Credit Risk Taking and Maturity Mismatch: the Role of the Yield Curve

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The opinions expressed in this presentation do not necessarily reflect those of the Bank of Italy
**Stylized facts on the yield curve**

- **Short-term interest rates and slope of the yield curve**
  - 2003-2011: correlation is high and negative
  - 2011-2017 (Low Interest Rate Environment, LIRE): correlation small and/or positive
Motivation

- Wide debate on financial stability on current LIRE, related to
  - banks’ profitability
  - risk-taking in banks’ portfolio (loans & securities)

- The objective is to
  - investigate the determinants of banks’ credit risk taking
  - assess the implication of a LIRE on banks’ credit risk taking
  - derive some implications of UMPs on banks’ credit risk taking

- In particular we address the following two questions:
  - Does banks’ risk taking depend on short term-interest rates and/or on the slope the yield curve?
  - What role for the banks’ business model (in terms of maturity mismatch) & capital?
Empirical literature on banks’ risk-taking

Role of the term structure

Lower short-term interest rates

- Higher lending to riskier borrowers (Jimenez et al., 2014; Ioannidu et al., 2015; Dell’Ariccia et al., 2017; Bonfim and Soares, 2018)
- Lower interest rates to riskier firms (Poligorova and Santos, 2017)
- Softer lending standards (Maddaloni and Peydrò, 2011)
- Larger portfolio risk (Altunbas et al., 2010; Delis and Kouretas, 2011)
- Substitution between loans and securities (Peydrò, Polo and Sette, 2018).

Role of bank capital

Lower short-term interest rates

- *more capitalized* banks take *more risk* (Dell’Ariccia et al., 2017)
- *less capitalized* banks take *more risk* (Jimenez et al., 2014)

Larger amount of CB reserves

- *more capitalized* banks take *more risk* (Peydrò, Polo and Sette, 2018)
Theoretical literature on banks’ risk-taking

Banks’ maturity mismatch and expected effect of yield curve on risk taking

<table>
<thead>
<tr>
<th>Duration Gap</th>
<th>&gt;0</th>
<th>&lt;0</th>
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<tbody>
<tr>
<td>Slope</td>
<td>+</td>
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</table>

Risk taking channel of monetary policy

Risk-taking depends **positively** on the **slope of the yield curve**:

- *Adrian and Shin (2011)*: **profitability** of financial firms with DG>0 **benefits** from steeper yield curve. They *reach-for-yield* to increase leverage.

- *Rajan (2005)*: **profitability** of financial firms with DG<0 **suffers** from steeper yield curve. They *search-for-yield* to sustain their profitability.
Theoretical literature on banks’ risk-taking

Banks’ maturity mismatch and expected effect of yield curve on risk taking

<table>
<thead>
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<th>Risk taking channel of monetary policy</th>
<th>Monitoring Moral hazard</th>
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<tr>
<td>Slope</td>
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</table>

Banking literature on moral hazard and monitoring:

For financial firms with $DG>0$ ($DG<0$) risk-taking depends positively (negatively) on the slope of the yield curve

- Allen et al. (2011) and Dell’Ariccia et al. (2014): monitoring incentives depend positively on the spread between loan and deposit rates (i.e. negatively on profitability)
Theoretical literature on banks’ risk-taking

Banks’ maturity mismatch, capital and expected effect of yield curve on risk taking

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<tr>
<td>Slope*Capital</td>
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</tbody>
</table>

Risk taking channel of monetary policy

- **Role bank capital**: Measure of banks’ ability to expand credit supply
- **For both type of banks**, the **higher** the capital, the **larger** the increase in risk-taking in response to a **steepening** of the yield curve.
Theoretical literature on banks’ risk-taking

Banks’ maturity mismatch, **capital** and expected effect of yield curve on risk taking

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<td>Slope</td>
<td>+</td>
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<td></td>
<td>+</td>
</tr>
<tr>
<td>Slope*Capital</td>
<td>+</td>
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</tr>
</tbody>
</table>

Banking literature on moral hazard and monitoring

- **Role bank capital:** Inverse measure of banks’ exposure to asymmetric information problems

- For banks with $\text{DG}>0$, the **lower** the capital, the **larger** the increase in **risk-taking** in response to a **flattening** of the **yield curve**.

