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DEGLI STUDI  
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CARLO BO

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**FINANCIAL FRAGILITY AND CREDITWORTHINESS OF  
SMEs: POTENTIALITIES OF THE FUZZY LOGIC**

Gail Denisse Chamochumbi Diaz, Laerte Sorini, Federica Palazzi

*University of Urbino Carlo Bo*

*With the collaboration of Banca di Pesaro Credito Cooperativo*

# Purpose of the study

- ▶ This paper aims to address the SME's credit access issues by providing a model based on fuzzy logic, which allows us to assign a level of creditworthiness considering both quantitative and qualitative indicators.
- ▶ Starting from a set of financial and non-financial parameters, the aim is to identify the SMEs which are most deserving and most capable of fulfilling their financial commitments to banks.

# Literature background

- ▶ Enterprises can only reach their full potential if they obtain the finances needed to start, sustain and grow their business (OECD, 2022).
- ▶ It is widely recognized that **SMEs are typically at a disadvantage** compared with larger firms **when accessing finance**, owing to opacity, under-collateralization, high transaction costs, and lack of financial skills (Kumar et al., 2022).
- ▶ Consequently, **SMEs generally face higher interest rates and tighter borrowing terms and are more likely to be credit-rationed** than large firms, **more so during periods of downturn** (Kremp & Sevestre, 2013).
- ▶ **Financial institutions**, such as banks which represent the primary financial source for SMEs (European Central Bank, 2021; European Central Bank, 2014), **employ credit assessment systems to manage credit risk by quantifying it** (Wang & Ku, 2021).
- ▶ **Measuring SMEs creditworthiness is inevitably complicated for banks** (Kumar et al., 2022).

# Literature background

- ▶ **Most extant credit rating systems are data-intensive**, mainly financial information, and have been criticized for struggling to accurately estimate SMEs' credit ratings (Kumar et al., 2022; Men & Xu, 2007).
- ▶ **To tackle the problem of the finance gap for SMEs, some studies propose credit assessment systems using financial and non-financial variables** (usually vague and difficult to define), adopting a fuzzy approach (Kumar et al., 2022; Guo & Zhao, 2017; Men & Xu, 2007). The fuzzy set theory can solve the practical problems in an uncertain environment (Stefanini et al., 2008).
- ▶ **Some advantages of fuzzy approach applying to SMEs creditworthiness:**
  - ❖ **Includes financial and non-financial information** (past and current data);
  - ❖ **Offers a means of tackling a multi-criteria decision process;**
  - ❖ **Versatility:** it can adapt to the lending policies decided by institutional intermediaries (i.e. tight, favourable, etc.);
  - ❖ **Adopt easy-to-use “natural” language to query data.**
- ▶ **However, there is a gap in the literature.** Until now few studies have adopted the fuzzy approach to assess SMEs, particularly in the Italian context.

# Methodology

- ▶ Sample selection criteria:
  - Small and medium sized: by number of employees (more than 9 and less than 250).
  - Geographical area: Municipality of Pesaro, Italy.
- ▶ Sources:
  - Atoka database (Cerved) was used to extract the sample and to obtain non-financial information, such as level of internationalization and engagement towards SDGs.
  - AIDA database to get financial information: profitability, leverage, and productivity ratios.
- ▶ Composition of final dataset: **117 SMEs**

# Fuzzy approach - Select n. 6 attributes or specifications

Attributes were identified based on current literature and consultation with practitioners.

## Financial information

1. Ebitda margin
2. Return on assets
3. Productivity ratio
4. Financial independence ratio



### *What do they reveal?*

- A snapshot of what the enterprise has been able to do.

