



Artificial intelligence and relationship lending*

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* The views expressed in this paper are those of the authors only and not necessarily those of the Bank of Italy or the BIS

Outline

- Introduction
- Data and stylized facts
- Empirical analysis
- Robustness checks
- Conclusions



Introduction

Motivation and research question

- ❑ **Artificial intelligence** (AI) allows the use of vast amounts of structured and unstructured data, reducing asymmetric information problems
- ❑ The financial sector is among those facing the greatest opportunities from the rise of AI, due to the high share of cognitively demanding tasks and its data intensive nature
- ❑ The application of AI in the banking sector enhances efficiency and lower costs by using hard information, with effects on the overall banking activity (Pierri and Timmer, 2022; Gambacorta et al., 2023; Foucault et al., 2025)

Motivation and research question (2)

- ❑ **Relationship lending** traditionally uses soft information about the borrower in order to mitigate information asymmetries
- ❑ Empirical literature documents that relationship borrowers pay higher interest rates in normal times but benefit from a protection during crises (Sette and Gobbi, 2015; Bolton et al., 2016; Beck et al., 2018; Banerjee et al., 2021)
- ❑ Banks that use AI models and investment more in IT might rely more on hard information, and less on soft information (Pierri and Timmer, 2022)
- ❑ What are the characteristic of AI lending vs relationship lending?
- ❑ What are their different real effects?

Contribution and main results

- ❑ This paper studies how the adoption of AI by banks affects the traditional role of relationship lending
- ❑ Focus on Italian bank-firm relationships between 2018:Q4 and 2020:Q4. We compare one “normal” year and the Covid crisis
- ❑ We find evidence that AI banks mitigate the “rent extraction effect” of relationship lending during “normal times” but offer lower protection during the Covid crisis
- ❑ This has effects on firms’ real activity: during the Covid crisis, exposure to AI lending reduced the positive effects of relationship lending on investments and employment