- For banks with $\text{DG}<0$, the **lower** the capital, the **larger** the increase in **risk-taking** in response to a **steepening** of the **yield curve**.
**Theoretical literature on banks’ risk-taking**

Banks’ maturity mismatch, *capital* and expected effect of yield curve on risk taking

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</tr>
</thead>
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<td>&lt;0</td>
</tr>
<tr>
<td>Slope</td>
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<td>+</td>
</tr>
<tr>
<td>Slope Capital</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
The dataset

- **Bank-firm panel data for Italy, sample period 2005-2016**
  - *Cerved*: firm rating (1-9) as measure of *ex-ante* credit risk and info about location and sector of economic activity (annual data)
  - *Italian Credit Register (TAXIA)*: bank-firm data about new loans conditions (quarterly data, 200 Italian banks + 10 branches and subsidiaries of foreign banks), which include size of granted loan, cost and maturity of the loan, repricing date of the loan.
  - *Supervisory Reports*: banks’ balance sheet indicators, which include consolidated (Duration Gap, Tier1 capital) and unconsolidated (deposit ratio, NPL ratio, liquidity ratio) data
  - *Macroeconomic variables*: short-term (EONIA) and long-term (IRS 10Y) interest rates, 10Y spread Italian government bond and German Bund, inflation and GDP Italy and euro area, others.
Ex-ante credit risk: why CERVED?

- In 2008, Cerved obtained recognition of external agency for evaluation of creditworthiness from the Bank of Italy.
- Some tradition in research analysis at the Bank of Italy:
  - Heterogeneity of credit supply conditions across firms: Albareto and Finaldi Russo (2012); Bonaccorsci and Finaldi Russo (2016);
  - Testing “Zombie-lending” following a credit supply shock: Albertazzi and Marchetti (2008); Schivardi, Sette and Tabellini (2017)

Empirical distribution of firm rating
Banks’ business model: The duration gap

Duration gap in the banking book as a measure of maturity mismatch between assets and liabilities (and interest rate risk)

- Consider both on-balance and off-balance sheet items
- Consider both maturity and repricing date of assets & liabilities
- Simplified methodology vs. internal models could be an issue

FIGURE 2. Developments in banks’ duration gap
(half-yearly observations)

<table>
<thead>
<tr>
<th>(a) Ratio of banks’ exposure to interest rate risk over tier1 capital</th>
<th>(b) Number of banks with positive vs. negative duration gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
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<tr>
<td>6</td>
<td>40</td>
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<tr>
<td>4</td>
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<tr>
<td>2</td>
<td>20</td>
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<tr>
<td>0</td>
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<tr>
<td>-2</td>
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<tr>
<td>-4</td>
<td>-10</td>
</tr>
<tr>
<td>-6</td>
<td>-20</td>
</tr>
<tr>
<td>-8</td>
<td>-30</td>
</tr>
</tbody>
</table>

- banks with duration gap > 0
- banks with duration gap < 0
- all banks


banks with duration gap > 0
banks with duration gap < 0
Banks’ business model: The duration gap

Correlation between duration gap and other banks’ characteristics (Tier1 capital, deposit ratio, NPL ratio, liquidity ratio) is very low,

- thus suggesting that the bank duration gap has independent information content with respect to the other banks’ features

![Figure 3. Cross-section correlation (half-yearly observations)](chart-image)
Methodology

We run two different regressions (not directly comparable) providing complementary information about banks’ risk-taking:

1. Effects on new loan rating class (Dell’Ariccia et al., 2017):

\[
\text{risk}_{i(j)t} = \omega_{ij} + \beta X_{jt} + \gamma Z_t + \rho Y_{ijt} + \alpha_1 \text{Eonia}_t + \alpha_2 10y\text{IRS}_t + \varepsilon_{ijt} \quad (1)
\]

2. Effects on the (log) amount of new lending lending (Jimenez et al., 2014):

\[
\ln(\text{new_lending})_{ijt} = \omega_{ij} + T_t + \beta X_{jt} + \rho Y_{ijt} + \\
\alpha_0 \text{risk}_{i(j)t} + \alpha_1 (\text{Eonia}_t \times \text{risk}_{i(j)t}) + \alpha_2 (10y\text{IRS}_t \times \text{risk}_{i(j)t}) + \varepsilon_{ijt} \quad (2)
\]

\text{risk}_{i(j)t} : \text{rating of firm i in bank-firm relationship (i,j) at time t}

Empirical test:

- $\alpha_1 < 0$ is evidence of risk-taking when the short-term rate is low
- $\alpha_2 < 0$ is evidence of risk-taking when long-term rate is low
## Main results: short-term rate vs. slope