## Non-financial information

1. Foreign market affinity
2. Engagement towards SDGs



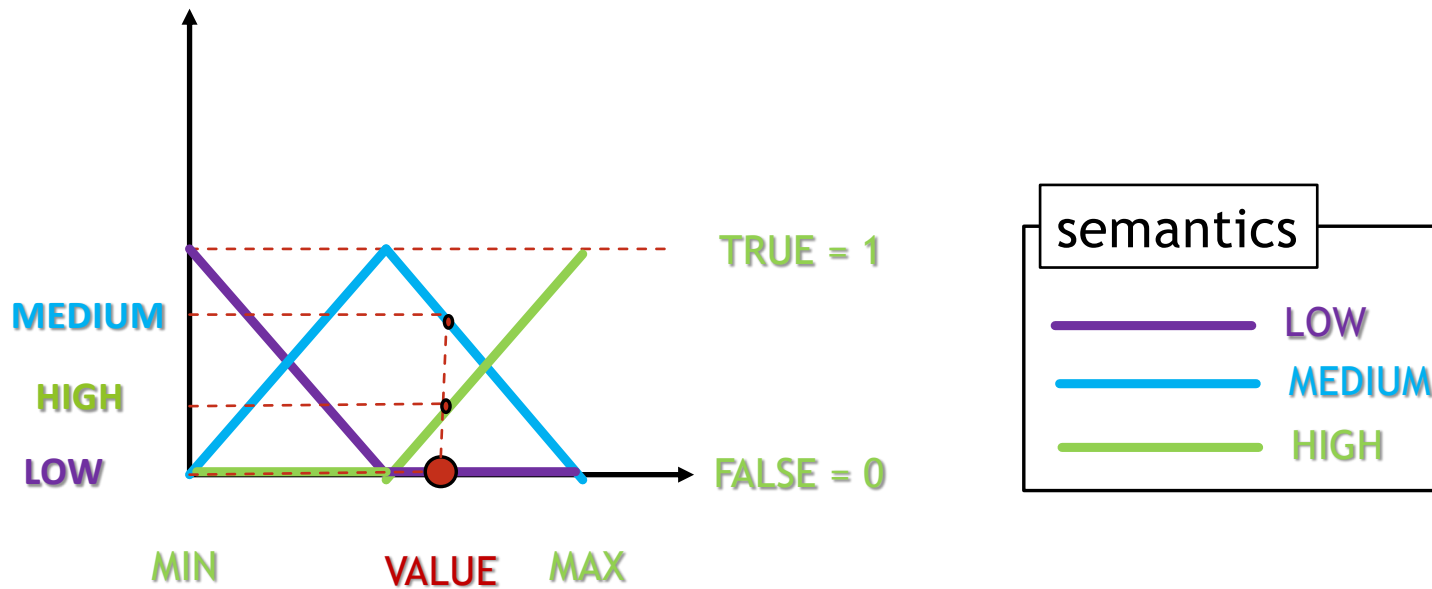
### *What do they reveal?*

- A proxy of strategic vision and planning in the long term.
- The firm's development prospects

# The Database

n°	Ragione Sociale	Foreign market affinity	SDGs	EBITDA/Vendite (%) 2021	(ROA) (%) 2021	Valore aggiunto pro-capite EUR 2021	Grado di indip. da terzi % 2021
1	ADRIA ASPIRAZIONI PNE S.P.A.	69,00	40,00	6,06	5,04	51560,00	0,18
2	AG	77,00	65,00	9,44	3,79	54390,00	0,24
3	A	91,00	40,00	6,87	2,68	45180,00	1,35
4		100,00	71,00	0,53	-0,38	45280,00	0,11
5		100,00	40,00	5,88	4,82	51330,00	0,15
6		99,00	39,00	0,77	-1,80	50140,00	0,37
7		100,00	63,00	3,44	6,54	158100,00	0,31
8		96,00	57,00	14,88	8,50	57600,00	3,25
9		43,00	40,00	25,33	6,16	65390,00	1,90
10		86,00	40,00	4,41	1,63	46580,00	0,54
11		100,00	39,00	8,77	6,49	64120,00	1,31
12		100,00	50,00	26,81	6,76	127960,00	7,79
13		23,00	40,00	12,15	10,49	59510,00	0,58
ID company							
112		70,00	40,00	15,02	24,35	56000,00	2,44
113		20,00	39,00	-1,77	-3,21	21670,00	0,04
114		100,00	44,00	7,04	6,67	58980,00	0,19
115		99,00	39,00	9,78	11,42	64900,00	0,61
116	XA	100,00	50,00	19,54	14,46	84480,00	2,13
117	ZAIA S.p.A.	14,00	40,00	6,22	6,46	32880,00	0,02
UNIVERSO	minimo valore del Cluster	7,00	39,00	-19,28	-9,88	11130,00	-0,50
	massimo valore del Cluster	100,00	76,00	45,49	38,29	224750,00	27,16
	range del Cluster	93,00	37,00	64,77	48,17	213620,00	27,66

