rating; while, from a regulatory point of view, the riskiness of unrated assets remains constant over time. Under SA, all uncollateralized loans granted to unrated firms have a risk weight of 100 per cent.

Under the IRB approach, the risk weight of each asset depends on banks' internal risk models. The determinants of asset risk estimates are four parameters: the probability of default (PD), the loss given default (LGD), the exposure at default (EAD), and the effective maturity of the loan.[2] Each model has to be approved and validated at least once a year by regulators. The estimates under

[2] Banks estimate all four parameters under the advanced IRB (AIRB) approach, while they estimate only the PD in the foundation IRB (FIRB) approach and fixed standard values are assumed for other parameters. The Italian IRB banks have almost exclusively adopted the AIRB method; therefore, this distinction does not affect the main findings.

IRB have to be periodically updated. Consequently, risk weights and related capital charges for each exposure may change over time.

Banks are incentivized to adopt the IRB approach because capital requirements are substantially lower under IRB than under SA, but the adoption is associated with substantial administrative costs and organizational efforts (Behn et al., 2016b). Therefore, only few large banks have adopted the IRB approach.

2.2. The main implications of the IRB approach

The financial literature has explored two main implications of the introduction of the IRB approach. First, several studies have underlined that the IRB risk-based requirements have raised the sensitivity of bank regulatory capital to asset risk compared with the flat requirements of SA (and Basel I) (Repullo and Suarez, 2004). A potential issue associated with the introduction of this regulation is that it may tend to amplify business (or financial) cycle fluctuations (Behn et al., 2016b; Kashyap and Stein, 2004; Repullo and Suarez, 2013) and to exacerbate financial instability (EBA, 2013). If asset risk measures are responsive to a negative shock, then capital requirements will rise after an increase in the borrower's riskiness. Banks that are unwilling or unable (e.g. less capitalized) to raise new equity may be forced to deleverage, exacerbating the negative impact of the shock. However, the incentive to reduce the loan portfolio riskiness when credit conditions deteriorate may enhance bank safety, and, consequently, the solvency of the banking system in the long-term (Repullo and Suarez, 2013).

Second, the literature finds evidence of a significant variability across IRB banks of RWA densities[3] (Le Leslé and Avramova, 2012; Mariathasan and Merrouche, 2014; Pérez Montes et al., 2018) and of risk-weights assigned to the same borrower (Behn et al., 2016a; Berg and Koziol, 2017; Plosser and Santos, 2014). Some degree of idiosyncratic variation in internal estimates is allowed and encouraged: if banks' risk models are too similar, then all banks would be doing the same action at the same time, raising endogenous risk concerns (Berg and Koziol, 2017). Moreover, the high complexity of internal risk models and the adoption of different business models make risk estimates comparison difficult across financial institutions (Cannata et al., 2012; Cucinelli et al., 2018). However, controlling for several confounding factors, the literature suggests that the risk estimates (RWA density and risk-weights) of IRB banks with lower capital on average are more downward biased than those of more capitalized IRB banks (Behn et al., 2016a; Plosser and Santos, 2014). This result is consistent with a strategic risk-modelling hypothesis, which consists of a systematic underestimation of asset risk by IRB banks to reduce capital requirements.

[3] The RWA density is defined as the ratio of risk-weighted assets to total assets.

As underlined by Behn et al. (2016a), the variability in IRB banks' risk estimates is lower when there is an external benchmark that can be compared with banks' internal estimates because misreporting would be more likely to be detected by the supervisors. Firestone and Rezende (2016) document that banks disagree less on their estimation of LGDs when they evaluate more transparent borrowers, such as public and rated firms. Plosser and Santos (2014) find that IRB banks, mainly those with lower capital, report on average downward biased estimates and that this bias is concentrated on the riskiness of private firms. For these borrowers, in fact, banks have greater discretion as to the inputs of their risk models.

2.3. The effects of being public

The decision of going public has relevant implications for firms. Public companies obtain better and cheaper access to external equity capital (Brav, 2009). Listed firms have lower costs of information production and greater bargaining power, they can therefore rely on a significant cost advantage in the loan market with respect to private companies (Pagano et al., 1998; Saunders and Steffen, 2011).

A strand of literature has examined the effect of exogenous shocks on the loan cost difference between public and private borrowers. Santos and Winton (2008) find that the increase in syndicated loan spreads during recessions is significantly lower for listed firms with public debt market access than for other listed companies. This evidence is consistent with the hypothesis that banks hold an informational monopoly that allows them to increase interest rates mostly to more opaque borrowers in contexts characterized by high information asymmetry (Rajan, 1992), such as in recessions. Gallo (2019) shows that the cost advantage of public firms in the syndicated loan market declines during high volatility periods because a rise in financial instability weakens their bargaining power and the information benefits of being listed.

Both empirical studies examine a sample of syndicated loans. However, the results obtained by analyzing these contracts might not be extended to the bilateral credit market. Since multiple syndicate participants charge a unique rate to the borrower, it is difficult to assess to which extent the characteristics of each bank (i.e. the regulatory approach adopted) affect loan pricing. Moreover, the presence of multiple lenders weakens the strength of the bilateral relationship between the borrower and a specific bank. Finally, a syndicated loan may not absorb regulatory capital of the lenders that decide to sell their shares of the loan in the secondary market. As a result, the impact of the regulatory approach adopted by each syndicate participant on loan rates may be more difficult to evaluate. In contrast, the adoption of a sample of bilateral loan contracts allows assessing how the

regulatory approach of the bank affects the cost of credit, controlling for the characteristics of the lender and the strength of bank-firm relationships.

Finally, the literature has also focused on the decision of several firms to remain private or to delist from a stock exchange (Bharath and Dittmar, 2010; Doidge et al., 2017). Among potential reasons, some companies may be interested in being more opaque and in decreasing outside scrutiny (Leuz et al., 2008; Marosi and Massoud, 2007). Since outside agents can rely on market prices continuously updated, each action of public firms is scrutinized and the reassessment of their value is easier than that of private companies. These studies suggest that the presence of an external benchmark may significantly affect firms' decisions.

3. Research hypotheses

The contributions mentioned in Section 2.2 indicate that IRB banks' evaluations on the creditworthiness of public firms may be closely related to borrowers' share prices.[4] Since internal estimates are risk-sensitive for IRB banks, a financial shock that negatively affects the stock market may be directly incorporated in IRB banks' evaluations of public firms, indicating an increase in their riskiness. As a result, IRB banks might raise the interest rates applied to public firms after a worsening of financial market conditions.

In contrast, lenders cannot rely on a firm-specific market benchmark for evaluating private borrowers. Therefore, the interest rates applied by IRB banks to private firms may be not or only weakly correlated to financial market conditions.

Finally, under SA, risk weights associated with credit exposures both to public and private borrowers do not strictly depend on financial market conditions because capital charges are determined when the loan is made and do not change (Behn et al., 2016b).[5] Consequently, the estimates of SA banks on the public firms' creditworthiness may be significantly less sensitive to a change in financial instability than those of IRB banks.

Overall, the adoption of the IRB approach may have a significant impact on loan pricing. For credit granted by IRB banks, the loan cost advantage of being public may decrease when financial market conditions deteriorate. In contrast, for SA loans, a change in the financial market climate may not affect the cost of credit for public and private borrowers differently. Therefore, the first testable hypothesis is:

[4] For example, several banks adopt a Merton-based methodology to evaluate public corporates (e.g. Barclays, 2015).
[5] Under SA, the risk weight can change over time for firms rated by credit rating agencies. Unreported analyses show that the main findings hold also controlling for the presence of rated firms in the examined sample.