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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</thead>
<tbody>
<tr>
<td><strong>Dependent variable: rating class of new loan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eonia rate</td>
<td>-0.1204***</td>
<td>-0.1243***</td>
<td>-0.0632***</td>
<td>-0.0298***</td>
<td>-0.0196***</td>
</tr>
<tr>
<td>10-year Eurirs rate</td>
<td>0.0157</td>
<td>0.0458***</td>
<td>0.0649***</td>
<td></td>
<td><strong>0.0564</strong>***</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Firm zip-code*sector fixed effects</td>
<td>no</td>
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<td>yes</td>
<td>no</td>
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<tr>
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<td>yes</td>
</tr>
<tr>
<td>Observations</td>
<td>2,498,790</td>
<td>2,498,790</td>
<td>2,446,268</td>
<td>2,375,238</td>
<td>2,131,448</td>
</tr>
<tr>
<td>Number of banks</td>
<td>144</td>
<td>144</td>
<td>144</td>
<td>144</td>
<td>143</td>
</tr>
<tr>
<td>Number of firms</td>
<td>359,111</td>
<td>359,111</td>
<td>313,917</td>
<td>235,559</td>
<td>205,307</td>
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<tr>
<td>Adjusted R-squared</td>
<td>0.096</td>
<td>0.096</td>
<td>0.524</td>
<td>0.723</td>
<td>0.764</td>
</tr>
</tbody>
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<tr>
<td><strong>Dependent variable: (log) amount new lending for different rating classes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm rating</td>
<td>-0.0542***</td>
<td>-0.1166***</td>
<td>-0.0639***</td>
<td>-0.0431***</td>
<td>-0.0316***</td>
</tr>
<tr>
<td>Eonia rate * Firm rating</td>
<td>-0.0101***</td>
<td>-0.0126***</td>
<td>-0.0044***</td>
<td>-0.0013</td>
<td>-0.0012</td>
</tr>
<tr>
<td>10-year Eurirs rate * Firm rating</td>
<td>0.0109***</td>
<td>0.0086***</td>
<td><strong>0.0084</strong>***</td>
<td></td>
<td></td>
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<tr>
<td>(Year:quarter) fixed effects</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<td>235,559</td>
<td>205,307</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.192</td>
<td>0.192</td>
<td>0.547</td>
<td>0.672</td>
<td>0.754</td>
</tr>
</tbody>
</table>
## Banks’ business model: Positive vs. negative duration gap

| Dependent variable: rating class of new loan | | | | |
|---------------------------------------------|
| | duration gap > 0 | duration gap < 0 | | |
| (1) | (2) | (3) | (4) | |
| Eonia rate | -0.0261*** | -0.0182** | -0.0291*** | -0.0089 |
| 10-year Eurirs rate | 0.0665*** | 0.0612*** | 0.0675*** | 0.0531*** |
| Firm rating | 0.0021 | 0.0032 | -0.0034* | -0.0039* |
| Eonia rate * Firm rating | 0.0100*** | 0.0090*** | 0.0069** | 0.0070*** |
| 10-year Eurirs rate * Firm rating | 0.0070*** | 0.0069** | -0.0039* | -0.0034* |

| Bank fixed effects | yes | - | yes | - |
| Firm fixed effects | yes | - | yes | - |
| Firm*Bank fixed effects | - | yes | - | yes |
| (Year:quarter) fixed effects | - | - | - | - |
| Other macro variables | yes | yes | yes | yes |
| [(Other macro variables) * (Firm rating)] | - | - | - | - |
| Bank controls | yes | yes | yes | yes |
| Loan-level controls | yes | yes | yes | yes |

| Number of banks | 121 | 119 | 140 | 139 |
| Number of firms | 144 192 | 122 660 | 163 087 | 138 260 |
| Observations | 1 049 169 | 910 423 | 1 224 020 | 1 060 542 |
| Adjusted R-squared | 0.746 | 0.793 | 0.730 | 0.789 |

### Dependent variable: (log) amount new lending for different rating classes

| | duration gap > 0 | duration gap < 0 | | |
|---------------------------------------------|
| | (5) | (6) | (7) | (8) | |
| Eonia rate | -0.0444*** | -0.0429*** | -0.0469** | -0.0356 |
| 10-year Eurirs rate | 0.0021 | 0.0032 | -0.0034* | -0.0039* |
| Firm rating | 0.0100*** | 0.0090*** | 0.0069** | 0.0070*** |
| Eonia rate * Firm rating | -0.0034* | -0.0039* | 0.0069** | 0.0070*** |
| 10-year Eurirs rate * Firm rating | 0.0070*** | 0.0069** | -0.0039* | -0.0034* |

| Bank fixed effects | yes | - | yes | - |
| Firm fixed effects | yes | - | yes | - |
| Firm*Bank fixed effects | - | yes | - | yes |
| (Year:quarter) fixed effects | - | - | - | - |
| Other macro variables | yes | yes | yes | yes |
| [(Other macro variables) * (Firm rating)] | - | - | - | - |
| Bank controls | yes | yes | yes | yes |
| Loan-level controls | yes | yes | yes | yes |

| Number of banks | 121 | 121 | 140 | 140 |
| Number of firms | 144 192 | 144 192 | 163 088 | 163 088 |
| Observations | 1 049 169 | 910 423 | 1 224 020 | 1 060 542 |
| Adjusted R-squared | 0.684 | 0.760 | 0.676 | 0.757 |
Banks’ business model: From Empirics to the Theory