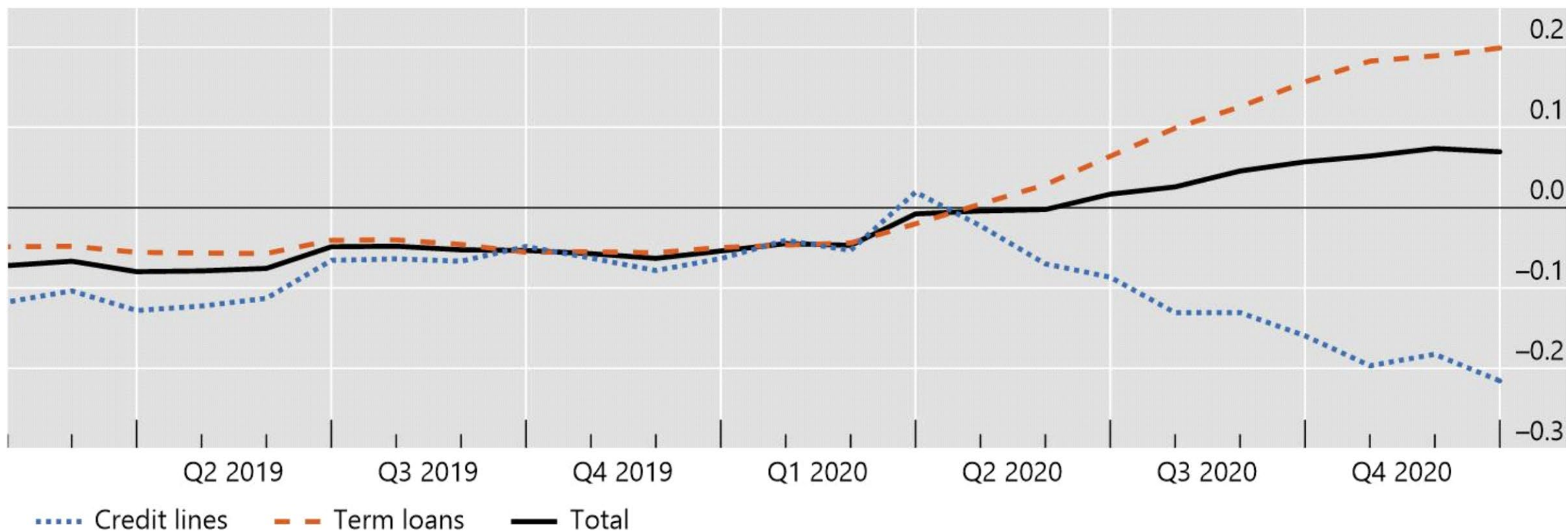


Data and stylized facts

Dataset

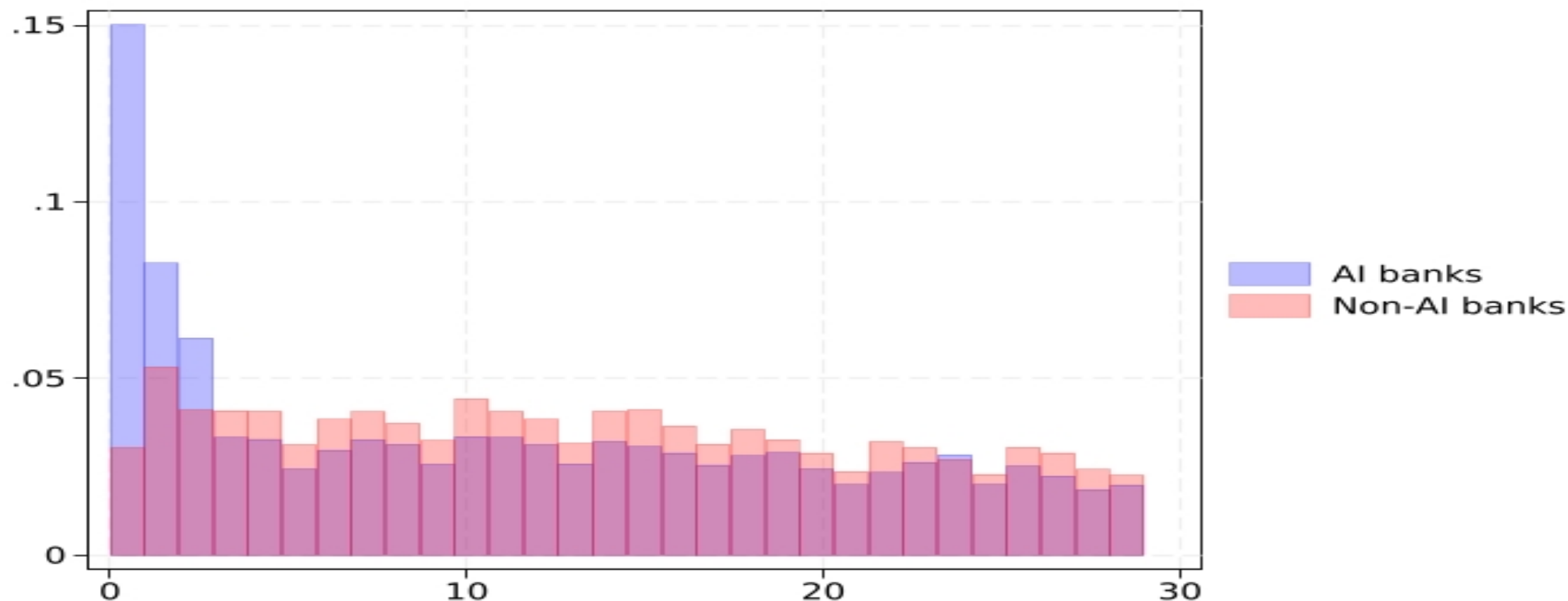
- ❑ We identify AI banks exploiting the **Regional Bank Lending Survey** (RBLs): according to our definition, an AI bank uses big data and machine learning models to evaluate the creditworthiness of their borrowers
- ❑ The dataset includes a total of 124 banks, 9 of which are AI at the beginning of the sample; 5 banks become AI in our sample
- ❑ We use the Italian Credit register to obtain granular information on the strength of “relationship lending”, measured as the log of relationship duration, expressed in quarters
- ❑ The final dataset has quarterly data at the bank-firm level and merges information from: AnaCredit, RBLs, Credit Register, Supervisory Reports (banks’ balance-sheet information), Cerved (firms’ balance-sheet information)

