Adverse Selection in the Loan Market

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Introduction I

- Asymmetric information is an important matter in insurance and credit markets
  - Enormous theoretical literature; seminal contributions from:
    - Akerlof (1970), Rothschild and Stiglitz (1976),
    - Stiglitz and Weiss (1981)
- But... empirical evidence about the scope and effects of asymmetric information is scarce:
  - Why?

Introduction II: Why little empirical evidence of AI?

- Asymmetric information is, by definition, hard to measure:
  - Adverse selection = Hidden information
  - Moral hazard = Hidden action(s)
- Empirical approaches in the literature:
  - Test for the presence of asymmetric info
    - e.g. Chiappori and Selanié (2000)
  - Estimate its distribution using structural methods
    - Some recent work in insurance markets
    - Very little in credit markets

Contribution I

What we do in this paper:

- Employ a unique set of linked datasets in the Italian market for small business lines of credit from 1988-1998
- Estimate a structural model of demand and supply (pricing) of credit with adverse selection
  - Based on Stiglitz and Weiss (1981)

The goals:

1. Measure the extent of asymmetric information in an important credit market
2. Understand the interaction between adverse selection and competition

Preview of Results

- None yet.
  - We are cleaning the data and developing our econometric model.
- The goal today:
  - Describe the kinds of data we are using
  - Briefly describe the model of adverse selection we'll be taking to this data

Literature

- Vast theoretical work on asymmetric info since 1970s.
  - (Discussed above)
- Recent interest in structural models of insurance and credit markets with asymmetric info.
  - Cohen and Einav (2007)
  - Lustig (2011), Starc (2012)
  - Einav, Jenkins, and Levin (2011)**
- Evidence on competition effects of asymmetric info in Italian credit markets.
  - (See next slide)

Asymmetric Information in Italian Banking

- New banking entrants often perform poorly relative to incumbents:
  - Bofondi and Gobbi (2006):
    - Entrants experience higher default rates than incumbents
  - Gobbi and Lotti (2004):
    - Interest rate spreads positively correlated with entry of de novo banks (but not existing banks in other markets)
- Mergers enhance pricing of (observable) risk:
  - Panetta, Schivardi, and Shum (2009):
    - Merged banks match better interest rates and default risk
    - Due to better information processing, not from info sharing

- Our focus: (unobserved) info effects on (price) competition
  - [Pavanini JMP (2013): Info effects on entry decisions]

The Data I

We employ a unique set of linked datasets in the Italian market for small business lines of credit from 1988-1998:

1. 1.2m individual loan contracts (S: *Centrale dei Rischi*)
   - By firm-bank-year: Credit granted, credit used, interest rate, default
2. 62k Italian non-financial and non-agricultural firms (S: *Centrale dei Bilanci*)
   - By firm-year: balance sheet, income statements, location
   - Wide coverage of small- and medium-sized firms
   - Representing 30% of gross operating profits of all Italian non-financial firms (S: *ISTAT*)

The Data II

Linked datasets, cont.:

3. 90 banks accounting for 80% of bank lending (S: Banking Supervision Register)
    - By bank-year: Size, assets, costs, share of bad loans
4. Yearly bank branches at city-council level ($\sim$ 8,000 in Italy)

Features of Credit Lines

- Defined as short-term non-collateralized loans
- With these features:
  - Bank can change interest rate anytime
  - Firm can close credit line without notice
- Main source of external financing of Italian firms
  - (53% of total firms' debt in 1994)

Firms (Obs: Firm-Year)

Variables	N	Mean	SD	5^{th}pc	Median	95^{th}pc
Year	145,510	1995	2.53	1990	1995	1998
Total Assets	145,510	28,370	588,445	1,632	7,715	65,698
Net Assets	145,510	7,543	301,499	36	1,031	14,583
ST Debts	145,510	5,463	61,307	0	1,271	15,525
Sales	145,510	29,415	294,744	1,698	10,967	73,855
Profits	145,510	2,879	87,280	-358	732	6,576
Cash Flow	145,510	2,085	72,809	-256	349	4,666
Leverage	145,504	0.55	12.84	0	0.64	0.98
Score	145,510	5.30	1.77	2	5	8

Assets, Debts, Sales, Profits, Cash Flow in thousands of €. Net Assets are Total Assets minus liabilities. ST Debts are debts within 1 year. Leverage is debt/liabilities. Obs is firm-year. Omitting left-censored observations (60% of loans, 49% of credit granted).

Firms' Observable Riskiness

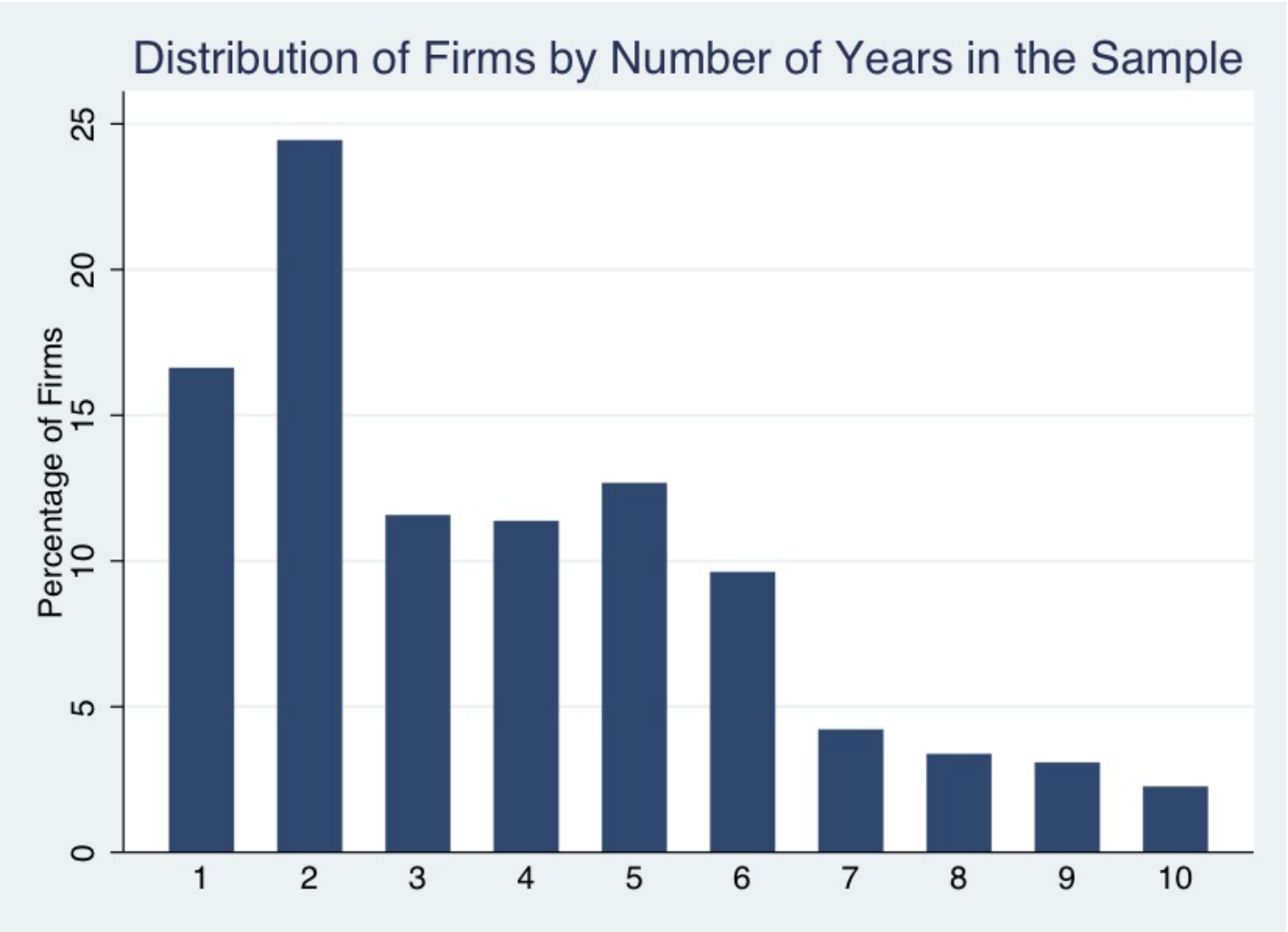
Score is an indicator of the risk profile of each firm, computed annually using a series of balance sheet indicators. It approximates the information available to the bank at the time of lending.