H1. *A deterioration in financial market conditions leads to an increase in IRB loan rates greater for public firms than for private companies, while for SA banks it has a similar impact on the cost of loans applied to public and private borrowers.*

Even if the internal models of IRB banks with different capital ratios indicate the same increase in capital charges, financial institutions may react by applying different loan rates. Less capitalized banks may have a stronger reaction to an increase in capital requirements because raising capital may be more problematic for them (Behn et al., 2016b). When capital requirements related to exposures to public firms rise after a financial shock, IRB banks with lower capital ratios may raise interest rates more than other IRB banks. Consequently, the reduction in the loan cost advantage of public firms associated with a worsening of the financial market climate (*H1)* may be lower for credit granted by more capitalized IRB banks. The second hypothesis tested in this paper is therefore that:

H2. *The loan rates applied to public firms by less capitalized IRB banks are more sensitive to financial market conditions than those applied by more capitalized IRB banks.*

4. Data and sample

4.1. Data sources

The sample consists of quarterly data on credit to Italian non-financial firms from the Italian Credit Register ("Centrale dei Rischi", CR) from the first quarter of 2008 to the second quarter of 2018. CR is maintained by the Bank of Italy and covers the population of individual borrowers' outstanding exposure of over €30,000 with a single intermediary.[6] For each exposure, the database provides detailed information on the lender, the borrower identity, and the type of credit (credit lines, term loans, and loans backed by accounts receivable). Data on the interest rates applied by banks are obtained from a section of the CR, TAXIA, which contains information on the interest rate charged on all loans granted by a representative sample of Italian banks.[7]

This work focuses on credit lines. Since rates on this source of financing are highly standardized among banks, they are more comparable than those on other credit types (Sette and Gobbi, 2015). In contrast to term loans, for example, credit lines do not have a specific maturity, are granted for no specific purpose, and are typically not backed by collateral.[8] The lender can modify quickly and unilaterally the contract terms, including prices. In addition, credit lines represent a significant source of financing for firms, mainly during crisis periods (Acharya et al., 2014).

[6] For CR, the reporting threshold was €75,000 before 2009.
[7] The credit granted by this sample of banks accounts for more than 80 per cent of total bank lending in Italy. For TAXIA, the reporting threshold is €75,000.
[8] The results are robust to using also interest rates on term loans and on loans backed by account receivables.

The baseline model considers interest rates on revolving credit lines inclusive of fees and commissions. Therefore, this measure takes into account the overall cost of credit charged to borrowers for each loan.[9] The interest rate for each credit line is estimated by dividing the amount due, including fees and commissions, by the amount of loans, multiplied by the days this amount was outstanding.

Firm accounting data are retrieved from the database of Cerved group, which is a leading information provider in Italy, while data on banks' balance sheets are obtained from Supervisory Reports of Bank of Italy. Information on securities issued by each firm is collected from the Securities Database of Bank of Italy; other financial variables are obtained from Datastream. Finally, the regulatory approach adopted by each Italian bank is singled out by relying on confidential supervisory information and publicly available banks' Pillar 3 reports.

In addition, the analysis also considers information on bank-firm relationships, which have significant effects in the Italian credit market (Sette and Gobbi, 2015).[10] Long relationships allow banks to accumulate more information about borrowers' creditworthiness over time (Boot, 2000). Similarly, holding a large share of the overall credit granted to the firm allows lenders to have better access to significant information (Elsas, 2005). As a result, borrowers may benefit from the reduction in information asymmetry associated with close relationships (long duration or a large share of credit). However, since a stronger relationship may indicate a greater hold-up power of lenders, it may imply also greater costs for borrowers in switching to different lenders (Ioannidou and Ongena, 2010; Rajan, 1992).[11] To take into account the potential effects of bank-firm relationships, information on the duration of the relationship and on the share of total credit for each bank-firm combination are also included in the estimations.

4.2. Sample construction

The sample is built as follows. First, credit is aggregated at the banking group level because lending and funding policies are typically decided at this level.

Second, the following loans are excluded: loans to firms with no balance sheet information in the Cerved database; non-performing loans; loans with a missing or nearly zero gross interest rates (less than 0.01 per cent); undrawn credit lines (drawn-to-granted amount ratio lower than 1 per cent); and

[9] The results obtained by adopting net interest rates are qualitatively similar to those presented in the following estimates.

[10] The analysis controls for mergers and acquisition among banks. If a firm had a relationship with a bank and the bank is acquired or merged, the relationship is considered as still existing with the newly constituted financial institution.

[11] The empirical evidence on the impact of stronger relationships on interest rates is mixed. For example, Berger and Udell (1995) and Bharath et al. (2011) find that the strength of relationships and interest rates are negatively related, while Degryse and Ongena (2005) and Ioannidou and Ongena (2010) show that interest rates rise when the relationship is stronger.

loans with extremely high interest rates.[12] To reduce the risk that outliers could affect results, the interest rate variable is also trimmed at the 5th and 95th percentile.

Third, the sample is restricted to firms with at least one loan granted respectively by a SA and an IRB bank in the same quarter. This allows comparing how IRB and SA lenders evaluate the same borrower, overcoming potential identification issues.

Fourth, a potential shortcoming of this analysis is that public firms are a small fraction of the overall number of borrowers.[13] In addition, as documented in the literature (Section 2.3), public firms are significantly different from private companies, both in terms of financial indicators (e.g. lower leverage ratios) and of unobservable characteristics (e.g. quality of management and governance). Therefore, these differences may impair the comparison between the borrowing costs of public and private firms. Previous studies on the loan cost advantage of being public have mainly adopted a sample of syndicated loans (e.g. Saunders and Steffen, 2011), which are typically granted to a subset of larger (public and private) firms. Other related studies focused on the impact of the initial public offering (IPO) on bank loan costs by comparing a sample of private firms that go public with other companies that remain private (e.g. Pagano et al., 1998).

To ensure comparability between public and private firms, two alternative sample specifications are employed. First, in the baseline model, the sample is restricted to firms with access to market financing (i.e. stock and bond markets). Since only few firms with a particular set of observable and unobservable characteristics have access to stock and bond markets (Denis and Mihov, 2003; Hale and Santos, 2008), this restriction allows examining more similar firms.

Companies listed in the stock market are considered as "public borrowers", while unlisted firms with access to the bond market are considered as "private borrowers". I define the firms with at least one outstanding bond in *t* as companies with access to the bond market.[14] These companies represent the control group of the analysis. Indeed, banks cannot rely on timely market information on firms with privately placed bonds because there are not publicly disclosed secondary market prices for these securities. Moreover, given that the liquidity in the secondary bond market of Italian firms is significantly low,[15] also public bond prices could not be a reliable external benchmark for

[12] Fees and commissions are applied on credit granted, while net interest rates in CR are estimated on the basis of the usage of the credit line. Consequently, if a credit line is used for a relatively small amount or for a short period, fees and commissions are larger than net interest rates. This leads to extremely large gross interest rates.
[13] Public companies are 0.2 per cent of the examined sample of borrowers, but they receive 5 per cent of the total credit granted in the analyzed period.
[14] The results are robust to considering in this category firms that have issued bonds in one, three, or ten years before *t*.
[15] Accornero et al. (2018) document that the Italian corporate bond market is significantly smaller than those of France, UK, and US.

banks. Consequently, also companies with public bond market access are included in the control group of private borrowers.[16]

The second alternative sample restriction relies on a matching procedure between listed firms and the full sample of unlisted borrowers. This method, described in Section 7.4, allows comparing firms with statistically similar credit risk, proxied by accounting-based (observable) characteristics.