Definition of fuzzy semantics on a single attribute through triangular fuzzy numbers with sum=1



**Foreign market affinity**

- MIN=7
- MAX=100
- MP=(medium point)=53,5

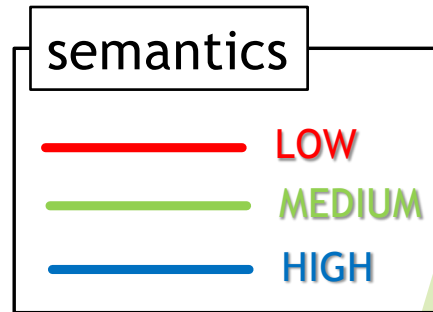
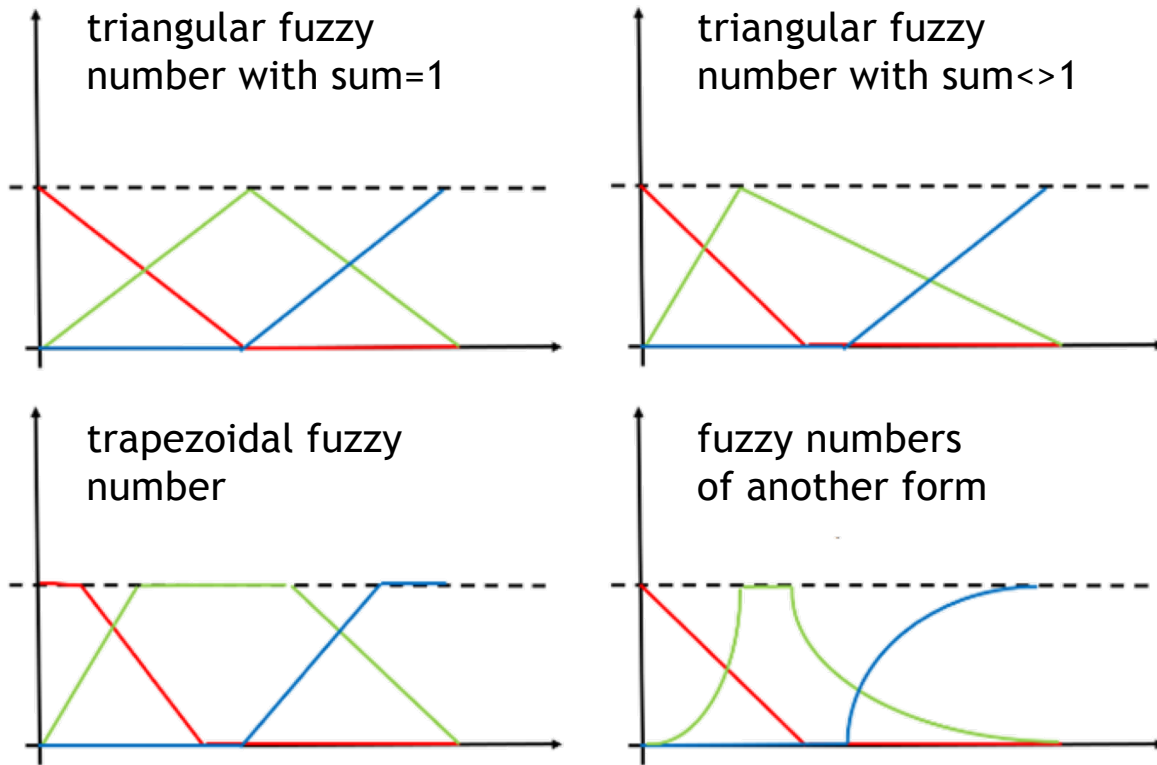