Firms across Risk Categories

Variables	Safe	Solvent	Vulnerable	Risky	Ever Defaulted
Total Assets	31,772	32,846	28,534	23,774	24,565
Net Assets	15,457	11,123	6,600	3,784	1,384
ST Debts	1,957	4,636	5,717	6,664	7,810
Sales	44,284	37,428	28,471	20,480	16,823
Profits	5,976	4,787	2,649	854	757
Cash Flow	5,106	3,931	1,849	133	-286
Leverage	0.20	0.41	0.63	0.66	0.83
Score	1.60	3.75	5.46	7.23	6.83
N of Firm-Year	10,543	39,605	47,298	48,064	5,344

Assets, Debts, Sales, Profits, Cash Flow in thousands of €. Net Assets are Total Assets minus liabilities. ST Debts are debts within 1 year. Leverage is debt/liabilities. Obs is firm-year. These are all means.

Observations Per Firm



Firm Dynamics

Variables	N	Mean	SD	5^{th}pc	Median	95^{th}pc
Years in Data	38,339	3.77	2.36	1	3	9
Max in-sample Δ Score	38,630	1.26	1.32	0	1	4
Last-First Δ Score	38,630	-0.06	1.43	-2	0	2
Max in-sample Δ Sales	38,630	11,273	77,017	0	3,094	36,029
Last-First Δ Sales	38,630	5,846	72,392	-5,937	657	26,989
Max in-sample Δ Leverage	38,630	0.38	3.46	0	0.17	0.95
Last-First Δ Leverage	38,625	0.08	3.44	-0.42	0	0.81

Obs is firm. Max in-sample Δ is the in-sample difference between the max and min of each variable.

Last-First Δ is the change in each variable between the beginning and end of the firm's sample life.

Banks (Obs: Bank-Year)

Variable	**Obs**	**Mean**	**SD**	5^{th}**pc**	**Median**	95^{th}**pc**
Total Assets	900	10,727	16,966	482	3,709	54,354
Employees	896	3,180	4,583	206	1,137	14,038
Bad Loans	893	6.2	6.3	1.9	4.9	15.8
Cost/Income	893	34.5	6.1	25.4	33.1	43.2

Obs is bank-year. Assets in millions of €. Cost/Income is Fixed Costs/Gross Income.

Other Firm and Bank Data

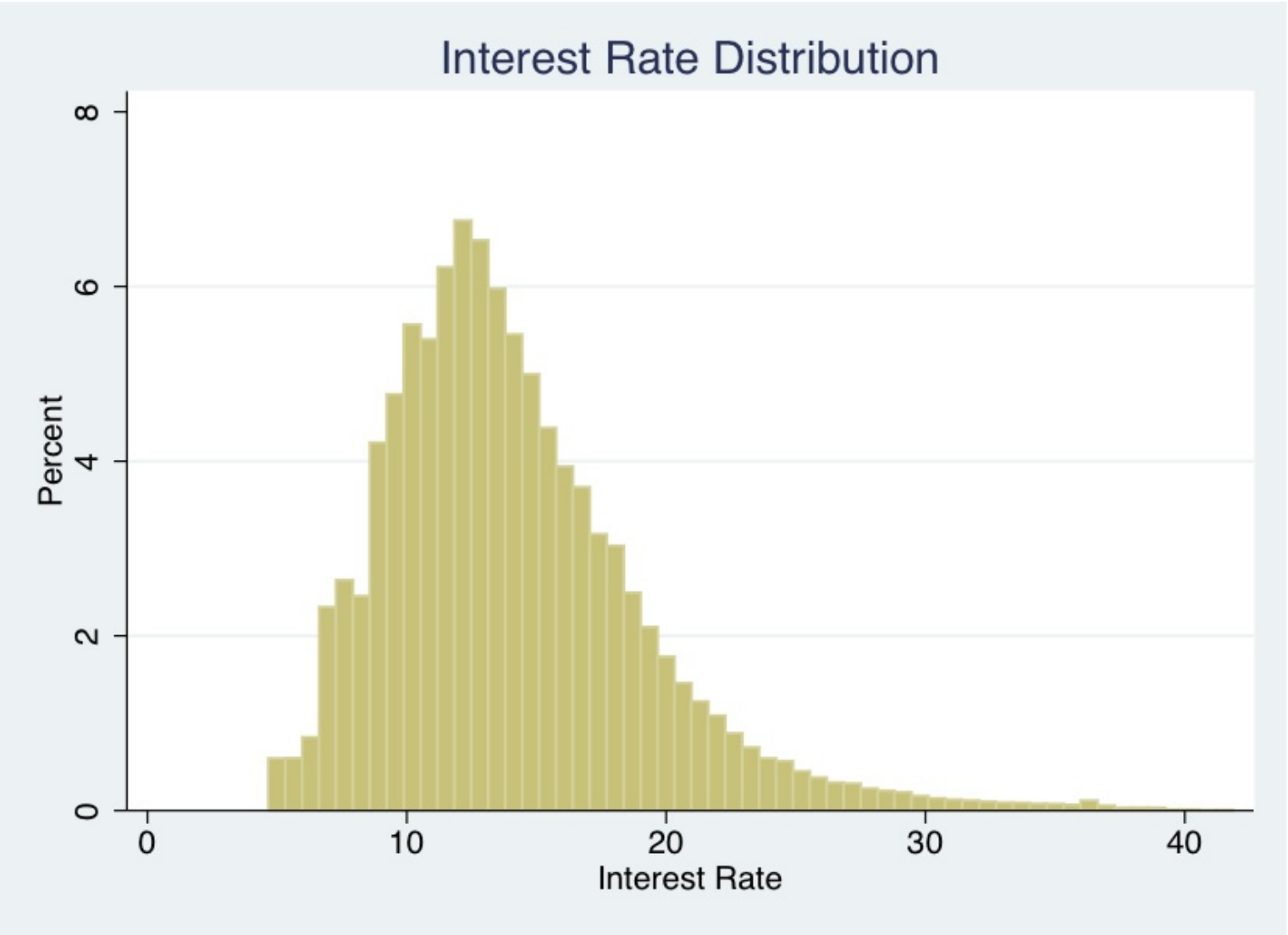
- Additional Firm Data:
  - Industrial sector at 4-digit level (648 sectors)
  - Operational location at city-council level
- Additional Bank Data:
  - Bank type (national, local, savings, cooperative, commercial)
  - Mergers and acquisitions
  - Location of each bank's branch network
- Together:
  - $\Rightarrow$ distance between firm and banks' nearest branch