Overall, the sample employed in the following analyses includes 30728 quarterly credit relationships (7318 loans to public firms, and 23410 to private companies) between 766 non-financial firms (188 public and 578 private borrowers) and 137 Italian banking groups.

With regard to the regulatory approach of lenders, 11 Italian banks have adopted the IRB approach in the analyzed period. The credit granted by IRB banks accounts for about 42 per cent of total bank lending granted to the borrowers included in the sample. Table 1 reports descriptive statistics of the bank-firm relationships included in the sample, indicating the shares of relationships with IRB banks and of the amount of revolving credit lines granted by IRB banks for public and private firms. Compared with private companies, public firms establish on average fewer relationships with IRB banks (41 versus 45 per cent) but they receive a greater share of credit from them (57 versus 52 per cent). Overall, both IRB and SA banks play a significant role for both categories of borrowers. This allows excluding that public or private companies mainly rely on a specific type of bank.

4.3. The measure of financial market instability

The VSTOXX index is the main measure of the level of financial market instability used in the paper. This index reflects the market expectations of equity volatility across all EURO STOXX 50 options over the next thirty days. By considering the implied volatility, a forward-looking perspective is adopted, more consistent with that of lenders. In addition, the use of a European volatility index allows employing a measure that is less affected by the idiosyncratic stock volatility of each Italian firm and signals more accurately the climate of international financial markets. For Italian non-financial firms, the significant rises in financial instability observed during the examined period (2008-2018) were largely unexpected and exogenous events. These elements allow improving the identification of the impact of financial instability on firms' borrowing costs.

Figure 1 shows the quarterly time series of the VSTOXX index over the investigated period. The volatility index exhibits large upward swings above the mean value equal to 24 (the median value is

[16] The reported findings remain unchanged by including firms with public bond market access in the group of public firms or by excluding these companies from the sample. An unreported robustness check documents that an increase in financial market instability does not affect loan rates for firms with public bonds differently than those applied to companies with privately placed bonds.

22), mainly during the great financial crisis and the sovereign debt crisis; the quarters after these crisis periods were characterized by lower volatility. Therefore, the presence of low and high volatility periods over the examined time interval constitutes an ideal setting for this analysis.

As a robustness check, qualitatively similar results are obtained by replacing VSTOXX with the historical volatility of the FTSE MIB index (the Italian main stock market index), estimated as the standard deviation of FTSE MIB index returns over the year preceding *t*.

5. Methodology and descriptive statistics

To test hypothesis *H1*, the following model is estimated for loans granted by SA and IRB lenders, separately:

$$Rate_{ijt} = \beta_1 Public_{it} + \beta_2 Public \cdot VSTOXX_{it} + \gamma Relationship_{ijt} + \eta Borrower_{it-1} + \delta_{jt} + \varepsilon_{ijt} \quad (1)$$

The dependent variable, *Rate*, is the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. *Public* is a dummy variable equal to 1 if the firm *i* is listed in *t* and to 0 otherwise. In line with previous studies mentioned in Section 2.3, I expect to find a negative coefficient of this variable both for SA and for IRB loans.

The main variable of interest, *Public·VSTOXX*, is the interaction between *Public* and *VSTOXX*, which is equal to the value of the VSTOXX index at the end of the quarter *t-1*.[17] Consistent with *H1*, the coefficient of this variable for IRB loans should be significant and positive. In contrast, the coefficient of *Public·VSTOXX* is expected to be not significant for loans granted by SA banks.

The main model specification also includes bank-quarter fixed effects (δ_{jt}), which control for bank-level unobserved heterogeneity in each quarter. They also absorb the impact of the variable *VSTOXX*, which therefore does not appear in Eq. (1).

Moreover, two vectors of control variables are added. First, the potential effects of bank-firm relationships (vector *Relationship*) is taken into account by introducing two variables: *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*; *RelDuration*, a dummy equal to 1 if the bank-firm relationship started at least in the year before *t*. A higher value of both variables indicates stronger bank-firm relationships.

Second, the borrower's characteristics are controlled by adding the vector *Borrower* in Eq. (1). It includes firms' accounting data (*Size*, *Leverage*, *Fixed Assets*, *EBITDA*, *IntCovRatio*) as well as

[17] The results are robust to adopting alternatively the value of the VSTOXX index at the end of the quarters *t-2*, *t-3*, and *t-4*.

Industry Dummies (indicator variables for the industry of firm *i* based on 2-digit ATECO).[18] This vector takes also into account a measure of the borrower's credit risk, *HighRisk*, estimated as a dummy variable equal to 1 if the credit score assigned by Cerved to firm *i* in the year preceding *t* is greater than six and 0 otherwise.[19]

The model described in Eq. (2) is estimated to test hypothesis *H2*:

$$Rate_{ijt} = \beta_1 Public_{it} + \beta_2 Public \cdot VSTOXX_{it} + \beta_3 Public \cdot HighBankCapital_{ijt} + \beta_4 Public \cdot VSTOXX \cdot HighBankCapital_{ijt} + \gamma Relationship_{ijt} + \eta Borrower_{it-1} + \delta_{jt} + \varepsilon_{ijt} \quad (2)$$

This model also includes the variable *HighBankCapital*, a dummy variable equal to 1 if the bank *j* has a capital ratio above the 75th percentile[20] of the distribution of capital ratios[21] in the year preceding *t* and 0 otherwise. Given the inclusion of bank-quarter fixed effects, the variable *HighBankCapital* does not appear in Eq. (2). The main focus is the triple interaction *Public·VSTOXX·HighBankCapital*. Consistent with *H2*, this variable is expected to have a significant and negative impact on interest rates only for loans granted by IRB banks.

Table A.1 in the Appendix presents the complete list of variables with their relative sources.

5.1. Descriptive statistics

Table 2 shows a set of descriptive statistics of public and private borrowers included in the sample (i.e. firms with access to market financing). Consistent with the literature on the loan cost advantage of public and private companies (Section 2.3), the average interest rate is lower for public borrowers than for private ones.

Public firms are significantly larger and have lower leverage than private companies. However, private borrowers included in the sample have better credit scores and greater accounting ratios. As regards the vector *Relationship*, private companies have slightly stronger bank-firm relationships, examining both the share of total credit and the duration. The variable *RelDuration* indicates that new bank-firm relationships are less than 10 per cent of the loans included in the sample, both for

[18] Unreported analyses show that the results are robust to controlling for additional variables, such as the number of financing banks, the ratio of revolving loans to total loans at the bank-firm level, and a set of indicator variables for geographical area of the country.

[19] The credit score is an indicator of the probability of default that is computed annually by Cerved, following the Z-score methodology (Altman et al., 1994). The Z-score varies from 1 (safest) to 9 (riskiest). Therefore, following Sette and Gobbi (2015), the variable *HighRisk* indicates the firms with a Z-score above the median.

[20] The choice of this threshold is due to the significant asymmetry in the distribution of Italian bank capital ratios. Few banks have significantly low or high capital ratios, while the others have ratios close to the median. Consequently, the identification of a significant heterogeneity among banks requires the adoption of a relatively high threshold. The results are robust to considering higher threshold values.

[21] The capital ratio is estimated as the ratio of total regulatory capital to risk-weighted assets.

public and private borrowers. The characteristics of control variables remain constant both in low and high volatility periods.