Lending growth to non-financial corporations in Italy



- In 2019, the growth rate of term loans and credit lines remained consistently negative, primarily due to weak demand
- In 2020, total loan growth increased, driven by a rise in term loans

Distribution of relationship length for AI and non-AI banks in 2018:Q4



- ❑ AI banks and non-AI banks have a slightly different degree of relationship-based lending
- ❑ At the end of 2018 (beginning of our sample), AI banks have a shorter median lending relationship (10 quarters) than non-AI banks (13 quarters)

Adoption of AI for credit scoring and bank characteristics

| Variables | (1) AI | (2) AI pre Covid |
|-------------------------|-----------------------|-----------------------|
| Capital ratio | 0.1053 (2.948) | 0.2237 (3.000) |
| Liquidity ratio | 1.9925 (2.177) | 1.9506 (2.335) |
| ROA | 0.5066 (0.475) | 0.0899 (0.541) |
| Interbank funding ratio | -1.3867 (1.430) | -1.5532 (1.478) |
| Size | 0.7748*** (0.187) | 0.8042*** (0.194) |
| Duration | -0.3299 (0.391) | -0.6207 (0.583) |
| Constant | -8.4024*** (1.756) | -7.9181*** (1.878) |
| Observations | 356 | 239 |

- Larger banks are more likely to adopt AI due to high fixed IT costs
- AI adoption is not correlated with relationship duration

Dynamic sorting test: AI banks and firm-specific characteristics

| Dependent variable is: | (1) ROA | (2) Leverage | (3) EBIDTA to int. expenses | (4) Log of total assets | (5) Credit rating |
|------------------------|-------------------|--------------------|--------------------------------|----------------------------|----------------------|
| AI | 0.6468 (0.509) | -1.9560 (1.338) | -2.1263 (1.785) | 0.0324* (0.018) | 0.0354 (0.026) |
| Observations | 5,440,806 | 5,437,036 | 5,092,583 | 5,376,939 | 5,436,618 |
| R-squared | 0.000 | 0.000 | 0.000 | 0.025 | 0.017 |
| Bank FE | yes | yes | yes | yes | yes |
| Time FE | yes | yes | yes | yes | yes |

Notes: Robust standard errors in parentheses (clustered at the firm level). $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

- Do firms with certain characteristics match with AI banks?
- No evidence of dynamic sorting



Empirical analysis

Empirical methodology: credit supply and research question

- We estimate the effects of the interplay between AI and relationship lending on credit supply (quantity and prices):

$$\begin{aligned} Y_{ijt} = & \beta_1 \log(\text{relationship duration})_{ijt-1} + \\ & \beta_2 \log(\text{relationship duration})_{ijt-1} \times AI_{it-1} + \\ & \beta_3 \log(\text{relationship duration})_{ijt-1} \times D(2020) + \\ & \beta_4 \log(\text{relationship duration})_{ijt-1} \times AI_{it-1} \times D(2020) + \\ & \text{Double and triple interactions} + \gamma Z_{ijt-1} + \alpha_{it} + \delta_{jt} + \varepsilon_{ijt} \end{aligned}$$

- $Y_{i,j,t}$: log difference of credit granted; level of interest rates
- $D(2020)$ is dummy equal to one in 2020 and zero otherwise
- Bank \times time (α_{it}) and firm \times time fixed effects (δ_{jt}) control for time-varying heterogeneity - both observable and unobservable - at the bank and firm level
- $Z_{i,j,t}$: vector of controls at the bank-firm level (dimension of loan, collateral over loan, residual duration, etc)