Credit Lines (Obs: Firm-Year-Loan)

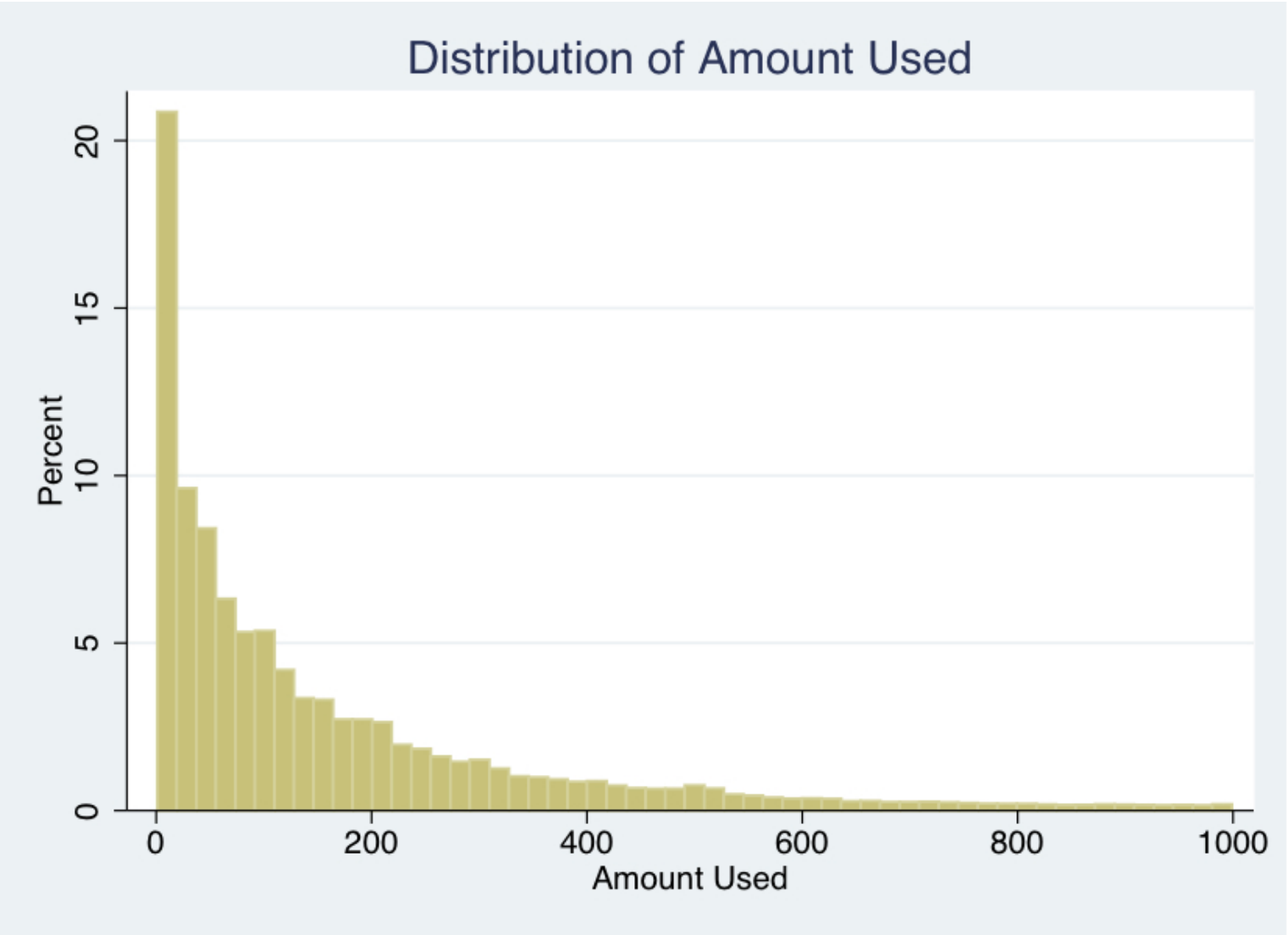
Variables	**N**	**Mean**	**SD**	5^{th}**pc**	**Median**	95^{th}**pc**
Year	502,515	1995	2.52	1990	1995	1998
First Main Line	502,515	0.24	0.43	0	0	1
Amount Used	502,515	245	2,147	0	37	832
Amount Granted	502,515	508	4,887	0	150	1,500
Used/Granted	465,828	0.61	2.41	0	0.36	1.58
Avg Loan Rate	502,515	14.10	5.01	7.43	13.26	23.27
Default	502,515	0.01	0.10	0	0	0

First main line is the largest loan (in amount used) in the first year the firm is in the sample. Amount Used and Granted in thousands of €. Obs is firm-bank-year.