The abovementioned differences between public and private borrowers motivate the inclusion of controlling variables in the main model and the adoption of a propensity score matching technique (Section 7.4).

6. Results

6.1. The impact of the IRB approach on loan rates for public and private firms

Table 3 reports the results obtained from the estimation of Eq. (1).[22] In column (1), the estimates obtained by examining the sample of SA loans show that the coefficient of *Public* is not significant, suggesting that the interest rates applied to public companies by SA banks are not significantly different from those charged to private firms. Probably, since SA banks adopt less sophisticated methods to evaluate the creditworthiness of their borrowers and they may rely more heavily on accounting measures. As a result, for credit granted by SA banks, the loan cost advantage of being public is not significant once borrower characteristics have been included. As regards the variable of interest, the interaction *Public·VSTOXX* does not have a significant impact on interest rates, consistent with *H1*.[23]

In contrast, the results presented in column (2) of Table 3, obtained with the sample of IRB loans, show that there is a clear-cut benefit for public firms: their cost of credit is on average 73 bps lower compared with private companies, as suggested by the coefficient of *Public*. Moreover, the interaction *Public·VSTOXX* has a positive and significant coefficient. As predicted by *H1*, this result implies that the loan cost advantage of being public depends on financial market conditions. An increase in VSTOXX of one standard deviation (about 8 units) raises interest rates by 31 bps more for public firms than for private companies.[24] Consequently, an increase of about 19 units in VSTOXX may potentially nullify the loan cost advantage of public borrowers.[25] At the same time, the results of this model imply that a reduction in financial instability raises the loan cost advantage of being public with the same magnitude.

As regards the effect of bank relationships, the coefficients of the two measures included in this vector (i.e. *Share* and *RelDuration*) have an opposite sign in both columns, implying that these variables might capture slightly different effects. The negative sign of *Share* indicates that a greater

[22] The following tables report robust standard errors. The results are robust to clustering at the firm level, the bank level, and the bank-firm level.
[23] As anticipated in Section 5, since the model includes bank-quarter fixed effects, it focuses on differential effects; while the level effect of *VSTOXX* is not estimated.
[24] Using the estimates in column (2): 8·0.039 = 0.312.
[25] Using the estimates in column (2): 0.731/0.039 = 18.74.

share of total credit held by the bank leads to a reduction in interest rates. This result may suggest the existence of evergreening practices. Indeed, banks may grant relatively "cheap" credit to a borrower to which they have a significant exposure in order to postpone the accounting of credit losses (Albertazzi and Marchetti, 2010). In contrast, the positive sign of *RelDuration* implies that longer bank-firm relationships are associated with greater loan rates, suggesting that banks may apply lower interest rates to new customers for commercial purposes. This result is consistent with the findings of Ioannidou and Ongena (2010), who find that firms switching to new banks obtain better contract terms.[26]

Other control variables have the expected signs, consistent with the literature. Both SA and IRB banks apply lower interest rates to borrowers with greater size, fixed assets, higher EBITDA, and better credit scores. Higher *Leverage* is associated with greater interest rates only in the model estimated by employing SA loans, while the interest coverage ratio (*IntCovRat*) does not significantly affect the cost of loans in both models when the credit score dummy (*HighRisk*) has been included.

Finally, column (3) of Table 3 presents the results obtained by employing the full sample (both IRB and SA loans) and by interacting *Public·VSTOXX* with *IRB* (a dummy variable equal to 1 if the bank *j* adopts the IRB approach in *t* and 0 otherwise).[27] The estimates obtained by including the triple interaction confirm previous findings.

Overall, the tests reported in this section are consistent with *H1* and confirm that the IRB approach has significantly raised the sensitivity of the loan cost advantage of public firms to financial market conditions.

Unreported analyses also verified whether the adoption of the IRB approach has an impact on the credit amount granted to public and private borrowers. This possibility is explored by using the quarterly change in the logarithm of the amount of total credit (revolving credit lines, term loans, loans backed by accounts receivables) granted by bank *j* to firm *i* as the dependent variable of Eq. (1). The coefficient of the interaction *Public·VSTOXX* is not statistically significant both for IRB and for SA loans.[28] These findings may suggest that IRB banks react to a worsening of financial market conditions mainly by adjusting interest rates instead of reducing credit quantity, at least in the short-term.

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[26] An unreported robustness check shows that the main findings remain unchanged also by interacting the *Relationship* variables with *VSTOXX*. This additional analysis documents that the level of financial instability does not affect the impact of relationship banking variables on loan rates in both subsamples.

[27] The variable *IRB* does not appear in the model because bank-quarter fixed effects absorb its impact.

[28] If Eq. (1) is estimated by using the quarterly change in the logarithm of the amount of revolving credit lines (instead of total credit) as the dependent variable, the results indicate that the credit quantity granted by IRB banks decreases relatively more for public borrowers than for private firms. However, the effect is economically small and the results do not hold employing other robustness checks.

6.2. Bank capitalization

As predicted by *H2*, the loan rates applied by less capitalized IRB banks to public firms may be more sensitive to financial market conditions. Table 4 shows the results of Eq. (2).[29] The main findings discussed in Section 6.1 remain unchanged both for SA loans, column (1), and for IRB ones, column (2). Moreover, the coefficient of the interaction *Public·HighBankCapital* is not significant in both columns. This suggests that banks with high capital ratios do not evaluate public firms differently than other lenders.

The results in column (2) show that *Public·VSTOXX·HighBankCapital* has a significant negative impact on interest rates only for loans granted by IRB banks. An increase in VSTOXX of one standard deviation (8 units) leads to a reduction in the loan cost advantage of public firms of 35 bps for loans granted by IRB banks with lower capital ratios, and of about 1 bp for loans granted by IRB banks with a capital ratio above the 75th percentile of the distribution.[30] These estimates imply that the loan rates applied to public borrowers by latter IRB banks are almost no sensitive to financial market conditions. It should be noted that the significance of *Public·VSTOXX·HighBankCapital* is low, probably because of the limited variability of capital ratios across IRB banks and over time. However, keeping this caveat in mind, the results suggest that more capitalized IRB financial institutions are able to mitigate the reduction in the loan cost advantage of being public during high volatility periods.

By comparison, the estimates reported in column (1) show that the triple interaction between *Public*, *VSTOXX*, and *HighBankCapital* does not have a significant impact on the interest rates applied by SA banks. Overall, these findings support the hypothesis *H2*.

7. Robustness checks

The following sections present further robustness checks to confirm the validity of the main findings. The first test controls for the stock volatility of each public borrower. The second and the third sets of robustness checks focus on the heterogeneity of banks and borrowers, respectively. The fourth test presents an alternative sample restriction by adopting a propensity score matched sample.

The following robustness checks focus mostly on Eq. (1) (hypothesis *H1*). However, also the main findings related to hypothesis *H2* hold when the same tests, unreported for space considerations, are replicated by employing Eq. (2).

[29] The reduction in the number of observations is due to some missing in the time series of consolidated bank capital ratios.

[30] Using the estimates in column (1): if *HighBankCapital*=0, 8·0.044 = 0.352; if *HighBankCapital*=1, 8·(0.044-0.043) = 0.008.

7.1. The stock volatility of public firms

Hypothesis *H1* suggests that IRB banks incorporate a change in financial market conditions in their assessment of the public firms' creditworthiness. If *H1* holds, the sensitivity to the stock volatility of each borrower should be greater for interest rates on IRB loans than for those on SA ones. Therefore, the interest rates applied to public firms with higher stock volatility by IRB banks should be significantly greater than those charged by SA intermediaries.