**Foreign market affinity**

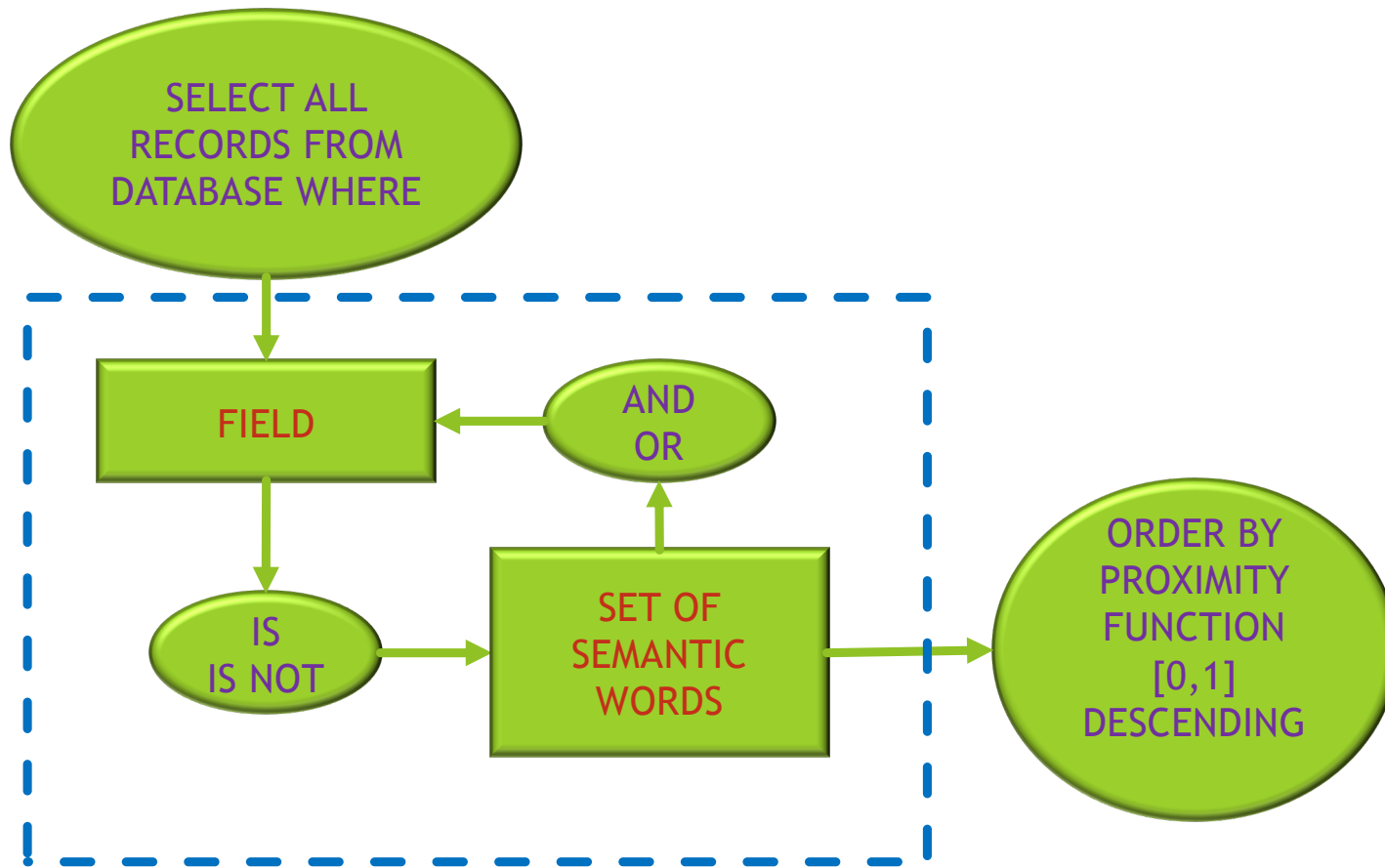
- VALUE=69
- LOW with value=0
- MEDIUM with value= 0,6666..
- HIGH with value= 0,33333..