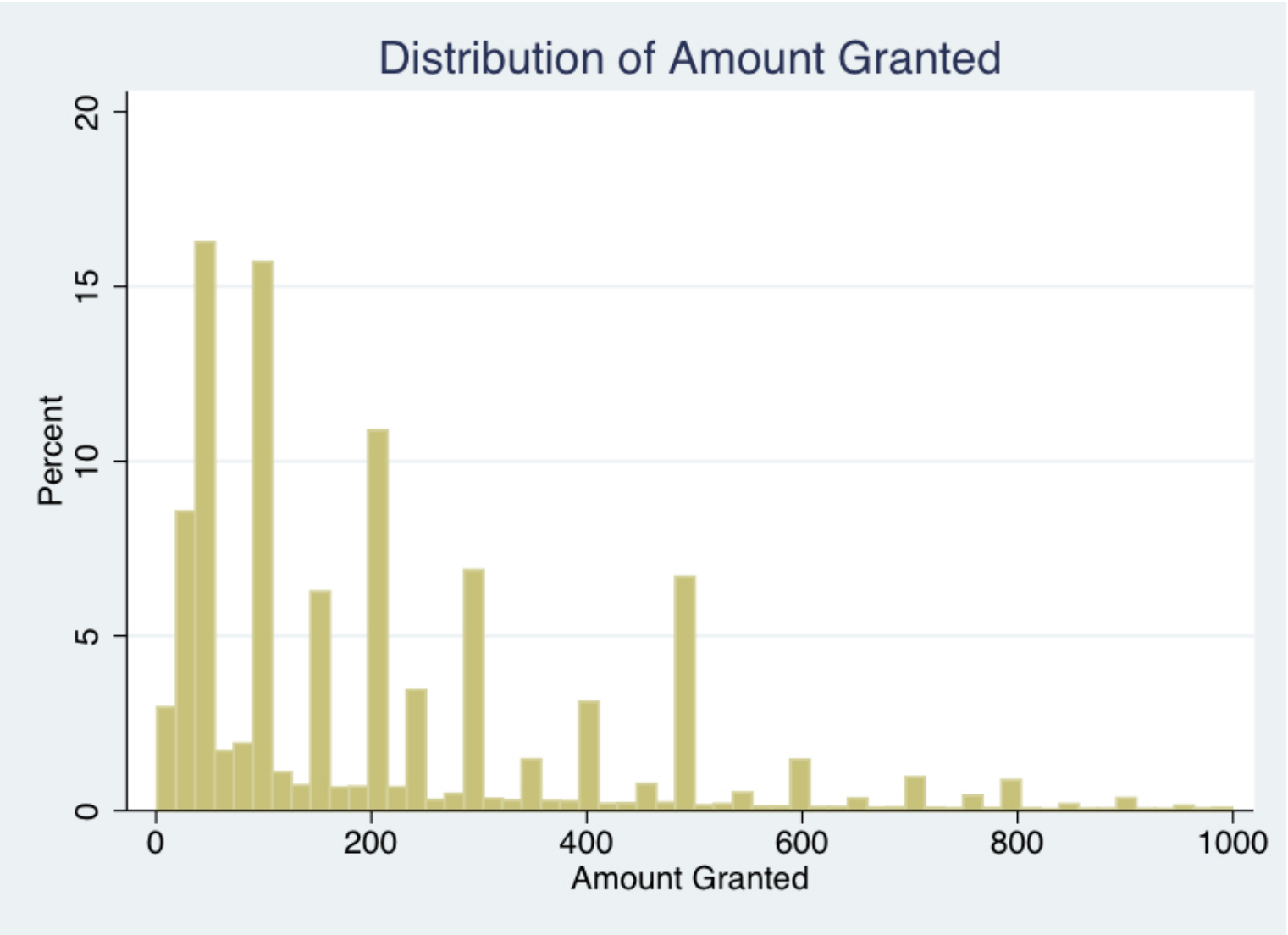
Distribution of Interest Rate - All loans



Distribution of Amount Used - All loans under 1 Mil. €



Distribution of Amount Granted - All loans under 1 Mil. €



Credit Lines per Firm (Obs: Firm-Year)

Variables	N	Mean	SD	5^{th}pc	Median	95^{th}pc
N of Lines	145,510	3.45	2.64	1	3	9
Amount Used	145,510	845	7,521	0	186	2,817
Amount Granted	145,510	1,754	19,170	20	500	4,978
Used/Granted	140,659	0.64	4.89	0	0.42	1.52
Interest Rate	145,510	14.28	4.40	8	13.78	21.92
Default	145,510	0.01	0.09	0	0	0
1st Main Used	82,801	520	3,661	0	122	1,761
1st Main Granted	82,801	765	7,486	0	250	2,300
1st Main Used/Granted	77,782	0.83	2.84	0	0.62	2
1st Main Interest Rate	82,801	14.08	4.82	7.63	13.31	22.93
1st Main Default	82,801	0.01	0.09	0	0	0
Share 1st Main Used	64,266	0.77	0.24	0.33	0.84	1
Share 1st Main Granted	79,315	0.66	0.31	0.13	0.67	1

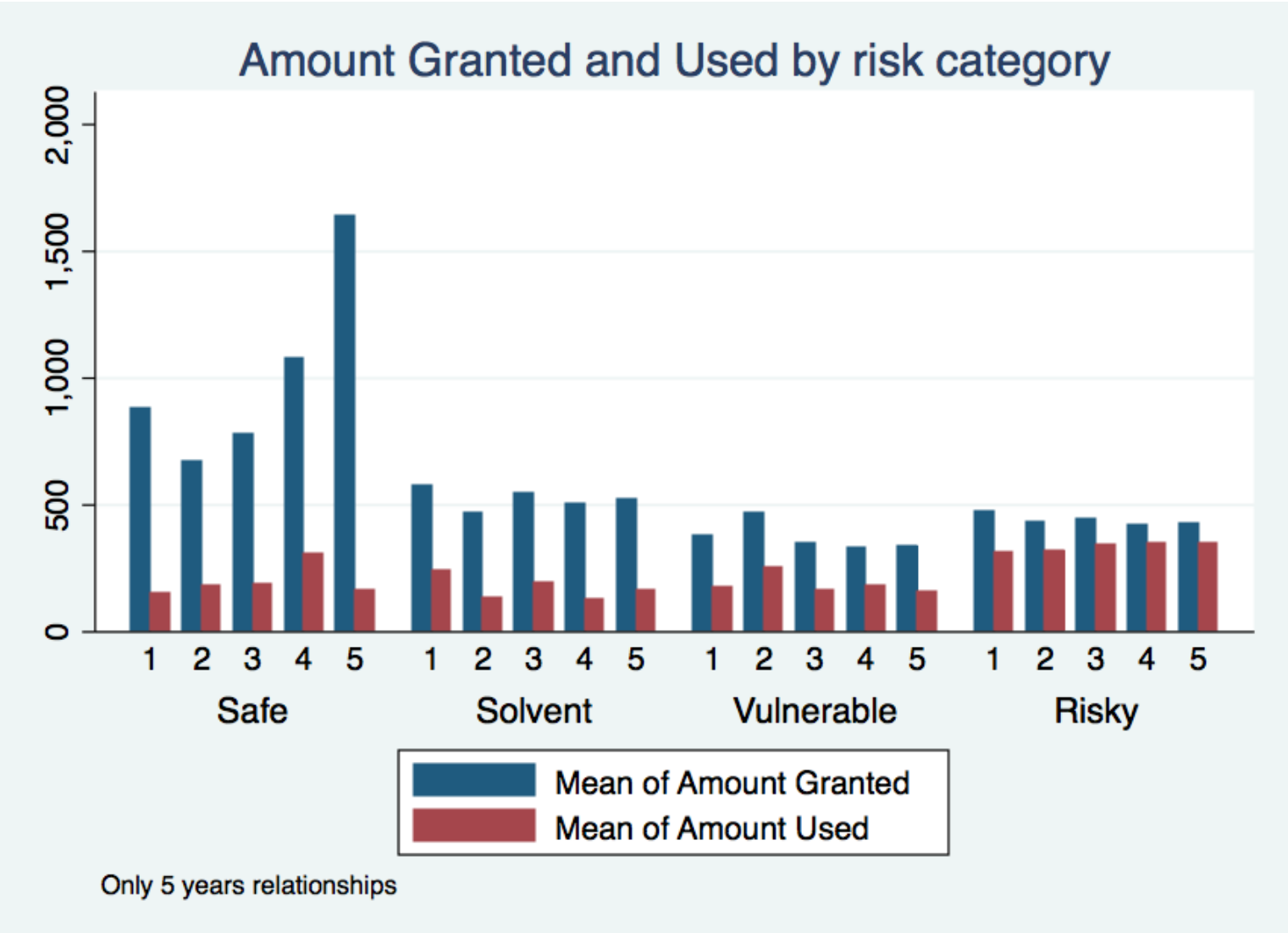
Amount Used and Granted in thousands of €. Obs is firm-bank-year.