To verify this implication of *H1*, Eq. (1) is estimated by employing the sample of IRB and SA loans granted only to public firms and by introducing *FirmVol*, the stock volatility of firm *i* estimated as the standard deviation of stock returns over the year prior to *t*, and the interaction *FirmVol·IRB*.

Table 5 presents the results of this test. Since the coefficient of *FirmVol* is not significant when controlling for borrowers' characteristics, the estimates indicate that firm stock volatility does not affect the interest rate applied by SA banks. In contrast, the coefficient of *FirmVol·IRB* is significant and positive, implying that the interest rates applied to public firms with higher stock volatility by IRB banks are significantly greater than those charged by SA banks. These findings are consistent with *H1* and strongly suggest that the adoption of the IRB approach has made loan rates for public firms significantly more market-oriented.

7.2. Bank heterogeneity

Notwithstanding the adoption of the IRB method is a voluntary decision of banks, an IRB lender cannot evaluate the borrowers in the same portfolio with different methods after the validation of the supervisors. In addition, it cannot immediately switch its approach after (or before) a worsening of quarterly financial market conditions. These elements minimize endogeneity concerns related to the choice of the regulatory approach. However, since only few large banks have decided to adopt internal models in Italy, IRB lenders may be significantly different from SA financial institutions. In the baseline model, bank heterogeneity is controlled by including bank-time fixed effects. However, this section presents three additional robustness checks to verify whether bank heterogeneity may drive the main findings.

(*i*) In the first test, the banks that have extended only IRB or SA loans are excluded from the sample. Therefore, this robustness check examines the subsample of SA banks that have adopted the IRB approach during the examined period, focusing on the discontinuity observed after the transition from the standardized approach to the IRB method. By exploiting the variation within banks, it is verified whether the main results are robust to examining the same lender that has granted both IRB and SA loans over the considered period.

Column (1) of Table 6 shows the results of Eq. (1) estimated by employing this subsample of banks. The model controls for the change in the adopted approach for each bank by including *IRB* and interacting this variable with *Public* and *Public·VSTOXX*. The results of this test confirm the main findings. Since the coefficient of *Public* is not significant, the interest rates on SA loans applied to public companies are not significantly different from those charged to private firms. Also the impact of *Public·VSTOXX* on loan rates is not significant, implying that the interest rates on SA loans for public firms are not sensitive to the financial market climate.

In contrast, the significant negative coefficient of *Public·IRB* indicates that, after the adoption of the IRB approach, the loan rates applied to public firms by these banks are relatively lower than those charged to private companies. Finally, the positive coefficient of *Public·VSTOXX·IRB* suggests that, for IRB loans, the loan cost advantage of public firms significantly decreases after a worsening of the financial market climate. Therefore, these findings are consistent with *H1*.

(*ii*) The second test verifies whether the results are robust to excluding the loans granted by the two major Italian banking groups. Both banks have adopted the IRB approach during the examined period. Given their relevance, the loan pricing of these lenders may drive the findings reported in previous sections. Column (2) of Table 6 shows the results of Eq. (1) estimated by employing the sample of SA and IRB loans without those granted by the two major Italian banking groups. The estimates indicate that the coefficient of *Public·VSTOXX·IRB* remains significant, confirming that the main findings are not exclusively due to the loan pricing of the major IRB banks. However, the considerable contribution of the two major banking group is witnessed by the lower significance of the triple interaction coefficient compared with that observed in column (3) of Table 3, which includes the loans granted by these intermediaries.

(*iii*) The third robustness check is a falsification test to mitigate potential concerns about structural differences in loan pricing across banks that are unrelated to the adopted regulatory approach. In this test the sample consists of loans granted between 2008 and 2012 by banks adopting SA throughout the entire period.[31] The model is estimated by replacing the variable *IRB* with *FutureIRB*, a dummy variable equal to 1 if the bank *j* has adopted the IRB approach after 2012 and 0 otherwise. Consequently, the IRB method is "imputed" to financial intermediaries that are still adopting the standardized approach in *t*.

Table 6 shows the results of Eq. (1) estimated by employing this sample and introducing the interactions *Public·FutureIRB* and *Public·VSTOXX·FutureIRB*. The coefficients of both variables are not significant, implying that the loan pricing in 2008-12 is not statistically different between the SA intermediaries that will change their approach after 2012 and the other SA banks. Therefore,

[31] The results are robust to considering also other time windows.

this result suggests that the main findings are strongly related to the approach adopted by banks and are not driven by characteristics observable before the regulatory method shift.

7.3. Borrower heterogeneity

This section addresses two potential issues deriving from (*i*) a different sample composition between periods of low and high volatility and (*ii*) firm sorting across IRB and SA banks.

(*i*) The characteristics of borrowers during periods of low financial market volatility may be significantly different from those observed in high volatility times. After a financial shock, for instance, banks might not extend credit to highly risky borrowers. In this case, risky firms will not be included in the analyzed sample during high volatility periods. The different sample composition between low and high volatility periods may affect the main findings.

To address this potential issue, Eq. (1) is estimated by considering a constant sample of borrowers that have received at least one IRB loan in both low and high volatility periods. In this analysis, a quarter is defined as a "low volatility period" if the VSTOXX value in the quarter *t-1* was lower than the 25th percentile of the distribution of the index over the examined period (2008-2018). In contrast, a quarter is defined as a "high volatility period" if the VSTOXX value in the quarter *t-1* was greater than the 75th percentile of the distribution of the index over the analyzed period.

Table 7 reports the results of this test. First, the model in column (1) considers all IRB loans extended to the constant sample of borrowers in all quarters. Second, the analysis in column (2) is restricted to the IRB loans granted to the constant sample only in low and high volatility quarters. The coefficient of *Public·VSTOXX* remains significant and positive in both analyses, suggesting that the results are robust to considering a different sample composition between low and high volatility periods.

(*ii*) The second set of tests addresses the bias related to the potential borrower sorting across the two groups of lenders. Indeed, the firm decision to borrow prevalently from IRB or SA banks may be endogenous and may be due to several characteristics that could also affect loan rates.

The first test examines only companies borrowing prevalently from IRB banks (i.e. those that receive a share of IRB credit greater than the median). Therefore, the sample of this analysis includes firms with similar choices in terms of lender type.

In addition, as argued in the literature (Repullo and Suarez, 2004), low-risk firms may tend to borrow mostly from IRB banks, while riskier companies may principally rely on SA ones. Also this sorting may affect the main findings: loan rates for riskier borrowers may have a limited upward variability because they are closer to the maximum loan rate (i.e. the usury threshold rate). To take

into account also this potential bias, the second exercise is restricted to firms borrowing prevalently from IRB banks and with a credit score greater than six (i.e. dummy *HighRisk* equal to 1).

Columns (1) and (2) of Table 8 show the results of both tests. Consistent with the main findings, the coefficient of *Public·VSTOXX* remains significant and positive by examining both companies borrowing prevalently from IRB banks (column 1) and riskier borrowers (column 2).

Finally, in order to tackle additional firm-related endogeneity bias, Eq. (1) is estimated by introducing firm-quarter fixed effects, which control for borrower-level unobserved heterogeneity in each quarter. In this model bank-quarter FE are excluded and the impact of the borrower control variables is absorbed by firm-quarter FE. The results reported in column (3) of Table 8 show that the coefficient of *Public·VSTOXX·IRB* is positive and significant, implying that the main findings are robust to employing this model specification.