# fuzzy number types with related semantics



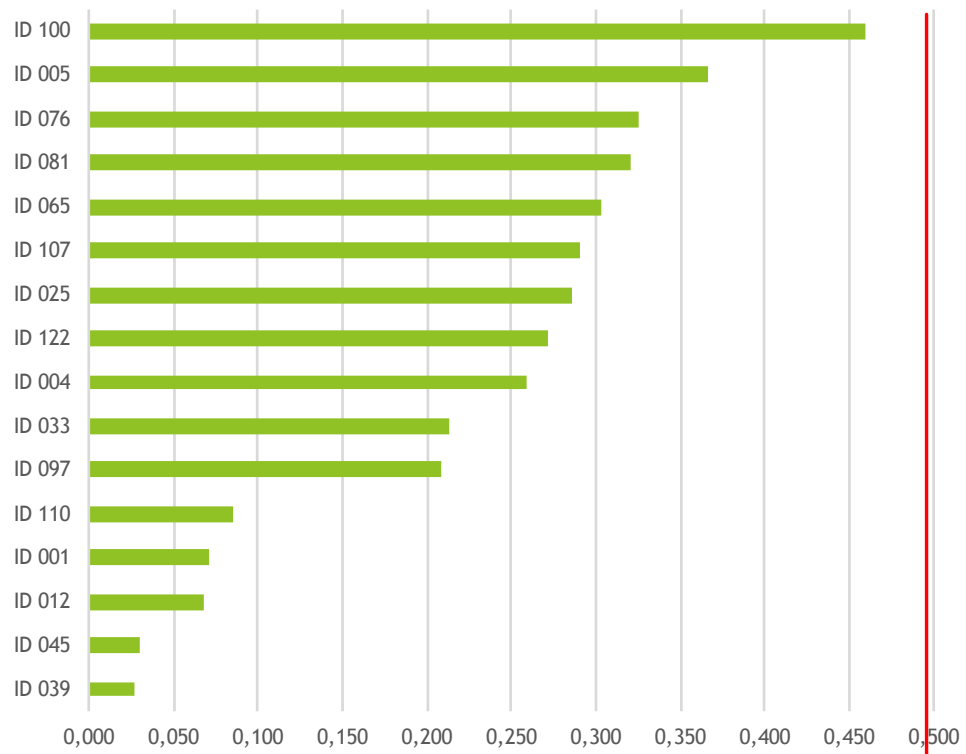
# building a natural language query like AI



# FOUR QUERIES AND SCENARIOS

	ATTRIBUTES																		
	NON FINANCIAL						FINANCIAL												
	Foreign market affinity			SDGs			EBITDA/Vendite (%) 2021			(ROA) (%) 2021			Valore aggiunto pro-capite EUR 2021			Grado di indep. da terzi % 2021			
query1	IS	LOW	AND	IS	LOW	AND	IS	LOW	AND	IS	LOW	AND	IS	LOW	AND	IS	LOW	Scenario "very precarious"	
query2	IS NOT	LOW	AND	IS NOT	LOW	AND	IS NOT	LOW	AND	IS NOT	LOW	AND	IS NOT	LOW	AND	IS NOT	LOW	Scenario "promising"	
query3	IS	LOW	AND	IS	LOW	AND	IS NOT	LOW	AND	IS NOT	LOW	AND	IS NOT	LOW	AND	IS NOT	LOW	Scenario "misleading"	
query4	IS NOT	LOW	AND	IS NOT	LOW	AND	IS	LOW	AND	IS	LOW	AND	IS	LOW	AND	IS	LOW	Scenario "potentially promising"	

► *Query 1: Show me firms with LOW financial indicators, and LOW non-financial indicators*