First Main Line across Risk Categories (Obs: Firm-Year)

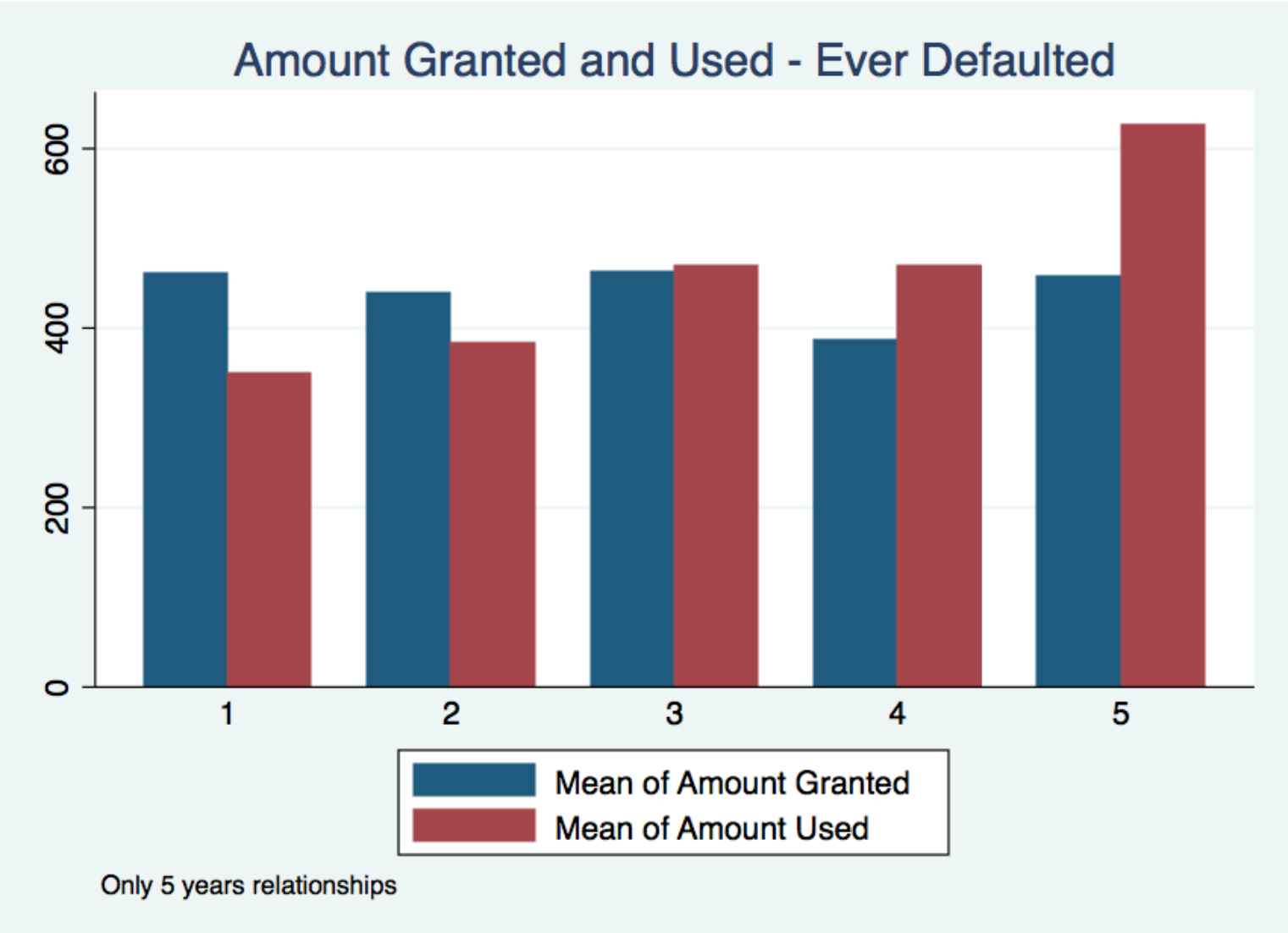
Variables	Safe	Solvent	Vulnerable	Risky	Ever Defaulted
1st Main Used	110	226	314	492	583
1st Main Granted	471	512	508	614	491
1st Main Used/Granted	0.25	0.47	0.72	1.01	1.40
1st Main Interest Rate	10.55	10.74	11.58	12.49	13.01
1st Main Default	0.00	0.00	0.00	0.02	0.19
Ever Defaulted	0.00	0.01	0.02	0.08	1.00
N of Firm-Year	10,543	39,605	47,298	48,064	5,344

Amount Used and Granted in thousands of €. Obs is firm-bank-year. These are all means.

Amount Granted and Used by Risk Category



Amount Granted and Used - Defaulters



Reduced Form Evidence I

- Following the previous literature
  - We analyzed our data for reduced-form evidence of asymmetric information
  - (e.g. Chiappori and Selanié (2000))
- The intuition:
  - A loan is like an insurance contract
    - The bank shares in the cost of a firm's bad investments
  - Riskier firms should therefore select larger loans
- (Analogous to sicker people choosing larger insurance cover)

Reduced Form Evidence II

- The test: specify reduced-form models of both
  1. Loan size (y_i)
  2. Ever defaulted (z_i)

$$\begin{aligned} y_i &= \mathbf{1}(X_i\beta + \varepsilon_i > 0) \\ z_i &= \mathbf{1}(X_i\gamma + \eta_i > 0), \end{aligned} \tag{1}$$

where X = year FE, region FE, sector FE, bank FE, score, other firm's balance sheet's variables

Reduced Form Evidence III

$$y_i = \mathbf{1}(X_i\beta + \varepsilon_i > 0)$$
$$z_i = \mathbf{1}(X_i\gamma + \eta_i > 0)$$