7.4. Propensity score matching

As underlined in Section 5.1, public firms are significantly different from private companies. Observable and unobservable differences may affect the comparability between the loan rates applied to public and private borrowers. To address this issue, in the baseline model the sample of private firms is restricted to those with access to the bond market. However, this restriction excludes from the analysis the subsample of private firms without access to market financing, which is the most common type of borrower in the Italian economic system.

This section presents an alternative sample restriction that allows including also previously excluded firms. A technique based on the propensity score matching (Heckman et al., 1997; Rosenbaum and Rubin, 1983) is employed to compare listed companies and the overall sample of unlisted firms (private companies with or without access to the bond market). The adoption of this method allows examining firms that have a similar propensity to being public, mitigating potential endogeneity issues associated with the significant differences between public and private borrowers' characteristics.

First, the quarters in which the VSTOXX value is lower than the median over the examined period are separated from those in which the VSTOXX value is greater than the median. The firms that have not received at least one loan in both periods (i.e. when the VSTOXX index is above or below the median) are excluded from the sample.[32] This allows examining a constant sample of borrowers.

[32] This analysis does not adopt the 25th and 75th percentiles as the threshold values for not reducing excessively the number of available observations for the matching procedure.

In this analysis the treated units are companies listed on the stock market (public borrowers). In contrast, the control group consists of unlisted firms (private borrowers). The propensity score of each firm is estimated by using *Public* as the dependent variable and *Borrower Variables* as independent ones.[33] Afterward, the nearest-neighbor matching is applied. Each loan to a treated firm in a period in which the VSTOXX was below the median is matched with the nearest-neighbor loan, in terms of its propensity score, granted to a control company in the same period. Finally, loans granted to firms without a match are excluded. The balancing properties for the main variables of interest, presented in Table A.3 in the Appendix, suggest that the matching procedure has significantly reduced the differences in mean between public and private firms.

Table 9 reports the estimates of Eq. (1) obtained by adopting the matched sample of borrowers. Columns (1) and (2) show the results for the sample of loans granted by SA and IRB banks, respectively. The main findings remain unchanged also by adopting this sample. The interaction variable *Public·VSTOXX* does not have a significant impact on loan rates charged by SA banks. In contrast, for loans granted by IRB banks, an increase in financial market volatility leads to a rise in interest rates significantly greater for treated public firms than for control private companies.

8. Conclusions

This paper examines the impact of bank capital regulation on the loan cost difference between public and private firms. The main findings indicate that the adoption of the IRB approach has made loan rates significantly more market-oriented for public firms. For credit granted by IRB banks, public firms benefit from a significant loan cost advantage with respect to private companies when the level of financial instability is low. However, a worsening of financial market conditions reduces the cost advantage of being public, leading to a rise in interest rates on IRB loans greater for public firms than for private ones. The analysis documents that the negative impact of financial instability on the loan cost advantage of public borrowers is significantly greater if the IRB bank has a lower capital ratio, suggesting that the main effect described in the analysis is mostly determined by banks that kept smaller capital buffers over the regulatory minimum.

In contrast, for credit granted by SA banks, public borrowers do not benefit from a significant loan cost advantage compared with private ones and a change in financial market conditions has a statistically similar effect on the borrowing costs of both types of companies.

The results are robust to considering the heterogeneity of banks and borrowers and using a matched sample.

[33] This model does not include *IntCovRatio* in the set of independent variables because the coefficient of this variable is not significant in the propensity score equation.

A caveat of this analysis is that the sample includes a limited number of borrowers. This restriction is common in the literature on public companies in European countries because only a small fraction of the firm population is listed on a stock exchange.

With due caution given the sample characteristics, the upside of these findings is that a market-oriented pricing of loans may lead to a more efficient allocation of resources in the financial system (Norden and Wagner, 2008). On the other hand, the main risk associated with market-based loan rates is that adverse shocks to financial markets may induce more volatility into public firms' borrowing costs, increasing the cost of bank credit and, in turn, worsening their financial conditions (Ivanov et al., 2016). Increasing dependence of loan rates for public borrowers on financial market conditions may reduce the stabilizing influence over the business cycle of bank credit, which is generally less sensitive to macroeconomic conditions than market financing (Norden and Wagner, 2008). As a result, this effect may reduce the net benefits of listing, decreasing the propensity of going or remaining public as predicted by the model of Doidge et al. (2017).

Given the potential implications associated with the adoption of the IRB approach, the results of this work support the orientation of regulators to enhance the scrutiny of internal models (BCBS, 2017).[34] Finally, the analysis highlights that bank capital plays a crucial role in reducing the transmission of unexpected shocks to borrowers. Indeed, large capital buffers allow IRB banks to offset almost completely the volatility in loan rates for public borrowers during uncertain financial market conditions.

[34] The reform constrains the use of internal models for large corporates and it also introduces "input floor" values for bank-estimated IRB parameters. The new framework will be implemented on 1 January 2023.

Appendix

Table A.1

Variables description.

Variable	Description	Source
Dependent Variable		
Rate	Interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*.	CR
Key Explanatory Variables		
Public	Dummy variable equal to 1 if the firm *i* is listed in *t* and 0 otherwise.	Cerved
VSTOXX	Value of the VSTOXX index at the end of the quarter *t-1*.	Datastream
HighBankCapital	Dummy variable equal to 1 if the bank *j* has a capital ratio above the 75th percentile of the distribution of capital ratios in the year preceding *t* and 0 otherwise.	Supervisory Reports
IRB	Dummy variable equal to 1 if the bank *j* adopts the IRB approach in *t* and 0 otherwise.	Supervisory and Pillar 3 information
FirmVol	The stock volatility of firm *i* estimated as the standard deviation of stock returns over the year prior to *t*.	Datastream
FutureIRB	Dummy variable equal to 1 if the bank *j* has adopted the IRB approach after 2012 and 0 otherwise.	Supervisory and Pillar 3 information
Relationship 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*.	CR
RelDuration	Dummy equal to 1 if the bank-firm relationship started at least in the year before *t*.	CR
Borrower Variables		
Size	Logarithm of the total assets of firm *i* in the year preceding *t*.	Cerved
HighRisk	Dummy variable equal to 1 if the credit score assigned by Cerved to firm *i* in the year preceding *t* is greater than six and 0 otherwise.	Cerved
Leverage	Ratio of total debt divided by the book value of assets of the firm *i* in the year preceding *t*.	Cerved
Fixed Assets	Ratio of fixed assets to total assets of the firm *i* in the year preceding *t*.	Cerved
EBITDA	Ratio of EBITDA to total assets of the firm *i* in the year preceding *t*.	Cerved
IntCovRatio	Ratio of EBITDA to interest expense of the firm *i* in the year preceding *t*.	Cerved
Industry Dummies	Indicator variables for the industry of firm *i* based on 2-digit ATECO.	Cerved

Table A.2

Balancing test: pre and post-matching *t*-test differences between public and private firms.

	Pre-matching	Post-matching
Size	3.17***	0.07
	(0.00)	(0.18)
HighRisk	-0.04***	0.02
	(0.00)	(0.20)
Leverage	-0.11***	-0.01*
	(0.00)	(0.06)
Fixed Assets	-0.12***	-0.01
	(0.00)	(0.90)
EBITDA	-0.02***	-0.01
	(0.00)	(0.59)

Differences in mean with respect to the group of control companies. ***, **, and * denote significance at the 1%, 5%, and 10% level in a *t*-test for means (*p*-values in parentheses).