Results: Effects of AI and lending relationship on quantity of credit (1)

| Dependent variables: | (I) Term loans | (II) Credit lines |
|----------------------|-------------------|----------------------|
| Log(Rel. duration) | -1.465*** | -0.753 |
| × AI× D(2020) | (0.388) | (1.148) |
| Log(Rel. duration) | 1.200*** | 0.355 |
| × AI | (0.291) | (0.643) |
| Log(Rel. duration) | 1.365*** | 1.411** |
| × D(2020) | (0.277) | (0.620) |
| Log(Rel. duration) | -0.450** | -1.345*** |
| | (0.183) | (0.313) |
| Observations | 957,750 | 505,034 |
| R-squared | 0.417 | 0.471 |
| Bank-firm controls | yes | yes |
| Bank*quarter FE | yes | yes |
| Firm*quarter FE | yes | yes |

- Relationship banks provide less credit in normal times ...

Results: Effects of AI and lending relationship on quantity of credit (2)

| Dependent variables: | (I) Term loans | (II) Credit lines |
|----------------------|-------------------|----------------------|
| Log(Rel. duration) | -1.465*** | -0.753 |
| × AI× D(2020) | (0.388) | (1.148) |
| Log(Rel. duration) | 1.200*** | 0.355 |
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- Relationship banks provide less credit in normal times ...
- ... but supply more credit in a crisis period (insurance effect)

Results: Effects of AI and lending relationship on quantity of credit (3)

| Dependent variables: | (I) Term loans | (II) Credit lines |
|----------------------|-------------------|----------------------|
| Log(Rel. duration) | -1.465*** | -0.753 |
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| Log(Rel. duration) | 1.200*** | 0.355 |
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- ❑ Relationship banks provide less credit in normal times ...
- ❑ ... but supply more credit in a crisis period (insurance effect)
- ❑ For the same amount of soft information, AI amplifies the offer of credit in normal times ...

Results: Effects of AI and lending relationship on quantity of credit (4)

| Dependent variables: | (I) Term loans | (II) Credit lines |
|--------------------------------------|----------------------|----------------------|
| Log(Rel. duration) × AI × D(2020) | -1.465*** (0.388) | -0.753 (1.148) |
| Log(Rel. duration) × AI | 1.200*** (0.291) | 0.355 (0.643) |
| Log(Rel. duration) × D(2020) | 1.365*** (0.277) | 1.411** (0.620) |
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- ❑ Relationship banks provide less credit in normal times ...
- ❑ ... but supply more credit in a crisis period (insurance effect)
- ❑ For the same amount of soft information, AI amplifies the offer of credit in normal times ...
- ❑ ... but reduces the insulation effects of relationship lending on the supply of credit in a crisis

Results: Effects of AI and lending relationship on interest rates (1)

| Dependent variables: | (I) Term loans | (II) Credit lines |
|------------------------------------|----------------------|----------------------|
| Log(Rel. duration)× AI× D(2020) | 0.047* (0.028) | 0.108* (0.058) |
| Log(Rel. duration)× AI | -0.065*** (0.021) | 0.107 (0.068) |
| Log(Rel. duration)× D(2020) | -0.088*** (0.018) | -0.019 (0.048) |
| Log(Rel. duration) | 0.156*** (0.014) | 0.509*** (0.055) |
| Observations | 957,750 | 545,335 |
| R-squared | 0.675 | 0.673 |
| Bank-firm controls | yes | yes |
| Bank*quarter FE | yes | yes |
| Firm*quarter FE | yes | yes |

- Relationship lending is more costly in normal times (rent extraction) ...

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- Relationship lending is more costly in normal times (rent extraction) ...
- ... but is significantly less expensive in a crisis (insulation effect)

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- ❑ Relationship lending is more costly in normal times (rent extraction) ...
- ❑ ... but is significantly less expensive in a crisis (insulation effect)
- ❑ AI banks apply lower rates on term loans in normal times ...