- Specify the distribution of (ε_i, η_i) as a joint Normal with correlation coefficient, ρ
  - $\Rightarrow$ Bivariate Probit model
- Positive and significant ρ suggests the presence of asymmetric information.
- Complementary evidence:
  - Correlation should be stronger for the first main line
  - Correlation should be stronger if we exclude observable risk measures ("score")

Reduced Form Results

Table: Bivariate probit regression's estimates of ρ

Loan Amount	**First Loan Ever**		**Whole Sample**	
	Score	No Score	Score	No Score
Used	0.107^{***}	0.139^{***}	0.073^{***}	0.099^{***}
	(0.014)	(0.014)	(0.003)	(0.003)
Used/Granted	0.166^{***}	0.205^{***}	0.130^{***}	0.166^{***}
	(0.015)	(0.015)	(0.004)	(0.003)

The Model: Introduction I

- To measure the extent of adverse selection in the Italian loan market
- We specify and estimate an econometric model based on the canonical work of Stiglitz and Weiss (1981)
- The intuition:
  - Firms are risk neutral, but differ in their underlying riskiness
    - Measured by the variance in their return from a project for which they seek loan financing
  - Firms know their risk type; banks do not
  - Banks are differentiated (by location, type, years in market) and set interest rates in competition with other banks

The Model: Introduction II

- Intuition, cont.:
  - Firms' expected profits increase with risk
    - Due to the insurance nature of loan contracts:
    - Banks share in the cost of bad project outcomes
  - At any interest rate, riskier firms are more likely to accept than safer firms
    - $\Rightarrow$ any bank increasing rates attracts a riskier group of firms...
    - ...raising their costs due to higher resulting default rates
  - Asymmetric info can soften the effects of market power:
    - Monopoly banks would like to raise rates
    - But adverse selection reduces the benefits of doing so

The Model

Formally:

$i = 1, .., I$ Firms:

- Want to invest in project with returns $Y_i \sim N(\mu_i, 1/\theta_i^2)$
- Have only access to loans offered to their type k
- Choose one bank j from which to borrow, amount B_j given
  - (Currently relaxing this assumption; will let firms choose loan amount)
- Choose to repay or default depending on project's success

$j = 1, .., J$ Banks:

- Provide credit (no rationing), observe μ_i but not θ_i
- Set interest rates r_{jk} from Bertrand-Nash competition and firms' types

The Model

Assumptions:

- Asymmetric information on variance of returns
- First year of main new credit line
- Posted interest rates for market and type of borrower
- Exogenous amount of credit B_j
- No moral hazard

The Model

Probability of default of firm i on loan j:

$$\begin{aligned} d_{ij} &= p(Y_i - (1+r_j)B_j \leq 0) \\ &= \Phi\big(\theta_i(1+r_j)B_j - \theta_i\mu_i\big). \end{aligned} \tag{2}$$

Firm's profits in case of successful project:

$$\begin{aligned} \mathbb{E}(\pi_{ij}|success) &= \mathbb{E}(Y_i - (1+r_j)B_j | Y_i > (1+r_j)B_j) \\ &= \mu_i + \frac{1}{\theta_i}\frac{\phi\left(\theta_i(1+r_j)B_j - \theta_i\mu_i\right)}{1-\Phi\left(\theta_i(1+r_j)B_j - \theta_i\mu_i\right)} - (1+r_j)B_j. \end{aligned} \tag{3}$$

DEMAND (Firm i's expected profits from access to credit):

$$\begin{aligned} \mathbb{E}\pi_{ij} &= (1-d_{ij})\mathbb{E}(\pi_{ij}|success) \\ &= (1-\Phi_{ij})\big(\mu_i - (1+r_j)B_j + \frac{1}{\theta_i}\frac{\phi_{ij}}{1-\Phi_{ij}}\big). \end{aligned} \tag{4}$$

Model Predictions

Credit as an insurance device for the firm:

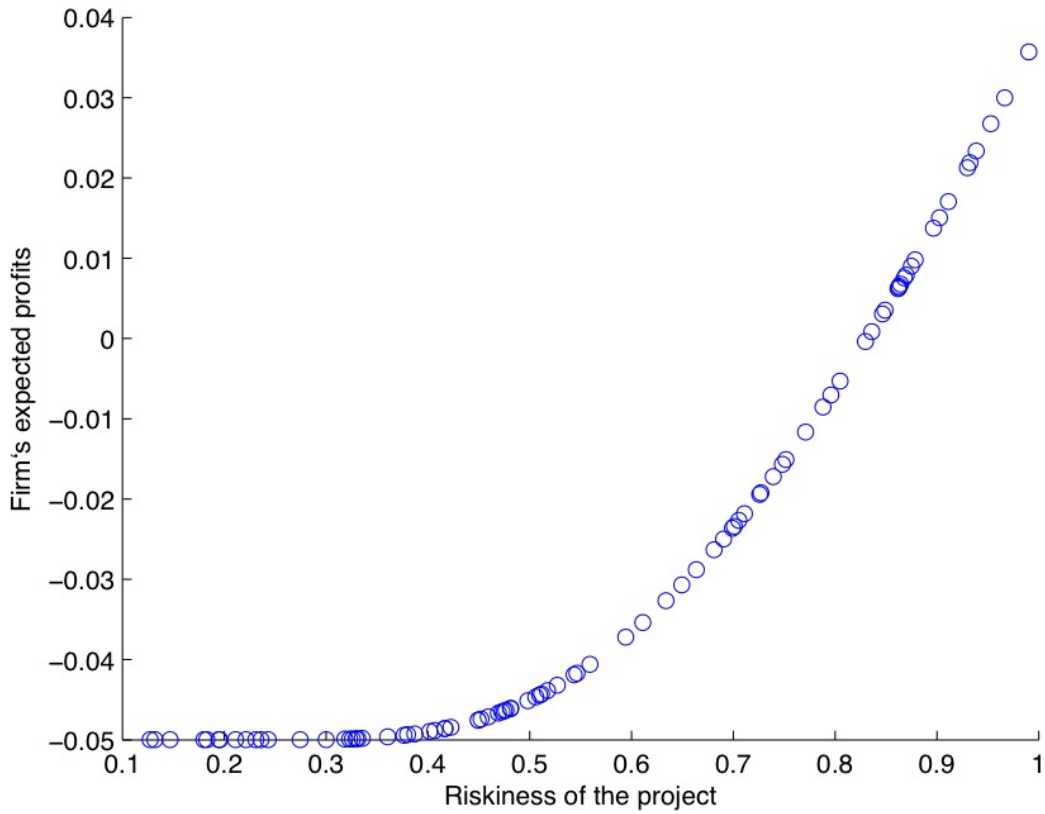


Figure: Firm's profits increase with risk

Model Predictions

Banks face riskier batch of firms as interest rate increases:

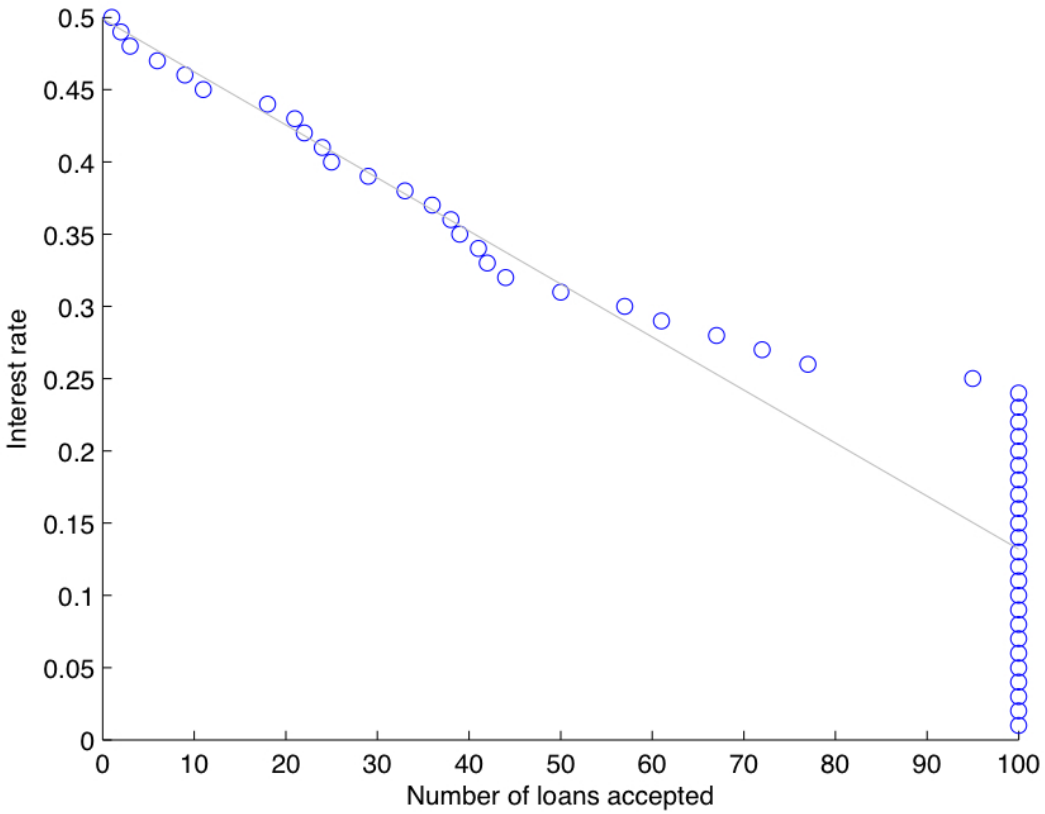


Figure: Demand for credit is decreasing in interest rate

Model Predictions

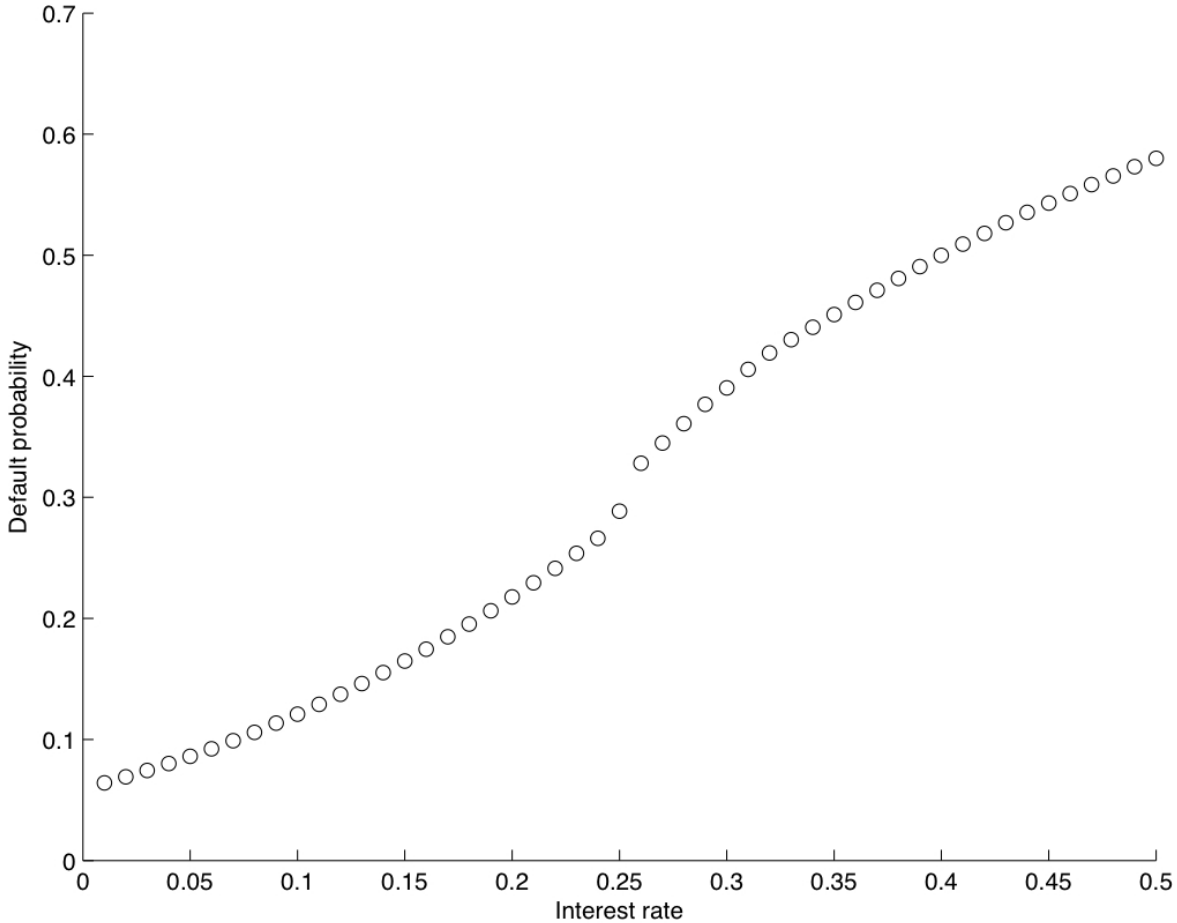


Figure: Default probability is increasing in the interest rate

The Model

Expected claim of firm i to lender j:

$$\begin{aligned}\mathbb{E}\gamma_{ij} &= (1-d_{ij})\mathbb{E}\big(\gamma_{ij}|Y_i > (1+r_j)B_j\big) + d_{ij}\mathbb{E}\big(\gamma_{ij}|Y_i \leq (1+r_j)B_j\big) \\ &= d_{ij}\left[(1+r_j)B_j - \mu_i + \frac{1}{\theta_i}\frac{\phi_{ij}}{1-\Phi_{ij}}\right]\end{aligned} \tag{5}$$