<table>
<thead>
<tr>
<th>Business model</th>
<th>DG&gt;0</th>
<th>DG&lt;0</th>
<th>DG&gt;0</th>
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<td><img src="https://via.placeholder.com/15" alt="+" /></td>
<td><img src="https://via.placeholder.com/15" alt="−" /></td>
<td><img src="https://via.placeholder.com/15" alt="+" /></td>
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</tbody>
</table>

- Reach-for-yield story for DUR_GAP>0
- What about DUR_GAP<0? …
- … Let’s look at another source of banks’ heterogeneity: capital
Banks’ business model and capitalization

Effects on **new loan rating class** (Dell’Ariccia et al., 2017):

\[ \text{risk}_{i(j)t} = \cdots + \alpha_1(Eonia_t \times Tier1\_ratio) + \alpha_2(10yIRS_t \times Tier1\_ratio) + \varepsilon_{ijt} \]

Effects on **the (log) amount of new lending** (Jimenez et al., 2014):

\[ \ln(\text{new\_lending})_{ijt} = \cdots + \alpha_1(Eonia_t \times Tier1\_ratio \times \text{risk}_{it}) + \alpha_2(10yIRS_t \times Tier1\_ratio \times \text{risk}_{it}) + \varepsilon_{ijt} \]

Empirical test:

- **\( \alpha_1 < 0 \)** is evidence of higher risk-taking when the **short-term** rate is **low** for banks with more capitalization
- **\( \alpha_2 < 0 \)** is evidence of higher risk-taking when **long-term rate** is **low** (slope of the yield curve is **flat**) for banks with more capitalization
### Banks’ business model and capitalization (1)

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<tbody>
<tr>
<td><strong>A) Dependent variable</strong>: change in the rating class of the new marginal loan</td>
<td></td>
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<tr>
<td>duration gap &gt; 0</td>
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<td></td>
</tr>
<tr>
<td>duration gap &lt; 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eonia rate * Tier1 ratio</td>
<td>-0.0010</td>
<td>0.0045</td>
<td>0.0030</td>
<td>0.0040**</td>
</tr>
<tr>
<td>10-year Eurirs rate * Tier1 ratio</td>
<td>0.0022</td>
<td>0.0022</td>
<td>-0.0017</td>
<td>-0.0065**</td>
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<tr>
<td>Eonia rate *</td>
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<td>-0.0001</td>
<td>-0.0014***</td>
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<td>10-year Eurirs rate *</td>
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<td>0.0020**</td>
<td>0.0032**</td>
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<td>Eonia rate * NPL ratio</td>
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<td>10-year Eurirs rate * NPL ratio</td>
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<td>Eonia rate * Deposit ratio</td>
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<td>10-year Eurirs rate * Deposit ratio</td>
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<tr>
<td>10-year Eurirs rate * Liquidity ratio</td>
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<td>-0.0004</td>
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<td>Eonia rate * Size</td>
<td>-0.0017</td>
<td>0.0008</td>
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<td></td>
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<tr>
<td>10-year Eurirs rate * Size</td>
<td>-0.100**</td>
<td>-0.0011</td>
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<td>(Year:quarter) fixed effects</td>
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<td>yes</td>
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<tr>
<td>Firm*Bank fixed effects</td>
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<td>yes</td>
<td>yes</td>
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<td>Bank controls</td>
<td>yes</td>
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<td>yes</td>
</tr>
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<td>Loan-level controls</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Observations</td>
<td>910,423</td>
<td>910,423</td>
<td>1,060,542</td>
<td>1,060,542</td>
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<tr>
<td>Adjusted R-squared</td>
<td>0.793</td>
<td>0.761</td>
<td>0.790</td>
<td>0.790</td>
</tr>
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### Banks’ business model and capitalization (2)

#### B) Dependent variable: change in new lending for different rating duration gap > 0  
<table>
<thead>
<tr>
<th></th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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<td>-0.0015</td>
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**Firm*(Year:quarter) fixed effects**
- no  yes  yes  no  yes  yes