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Tables and figures

Figure 1

The quarterly time series of the VSTOXX index between 2008Q1 and 2018Q2.

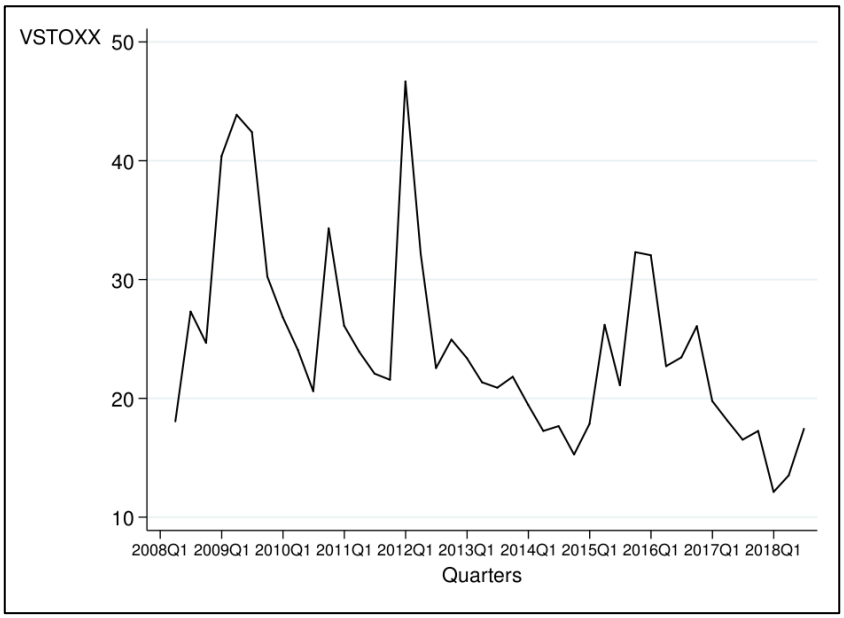

Table 1

Bank-firm relationships included in the sample.

	Public Firms	Private Firms
Share of relationships with IRB banks	41.47%	44.88%
Share of credit granted by IRB banks	57.06%	52.28%

Table 2

Summary statistics comparing public and private firms.

Variable	Public Firms			Private Firms			Differences	
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	Diff. in mean[1]	Diff. in median[2]
Rate (*%*)	8.44	7.48	4.02	8.85	8.23	3.76	-0.41***	-0.74***
VSTOXX	26.23	24.06	8.33	25.70	23.38	8.29	0.54***	0.67***
HighBankCapital	0.23	0.00	0.42	0.23	0.00	0.42	0.01	0.00
Share	0.14	0.09	0.15	0.16	0.11	0.15	-0.02***	-0.02***
RelDuration	0.91	1.00	0.29	0.93	1.00	0.25	-0.03***	0.00***
Size (*ln*)	12.02	11.89	1.89	10.57	10.52	1.08	1.45***	1.37***
HighRisk	0.63	1.00	0.48	0.59	1.00	0.49	0.03***	0.00***
Leverage	0.70	0.70	0.23	0.77	0.77	0.23	-0.06***	-0.07***
FixedAsset	0.13	0.07	0.16	0.28	0.22	0.25	-0.15***	-0.15***
EBITDA	0.02	0.02	0.08	0.03	0.04	0.07	-0.01***	-0.01***
IntCovRat	1.87	1.22	9.04	2.06	1.77	5.99	-0.20**	-0.55***

[1] *** Significant at 1%, ** significant at 5%, * significant at 10% in a *t*-test for means.
[2] *** Significant at 1%, ** significant at 5%, * significant at 10% in a Pearson χ^2 test for medians.

Table 3

The interest rates applied to public and private firms by SA and IRB banks.

	(1) *SA banks*	*(2)* *IRB banks*	*(3)* *All banks*
Public	0.203	-0.731***	0.291
	(0.397)	(0.005)	(0.211)
Public·VSTOXX	0.004	0.039***	0.004
	(0.655)	(0.000)	(0.607)
Public·IRB	-	-	-1.099***
			(0.001)
Public·VSTOXX·IRB	-	-	0.034***
			(0.007)
Share	-1.940***	-1.007***	-1.494***
	(0.000)	(0.000)	(0.000)
RelDuration	0.347**	0.527**	0.412***
	(0.016)	(0.031)	(0.001)
Size	-0.503***	-0.642***	-0.563***
	(0.000)	(0.000)	(0.000)
HighRisk	0.815***	0.976***	0.898***
	(0.000)	(0.000)	(0.000)
Leverage	0.664***	0.138	0.402***
	(0.000)	(0.409)	(0.001)
FixedAsset	-0.263*	-0.291*	-0.271***
	(0.060)	(0.058)	(0.009)
EBITDA	-2.521***	-1.402**	-1.986***
	(0.000)	(0.011)	(0.000)
IntCovRat	0.009	-0.003	0.003
	(0.142)	(0.544)	(0.378)
Industry dummies	*Yes*	*Yes*	*Yes*
Bank-quarter FE	*Yes*	*Yes*	*Yes*
Observations	16056	13850	29906
Adj R-squared	0.167	0.149	0.160

The table shows the results obtained from the estimation of Eq. (1) by analyzing loans granted by SA banks, in column (1), and those granted by IRB banks, in column (2). Column (3) presents the results of Eq. (1) estimated by employing the full sample of loans and by introducing the interaction variables *Public·IRB* and *Public·VSTOXX·IRB*. The dependent variable is *Rate*, the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 4

The effect of bank capitalization on the interest rates applied to public and private firms by SA and IRB banks.

	(1) *SA banks*	*(2)* *IRB banks*
Public	-0.071	-0.765**
	(0.812)	(0.023)
Public·VSTOXX	0.012	0.044***
	(0.286)	(0.000)
Public·HighBankCapital	1.155	0.650
	(0.175)	(0.307)
Public·VSTOXX·HighBankCapital	-0.026	-0.043*
	(0.324)	(0.094)
Share	-1.799***	-1.033***
	(0.000)	(0.000)
RelDuration	0.250	0.426
	(0.138)	(0.115)
Size	-0.507***	-0.682***
	(0.000)	(0.000)
HighRisk	0.763***	0.971***
	(0.000)	(0.000)
Leverage	0.641***	0.095
	(0.000)	(0.593)
FixedAsset	-0.058	-0.241
	(0.709)	(0.142)
EBITDA	-2.720***	-1.262**
	(0.000)	(0.045)
IntCovRat	0.016	0.002
	(0.152)	(0.740)
Industry dummies	*Yes*	*Yes*
Bank-quarter FE	*Yes*	*Yes*
Observations	13163	12026
Adj R-squared	0.157	0.147

The table shows the results obtained from the estimation of Eq. (2) by analyzing loans granted by SA banks, in column (1), and those granted by IRB banks, in column (2). The dependent variable is *Rate*, the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 5

The interest rates applied to public firms on SA and IRB loans by considering firm stock volatility.