Results: Effects of AI and lending relationship on interest rates (4)

| Dependent variables: | (I) Term loans | (II) Credit lines |
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- ❑ Relationship lending is more costly in normal times (rent extraction) ...
- ❑ ... but is significantly less expensive in a crisis (insulation effect)
- ❑ AI banks apply lower rates on credit lines in normal times ...
- ❑ ... but have a significantly lower insulation effect during a crisis

Empirical methodology: real effects

- We estimate the differential effect of AI on firms' credit, investment and employment in 2020 vs 2019:

$$\Delta Z_{jt} = \beta_1 \overline{dur}_{j,2018} \times D_t(2020) + \beta_2 \overline{AI}_{j,2018} \times D_t(2020) \\ + \beta_3 \overline{dur}_{j,2018} \times \overline{AI}_{j,2018} \times D_t(2020) + \beta_4 X_{jt-1} + \alpha_j + \gamma_t + \varepsilon_{jt}$$

- $\Delta Z_{j,t}$: growth in loans, investments, employment over firms' total assets
- $\overline{dur}_{j,2018}$: length of the relationship with the firm's main lender, weighted by the main lender's credit share of the firm's total loans
- $D(2020)$: dummy equal to 1 in 2020 and 0 otherwise
- $\overline{AI}_{j,2018}$: share of the main lender if this is an AI bank and zero otherwise
- $X_{j,t}$: vector of controls at the firm level (ROA, size, Leverage, EBITDA-to-interest expenses ratio, Z-score, etc).
- α_j : firm fixed effects; γ_t : time fixed effects

Results: The real effects of AI and lending relationship at the firm level (1)

| Dependent variables: | (I) Credit | (II) Investments | (III) Employment |
|--|----------------------|----------------------|----------------------|
| $\overline{Dur} \times D(2020)$ | 0.0476*** (0.007) | 0.2481*** (0.018) | 0.0163*** (0.001) |
| $\overline{Dur} \times \overline{AI} \times D(2020)$ | -0.0277** (0.014) | -0.0883* (0.048) | -0.0047* (0.003) |
| $\overline{AI} \times D(2020)$ | 0.0154 (0.010) | 0.0255 (0.031) | -0.0007 (0.002) |
| Observations | 292,666 | 296,296 | 220,642 |
| R-squared | 0.927 | 0.696 | 0.982 |
| Firm controls | yes | yes | yes |
| Firm FE | yes | yes | yes |
| Time FE | yes | yes | yes |

- During the COVID-19 crisis, firms with longer average relationship duration obtained more credit and increased by more investments and employment

Results: The real effects of AI and lending relationship at the firm level (2)

| Dependent variables: | (I) Credit | (II) Investments | (III) Employment |
|---|----------------------|----------------------|----------------------|
| $\overline{Dur} \times D(2020)$ | 0.0476*** (0.007) | 0.2481*** (0.018) | 0.0163*** (0.001) |
| $\overline{Dur} \times \underline{AI} \times D(2020)$ | -0.0277** (0.014) | -0.0883* (0.048) | -0.0047* (0.003) |
| $\overline{AI} \times D(2020)$ | 0.0154 (0.010) | 0.0255 (0.031) | -0.0007 (0.002) |
| Observations | 292,666 | 296,296 | 220,642 |
| R-squared | 0.927 | 0.696 | 0.982 |
| Firm controls | yes | yes | yes |
| Firm FE | yes | yes | yes |
| Time FE | yes | yes | yes |

- During the COVID-19 crisis, firms with longer average relationship duration obtained more credit and increased by more investments and employment
- However, this effect was lower for firms borrowing from AI banks



Robustness checks

Covid, public guarantees and changes in firm-specific conditions

- ❑ Banks' use of AI or the average duration of their client relationships may be correlated with their exposure to the service sector, which was more affected by the pandemic
- ❑ AI and non-AI banks may have had different incentives when granting publicly guaranteed loans during the pandemic
- ❑ The analysis controls for the differential responsiveness of AI and non-AI banks to firm-specific conditions: AI banks react significantly more to changes in firms' profitability



Conclusions

Main takeaways

- ❑ We find that the adoption of AI by banks affects the countercyclical characteristics of relationship lending
- ❑ Specifically, AI dampens the “rent extraction effect” in normal times and the insulation effect in crisis times, which is typically associated with relationship lending
- ❑ This has effects on firms’ real activity: all else being equal, employment and investments increased more during the COVID-19 crisis for firms borrowing from relationship banks