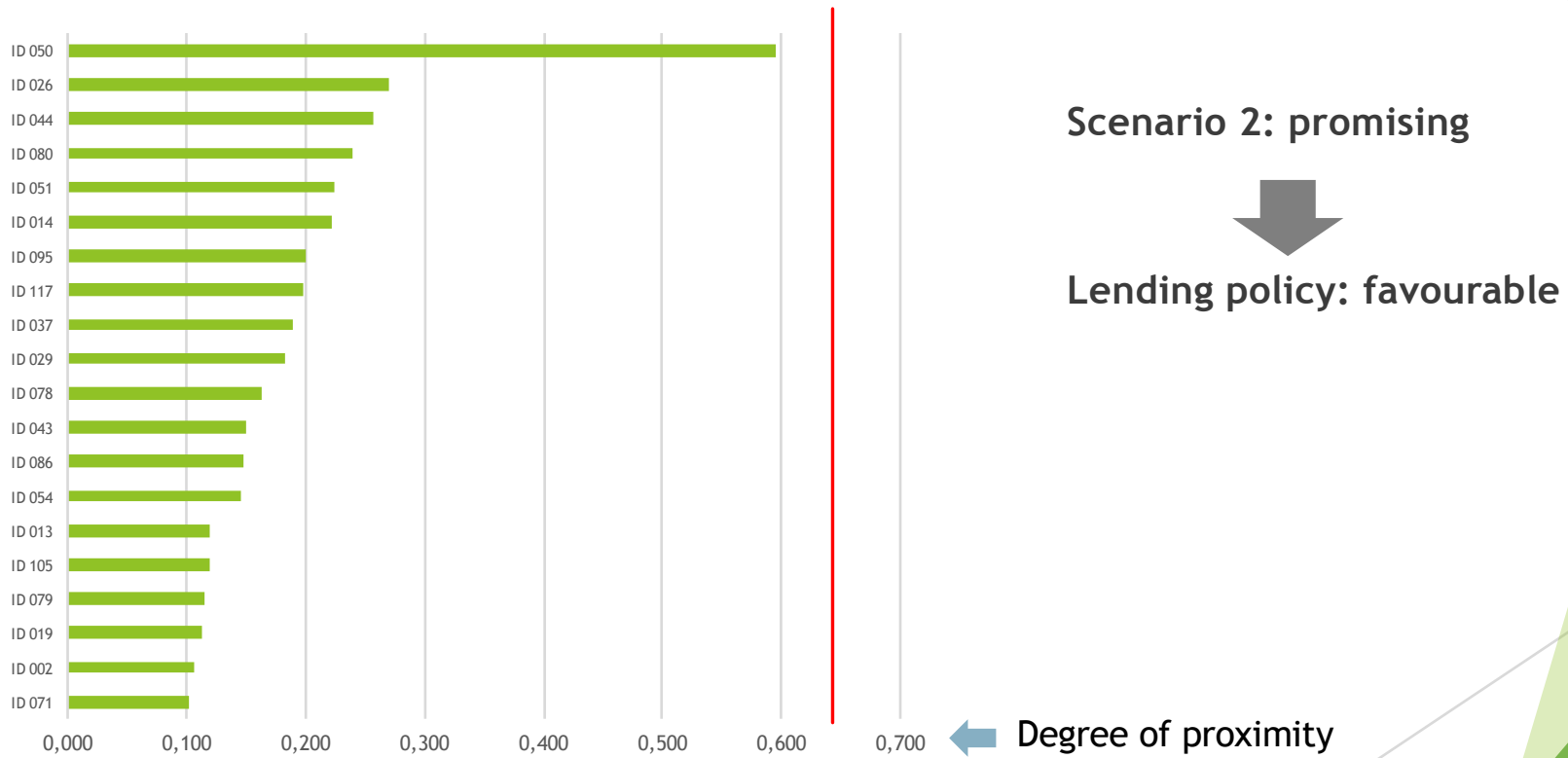
Scenario 1: very precarious



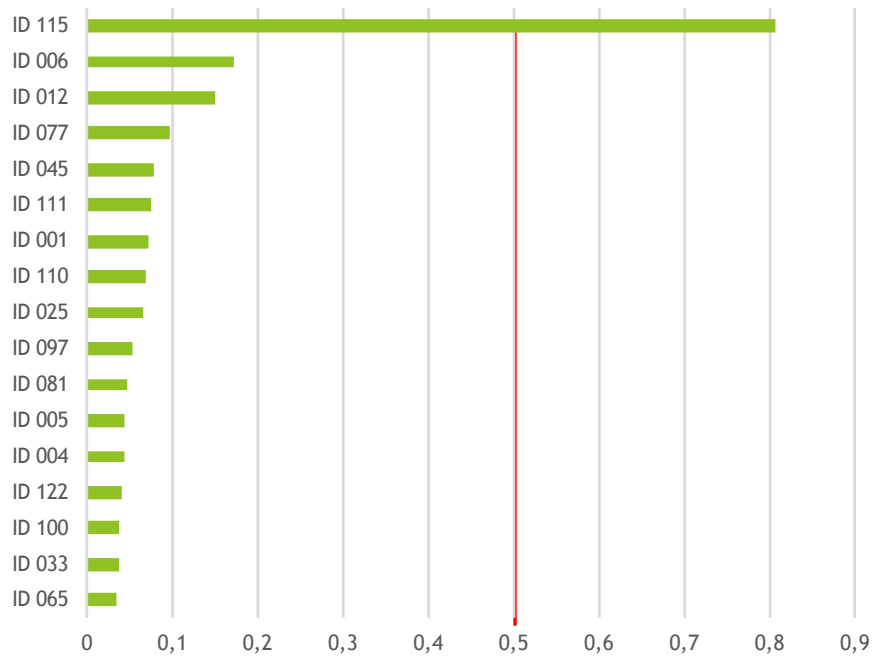
Lending policy: tight

← Degree of proximity (from 0 to 1)