SUPPLY (Bank j's expected profit function):

$$\mathbb{E}\Pi_j = \sum_k \left[(1+r_{jk})TB_{jk} - TC(TB_{jk})\right] \tag{6}$$

PRICING EQUATION (f.o.c. of profit function):

$$\begin{aligned}\frac{\partial \Pi_j}{\partial(1+r_{jk})} &= (1+r_{jk}) + \frac{(1+r_{jk})}{e_{jk}} - MC_{jk} \\ &= (1+r_{jk}) + \frac{(1+r_{jk})}{e_{jk}} - (DP_j + \textstyle\sum_i^k \mathbb{E}\gamma_{ij}),\end{aligned} \tag{7}$$

Model Predictions

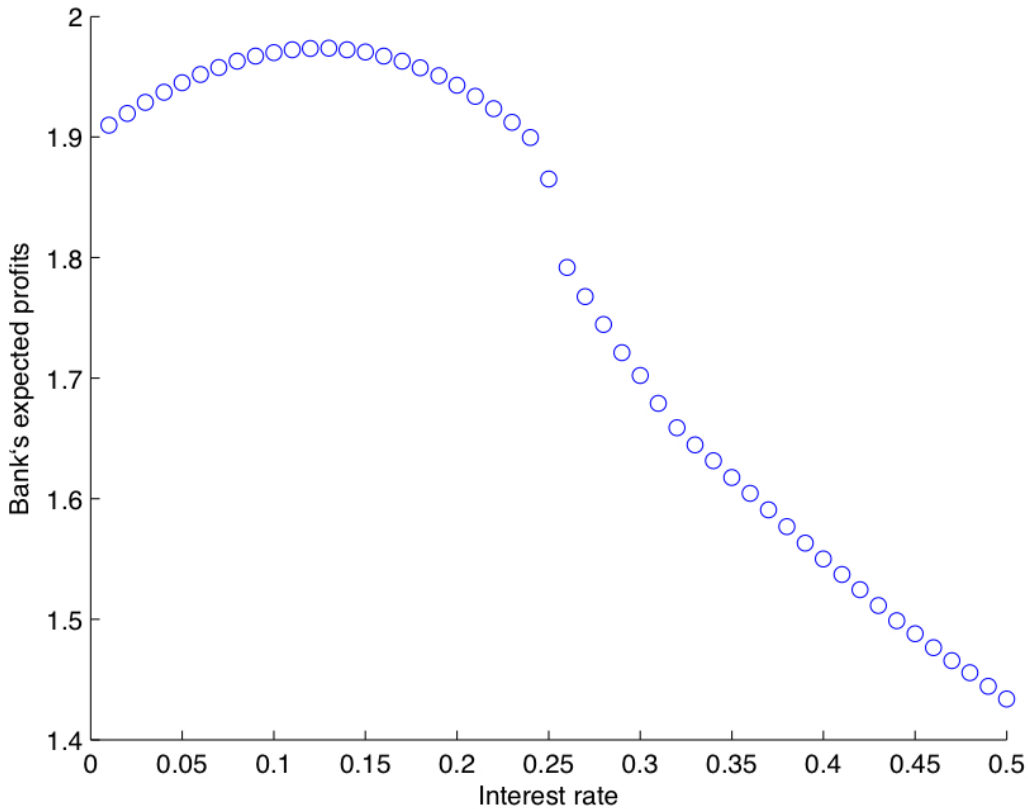


Figure: Bank's profits are concave in the interest rate

Econometric Specification

Let:

- $m = 1, .., M$ index markets (omit for convenience)
- $k = 1, .., K$ index types (omit for convenience)
- X_i' be firm observable characteristics
- W_j' be bank/loan observable attributes
- ξ_j be bank/loan unobservable attributes
- $Y_i \sim N(X_i'\beta, 1/\theta_i^2)$ be returns from i's project
- Parameters to be estimated: $\alpha, \beta, \theta_i, \omega$, with $\theta_i = \theta + \sigma_\theta \nu_i$ and $\nu_i \sim N(0, 1)$. θ_i evidence of adverse selection

Probability of default of firm i on loan j:

$$d_{ij} = \Phi\big[D_{ij}\big], \quad \text{with } D_{ij} = \theta_i(1 + r_j)B_j - \theta_i(X_i'\beta). \tag{8}$$

Econometric Specification

DEMAND (Expected profit for firm i from loan j):

$$\pi_{ij} = \delta_j + \bar{\pi}_{ij} + \varepsilon_{ij} \tag{9}$$

$$\text{with} \begin{cases} \delta_j = \alpha(1+r_j)B_j + W_{1j}'\omega_1 + \xi_j, \\ \bar{\pi}_{ij} = (1-d_{ij})\left[X_i'\beta + \frac{1}{\theta_i}\frac{\phi(D_{ij})}{1-\Phi(D_{ij})}\right] - d_{ij}\alpha(1+r_j)B_j + W_{2ij}'\omega_2, \\ \varepsilon_{ij} \sim \text{IID Type 1 EV.} \end{cases}$$

Probability that firm i chooses bank/loan j:

$$s_{ij} = \int \frac{\exp\left(\delta_j + \bar{\pi}_{ij}\right)}{1 + \sum_{j=1}^{J_m} \exp\left(\delta_j + \bar{\pi}_{ij}\right)} \phi(\nu_i) d\nu_i. \tag{10}$$

MPEC Estimation of Demand and Default

Let ψ be the parameters to be estimated, the moment conditions to construct the GMM objective function are:

$$\begin{aligned} g_1(\psi) &= \sum_i \sum_j \left[Q_{ijm} - q_{ijm}(\psi) \right] = 0, \\ g_2(\psi;\xi) &= \sum_i \sum_j \left[P_{ijm} - p_{ijm}(\psi;\xi) \right] z_{ijm} = 0, \\ g_3(\psi;\xi) &= \sum_j \sum_m \xi_{jm}(\psi) z_{jm} = 0, \end{aligned} \tag{11}$$

MPEC constrained optimization approach:

$$\begin{aligned} \min_{\psi,\xi,g_1,g_2,g_3} \quad & g' W g \\ \text{subject to} \quad & s(\psi;\xi) = S \\ & g_1 = g_1(\psi) \\ & g_2 = g_2(\psi;\xi) \\ & g_3 = g_3(\psi;\xi) \end{aligned} \tag{12}$$

Preliminary Results

Table: Estimates of Default and Demand Parameters

Variables	**(1)**
θ	1.558
σ_θ	0.657
β_0	24.503
β_1	9.195
ω_2	2.087
α	0.040
N	1,803

Counterfactuals (Planned)

- No asymmetric information
- Greater competition with asymmetric information

Conclusions

- Estimate the extent of adverse selection in Italian loan markets
  - And how competition and adverse selection interact to influence interest rates and credit
- Exploit a unique set of proprietary datasets with detailed information about loans, firms, and banks
  - Reduced-form evidence in the data suggest the presence of asymmetric information
- Econometric estimation and counterfactual experiments in progress

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