

PRODUCTIVITY DYNAMICS OF ITALIAN FIRMS: PATTERNS, DETERMINANTS AND NEW CHALLENGES IN THE WAKE OF THE PANDEMIC CRISIS

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ITALIAN FIRMS IN TIME OF TROUBLES: COVID-19 PANDEMIC AS A TEST OF STRUCTURAL SOLIDITY

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Motivation

- Covid-19 pandemic generated the deepest recession from WWII
- Sectors and firms have been (and are being) affected both directly (selective lock-downs and limitation in activities) and indirectly (decrease in consumption, bottlenecks in domestic and international supply chains, liquidity issues)
- Though generalised, the consequences of the pandemic hit firms and industries heterogeneously
- Differences may also depend on structural and behavioural characteristics of firms and industries before the pandemic
- In order to study the capability of recovery of the Italian business system we need to know which are the elements that allow firms for being resilient (and avoiding to suffer from long-Covid)
- In particular, we study the structural robustness of the business system by stressing the profile of solidity and fragility of Italian firms

Literature

- The work refers to the literature that study the effects of the pandemic trying to stress the elements of resilience and fragility, focusing on pre-crisis structural, strategic and performance profiles of firms. Three main strands can be acknowledged, according to the focus of the analysis:
 - **Business dynamics** (size, productivity, innovation) (OECD, 2020; Bartik et al., 2020; WTO, 2021)
 - **Digitalisation** (intangibles, network effects) (Andrews et al., 2016; Gal et al., 2019; Corrado et al., 2021)
 - **Financial solidity** (Çelik et al, 2019; Aramonte and Avalos, 2020; Demmou et al., 2021)
- In the work, the analysis is focused on five pillars that may explain the structural solidity/fragility:
 - Economic dimension
 - Performance
 - Internal organization
 - External organization
 - Digitalisation and innovation

Highlights from the pandemic

- At the end of 2020, almost 60% of firms reported a decrease in turnover higher than 10%, and about 62% of firms expected revenues to decrease also in the first six months of 2021
- 32.3% of firms reported the presence of economic and organizational factors capable of jeopardize their survival
- Less than one out of five firms expected to expand its activity or keep it up in the first half of 2021
- 38.3% of firms indicated the decrease in domestic demand among the major constraints on the possibility of recovery during the first half of 2021, 15.8% of firms reported problems on foreign demand
- 34.1% expected risks of illiquidity
- In all industries the share of firms with a sharp decline in turnover, as well as that of firms at operational risk, tends to decrease as the firms size increases

Data

- The dataset used covers 40.2K firms representative of the whole population of about 1.0M business units over 3 workers
- It integrates the following informative sources:
 - Covid-19 survey (2nd wave, December 2020)
 - Frame-SBS Register
 - RACLI Register
 - ASIA Groups Register
 - Multi-purpose survey (Permanent Census Plan)

Industries	Firms	Turn-over		Value added		Workers	
	Units	Mln euros	Percentage	Mln euros	Percentage	Units	Percentage
Sample							
Industry	13740	489390	53.1	103085	47.7	1078744	38.4
Construction	3529	18860	2.0	5397	2.5	89131	3.2
Market services	19850	396897	43.1	100791	46.6	1522503	54.2
Personal services	3125	16162	1.8	6900	3.2	117623	4.2
Total	40244	921309	100.0	216173	100.0	2808002	100.0
Population							
Industry	192723	1204276	39.3	281654	38.2	3741755	29.9
Construction	109718	135376	4.4	43773	5.9	874339	7.0
Market services	621697	1638705	53.5	382889	51.9	7148718	57.2
Personal services	94087	85134	2.8	29606	4.0	742383	5.9
Total	1018225	3063490	100.0	737921	100.0	12507194	100.0

Empirical strategy | Classification problems

- The work aims at providing a taxonomy of structural solidity of Italian firms based on a set of five complex characteristics
- The classification is defined by using ROC analysis
- ROC analysis is rooted in classification problems where a classifier is used to explain the status of observations
- The classifier can give four different outcomes with respect to the actual status of observations (confusion matrix), where the efficiency of the classifier can be assessed by using two metrics:
 - **Sensitivity** measures the ability of the classifier to detect true positives, i.e. $TP/(TP+FN)$
 - **Specificity** measures the ability of the classifier to detect true negatives, i.e. $TN/(TN+FP)$