**(Year:quarter) fixed effects**
- yes  yes  yes  yes  yes  yes

**Firm*Bank fixed effects**
- yes  yes  yes  yes  yes  yes

**Bank controls**
- yes  yes  yes  yes  yes  yes

**Loan-level controls**
- yes  yes  yes  yes  yes  yes

**[Other macro vars]*[Tier1 ratio]*[Firm rating]**
- yes  yes  yes  yes  yes  yes

**[Other macro vars]*[Other bank controls]*[Firm rating]**
- no  no  yes  no  no  yes

**Observations**
- 323,188  323,188  323,188  1,060,542  381,677  381,677

**Adjusted R-squared**
- 0.676  0.677  0.679  0.757  0.688  0.688
Banks’ credit risk-taking: From Empirics to the Theory

Reach-for-yield story for DUR_GAP>0
What about DUR_GAP<0? …
… Monitoring and moral hazard story for DUR_GAP<0
Both level and slope of the yield curve are relevant drivers of banks’ credit risk-taking.

- Controlling for firms fixed-effects magnifies the role of the slope and reduces the one of the level.
- Results are consistent across different measures of risk-taking and model specifications.

Controlling for the bank business model is important to validate theory. Low level and steep slope leads financial institutions:

- with positive duration gap to increase “reach-for-yield” (Adrian and Shin, 2011)
- with negative duration gap to reduce monitoring for moral hazard considerations (Dell’Ariccia et al., 2014)
Financial stability implications:

- Reassuring answers to concerns for financial stability (in terms of banks’ credit risk-taking) stemming from a LIRE characterized by low short and long-term interest rates and a relatively flat yield curve.

Monetary policy implications:

- The risk-taking channel may work differently for monetary policies that reduce the long-term part of the yield curve. In particular,
  - APP does not increase banks’ credit risk-taking.
Average firm rating and interest rates

(quarterly data; simple average)
## The data: descriptive statistics

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<td>9.9</td>
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<td>Profitability (%)</td>
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<td>0.8</td>
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### Risk-taking measure: rating class of the new loan

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<td>-0.1243***</td>
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<td>0.0027</td>
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<td>Italian unemployment rate</td>
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<td>-0.0539***</td>
<td>-0.0059</td>
<td>0.0248***</td>
<td>0.0330***</td>
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<td>Italian business cycle</td>
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<td>0.0178**</td>
<td>-0.0233***</td>
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<td>0.0043</td>
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Bank fixed effects: yes, yes, yes, yes, no
Firm zip-code*sector fixed effects: no, no, yes, no, no
Firm fixed effects: no, no, no, yes, no
Firm*Bank fixed effects: no, no, no, yes, yes
Observations: 2,498,790, 2,498,790, 2,446,268, 2,375,238, 2,131,448
Number of banks: 144, 144, 144, 144, 143
Number of firms: 359,111, 359,111, 313,917, 235,559, 205,307
Adjusted R-squared: 0.096, 0.096, 0.524, 0.723, 0.764
Risk-taking measure: (log) amount of new lending for different rating classes

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<td>Interactions with macroeconomic variables</td>
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<td>10-year Eurirs rate * Firm rating</td>
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<td>0.0099***</td>
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<td>-0.0030***</td>
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</tr>
<tr>
<td>Duration gap</td>
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<td>0.0008***</td>
<td>0.0003</td>
<td>0.0001</td>
<td>-0.0001</td>
</tr>
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<td>-0.2279***</td>
<td>-0.2075***</td>
<td>-0.2035***</td>
</tr>
<tr>
<td>Subsidized loans</td>
<td>-0.2958***</td>
<td>-0.2961***</td>
<td>-0.0901</td>
<td>-0.0311</td>
<td>-0.0515</td>
</tr>
<tr>
<td>(Year:quarter) fixed effects</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Bank fixed effects</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Firm zip-code*sector fixed effects</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Firm*Bank fixed effects</td>
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<td>no</td>
<td>no</td>
<td>no</td>
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<tr>
<td>Observations</td>
<td>2,498,790</td>
<td>2,498,790</td>
<td>2,446,268</td>
<td>2,375,238</td>
<td>2,131,448</td>
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<tr>
<td>Number of banks</td>
<td>144</td>
<td>144</td>
<td>144</td>
<td>144</td>
<td>143</td>
</tr>
<tr>
<td>Number of firms</td>
<td>359,111</td>
<td>359,111</td>
<td>313,917</td>
<td>235,559</td>
<td>205,307</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.192</td>
<td>0.192</td>
<td>0.547</td>
<td>0.672</td>
<td>0.754</td>
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