	(1)
	Public firms
FirmVol	-0.306
	(0.283)
FirmVol·IRB	0.823**
	(0.035)
Share	-2.158***
	(0.000)
RelDuration	0.218
	(0.404)
Size	-0.664***
	(0.000)
HighRisk	0.135
	(0.317)
Leverage	0.431
	(0.101)
FixedAsset	-1.562***
	(0.000)
EBITDA	-1.206
	(0.183)
IntCovRat	0.006
	(0.340)
Industry dummies	*Yes*
Bank-quarter FE	*Yes*
Observations	5747
Adj R-squared	0.202

The table presents the results of Eq. (1) estimated by employing a sample of IRB and SA loans granted only to public firms and introducing *FirmVol* and the interaction *FirmVol·IRB*. The dependent variable is *Rate*, the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 6

The interest rates applied to public and private firms on SA and IRB loans by considering bank heterogeneity.

	(1) *Subsample of banks*	*(2)* *Excl. major bank. groups*	*(3)* *Falsification test*
Public	0.362	0.197	0.702
	(0.341)	(0.408)	(0.105)
Public·VSTOXX	-0.009	0.005	-0.002
	(0.492)	(0.571)	(0.905)
Public·IRB	-1.486***	-1.070**	-
	(0.002)	(0.015)	
Public·VSTOXX·IRB	0.054***	0.031*	-
	(0.001)	(0.060)	
Public·FutureIRB	-	-	-0.255
			(0.667)
Public·VSTOXX·FutureIRB	-	-	0.002
			(0.924)
Share	-1.278***	-1.759***	-1.813***
	(0.000)	(0.000)	(0.000)
RelDuration	0.392*	0.389***	0.187
	(0.055)	(0.003)	(0.307)
Size	-0.614***	-0.544***	-0.566***
	(0.000)	(0.000)	(0.000)
HighRisk	0.978***	0.866***	0.990***
	(0.000)	(0.000)	(0.000)
Leverage	0.307*	0.277**	0.719***
	(0.051)	(0.042)	(0.008)
FixedAsset	-0.779***	-0.401***	-0.242
	(0.000)	(0.001)	(0.224)
EBITDA	-1.116**	-2.445***	-3.910***
	(0.028)	(0.000)	(0.000)
IntCovRat	-0.002	0.012*	0.056***
	(0.666)	(0.055)	(0.000)
Industry dummies	*Yes*	*Yes*	*Yes*
Bank-quarter FE	*Yes*	*Yes*	*Yes*
Observations	14984	22314	8928
Adj R-squared	0.153	0.157	0.182

Column (1) presents the results of Eq. (1) estimated by employing SA and IRB loans granted by a subsample of banks and by introducing the interaction variables *Public·IRB* and *Public·VSTOXX·IRB*. Column (2) presents the results of Eq. (1) estimated by employing the sample of SA and IRB loans without those granted by the two major Italian banking groups and by introducing the interaction variables *Public·IRB* and *Public·VSTOXX·IRB*. Column (3) shows the results of Eq. (1) estimated by employing loans granted between 2008 and 2012 by banks adopting SA throughout the entire period. The model includes the interaction variables *Public·FutureIRB* and *Public·VSTOXX·FutureIRB*. The dependent variable is *Rate*, the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7

The interest rates applied on IRB loans to a constant sample of public and private firms.

	(1) *Constant sample*	*(2)* *Low and high vol. periods*
Public	-1.072***	-1.366***
	(0.000)	(0.001)
Public·VSTOXX	0.052***	0.060***
	(0.000)	(0.000)
Share	-1.268***	-1.289***
	(0.000)	(0.000)
RelDuration	1.046***	1.130***
	(0.000)	(0.008)
Size	-0.703***	-0.711***
	(0.000)	(0.000)
HighRisk	0.874***	0.830***
	(0.000)	(0.000)
Leverage	-0.219	-0.093
	(0.208)	(0.701)
FixedAsset	-0.466***	-0.356
	(0.003)	(0.158)
EBITDA	-1.020	-0.679
	(0.103)	(0.494)
IntCovRat	-0.001	0.003
	(0.890)	(0.791)
Industry dummies	*Yes*	*Yes*
Bank-quarter FE	*Yes*	*Yes*
Observations	12151	5112
Adj R-squared	0.161	0.172

The table shows the results obtained from the estimation of Eq. (1) by considering a constant sample of borrowers that have received at least one IRB loan in both low and high volatility periods. In column (1) the model is estimated by considering all IRB loans extended to the constant sample of borrowers. In column (2) the model is estimated by considering only IRB loans granted in low and high volatility periods. The dependent variable is *Rate*, the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 8

The interest rates applied to public and private firms by considering borrower heterogeneity.

	(1) *Prev. IRB Borr.*	*(2)* *Prev. IRB HR Borr.*	*(3)* *Firm-quarter FE*
Public	-0.945***	-1.930***	-
	(0.005)	(0.000)	
Public·VSTOXX	0.052***	0.065***	-
	(0.000)	(0.000)	
IRB	-	-	1.780***
			(0.000)
IRB·VSTOXX	-	-	-0.039***
			(0.000)
Public·IRB	-	-	-1.098***
			(0.001)
Public·VSTOXX·IRB	-	-	0.030***
			(0.008)
Share	-1.117***	-1.041***	-0.655***
	(0.000)	(0.004)	(0.000)
RelDuration	1.087***	0.729*	0.473***
	(0.000)	(0.089)	(0.000)
Size	-0.637***	-0.733***	-
	(0.000)	(0.000)	
HighRisk	1.009***	-	-
	(0.000)		
Leverage	-0.065	-0.366	-
	(0.746)	(0.137)	
FixedAsset	0.345	-0.036	-
	(0.109)	(0.906)	
EBITDA	-0.082	-3.417**	-
	(0.913)	(0.011)	
IntCovRat	-0.001	0.056**	-
	(0.931)	(0.011)	
Industry dummies	*Yes*	*Yes*	*No*
Bank-quarter FE	*Yes*	*Yes*	*No*
Firm-quarter FE	*No*	*No*	*Yes*
Observations	8150	4778	29906
Adj R-squared	0.138	0.155	0.343

Column (1) shows the results obtained from the estimation of Eq. (1) by considering only IRB loans granted to borrowers that receive a share of credit from IRB banks greater than the median. The estimates in column (2) take into account only IRB loans granted to high-risk borrowers (i.e. a credit score greater than six) that receive a share of credit from IRB financial institutions greater than the median. Column (3) shows the results of Eq. (1) estimated by introducing firm-quarter fixed effects. The dependent variable is *Rate*, the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 9

The interest rates applied to a matched sample of public and private firms.

	(1) *SA banks*	*(2)* *IRB banks*
Public	-0.094	-1.282***
	(0.722)	(0.000)
Public·VSTOXX	0.006	0.047***
	(0.521)	(0.000)
Share	-2.273***	-1.011***
	(0.000)	(0.000)
RelDuration	0.183	0.163
	(0.142)	(0.488)
Size	-0.601***	-0.647***
	(0.000)	(0.000)
HighRisk	0.925***	0.985***
	(0.000)	(0.000)
Leverage	0.208	0.113
	(0.225)	(0.525)
FixedAsset	-1.236***	-1.142***
	(0.000)	(0.000)
EBITDA	-0.819***	-0.502**
	(0.000)	(0.014)
IntCovRat	-0.001*	-0.001
	(0.077)	(0.932)
Industry dummies	*Yes*	*Yes*
Bank-quarter FE	*Yes*	*Yes*
Observations	17415	13197
Adj R-squared	0.153	0.129

The table shows the results obtained from the estimation of Eq. (1) by adopting the matched sample of loans granted by SA banks, in column (1), and those granted by IRB banks, in column (2). The dependent variable is *Rate*, the interest rate on revolving credit lines granted by bank *j* to firm *i* on quarter *t*. Robust *p*-values in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

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