► **Query 2: Show me firms with MEDIUM and HIGH financial and non-financial indicators**



► **Query 3: Show me firms with MEDIUM and HIGH financial indicators and LOW non-financial indicators**



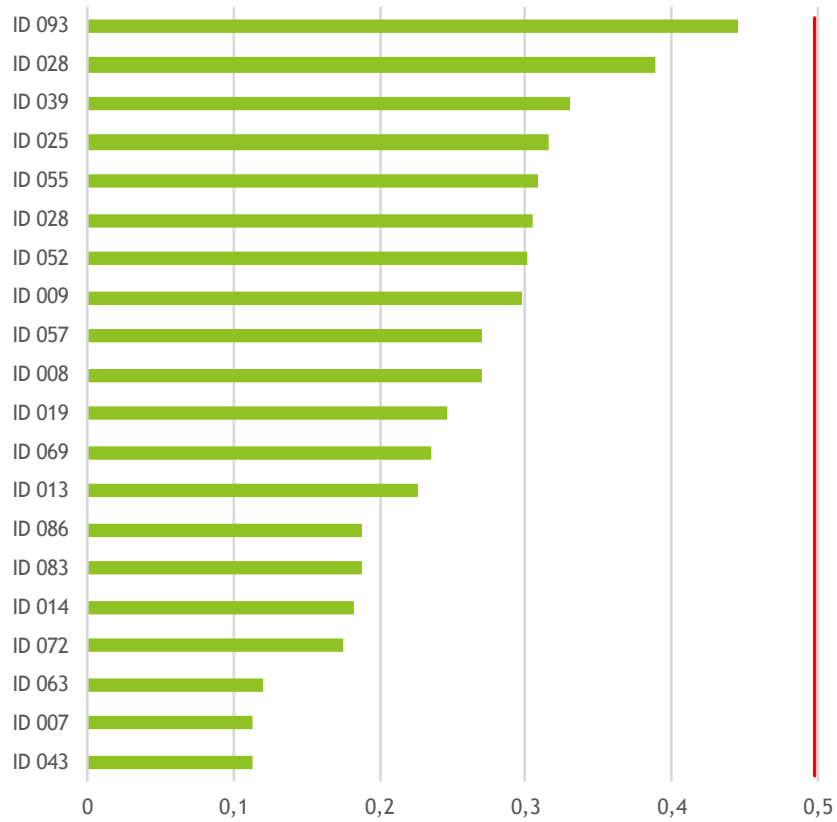
**Scenario 3: misleading**



**Lending policy: cautious**

← **Degree of proximity**

► **Query 4:** Show me firms with *LOW* financial indicators and *MEDIUM* and *HIGH* non-financial indicators



Scenario 4: potentially promising



Lending policy: enterprising

← Degree of proximity

# Implications

From a theoretical point of view:

- The study advances the extant literature about creditworthiness in SMEs, specifically in the Italian context.
- It offers empirical evidence of the adoption of the alternative «fuzzy approach» to credit assessment systems including non-financial information.

From a practical standpoint:

- Entrepreneurs should be more cooperative with financial institutions, providing clear and relevant information about their growth strategies.
- Financial institutions should be more aware of the urgent need to include non-financial information in SMEs' creditworthiness process. This can improve the efficient allocation of funds to the most promising enterprises, avoiding the so-called «zombies».
- For financial institutions the “fuzzy approach” represents a predictive and constructive means to support their decision-making process.



## Limits

- ▶ A limited number of SMEs were considered in the dataset; future research could embrace a wider sample of Italian SMEs, so as to offer a complete picture at the regional level.
- ▶ Regarding non-financial variables used, we considered the level of internationalization and the commitment to SDGs; the next step would be to include other non-financial information considered by lenders as relevant to assess the firm's "state of health", such as market and social position.
- ▶ The findings might change over time; as a result, a periodic evaluation may reveal additional information about the enterprise's performance.
- ▶ Another future step work on a fuzzy database that contains non-numeric but fuzzy information.



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# Thank you for your attention

Denisse Chamochumbi [gail.chamochumbidiaz@uniurb.it](mailto:gail.chamochumbidiaz@uniurb.it)  
Laerte Sorini [laerte.sorini@uniurb.it](mailto:laerte.sorini@uniurb.it)  
Federica Palazzi [federica.palazzi@uniurb.it](mailto:federica.palazzi@uniurb.it)