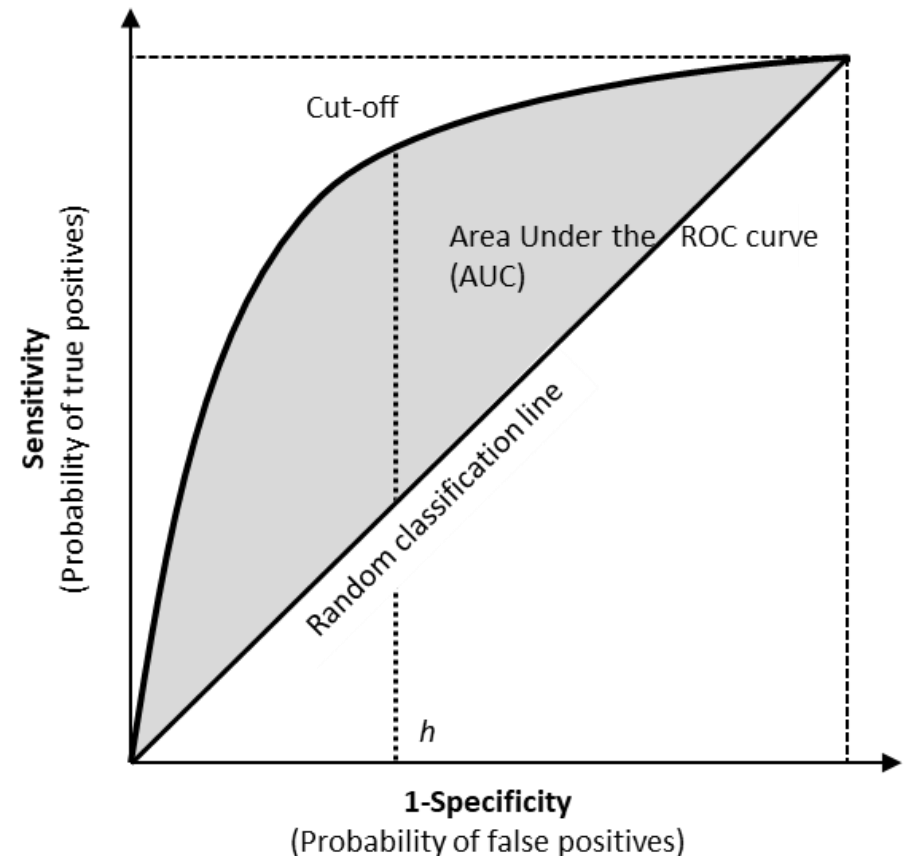
		Estimated classification	
		1	0
True classification	1	<i>TP</i>	<i>FN</i>
	0	<i>FP</i>	<i>TN</i>

Empirical strategy | ROC analysis

- Considering a logit model, the distribution of probabilities resulting from the estimates can be displayed in the space of **Sensitivity** and **1-Specificity** by the ROC curve
- the ROC curve represents the probabilities assigned to each observation considering the trade-off between the probability of detecting true or false positives across all possible cut-off along the values of the classifier
- The observation that most efficiently discriminates between positives and negatives (*Cut*), can be obtained by maximizing the following:

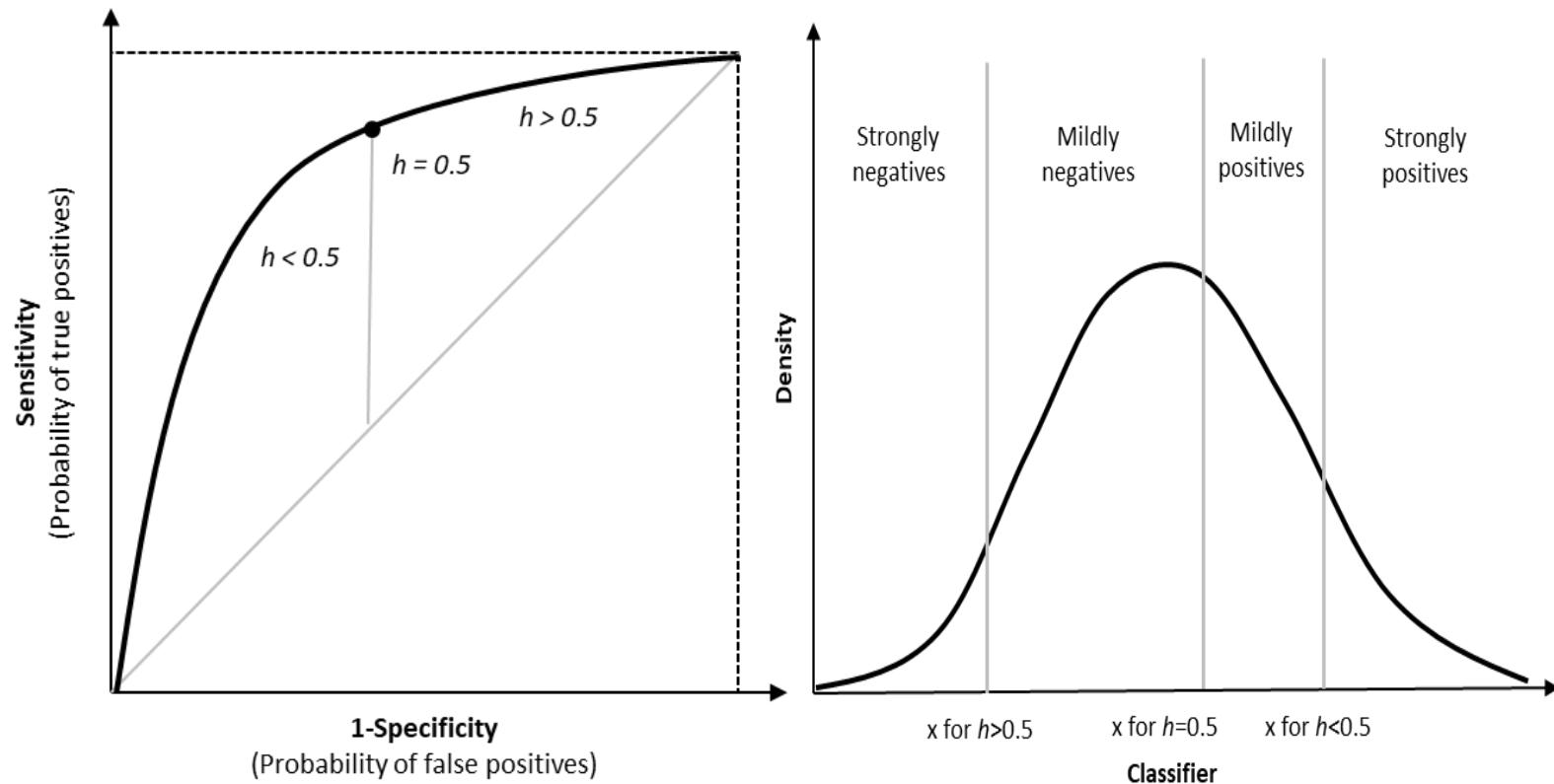
$$Cut = h * sensitivity - (1 - h) * (1 - specificity)$$

where h and $(1 - h)$ represent the relative weights to manage the trade-off between true and false positives



Empirical strategy | Sliding h

- Setting-up a value of h two estimated classes of observations (Manichean classification) can be obtained, according to the relative position of each of them with respect to the cut-off unit
- $h < 0.5$ (h_-) corresponds to a **conservative** selection
- $h > 0.5$ (h_+) corresponds to a **liberal** selection
- $h = 0.5$ ($h_=\!)$ corresponds to a **neutral** selection (Youden's index)
- Shifting the value of h from 0 to 1, therefore, allows to define different cutoffs (and, thus, classifications), involving different "evidences" with respect to the given estimated status



Empirical strategy | Variables

Risk (dependent variable)	Elementary components	Type
Operative risk	Item of the questionnaire of the Covid-19 survey 2nd wave	Binomial
Pillars (covariates)	Elementary components	Type
Economic size	Numer of workers	Continuous
	Turn-over	Continuous
	Age	Continuous
	Capital intensity	Continuous
Performance	Productivity	Continuous
	Profitability	Continuous
	Cost competitiveness	Continuous
Internal organization	Presence of external management	Binomial
	Belonging to groups	Binomial
	Share of high skilled workers	Continuous
	Share of workers with permanent position	Continuous
	Average compensation of employees	Continuous
	Presence of investments in human resources	Binomial
External organisation	Presence of non-arms lenght agreements with other firms	Binomial
	Number and typology of non arms-lenght agreements with other firms	Multinomial
	Capability of activation of the productive system	Continuous
	Internationalisation	Binomial
Digitalisation and innovation	Presence of investments in innovation	Binomial
	Technology adoption	Continuous
	Presence of investments in digitalisation	Binomial

Empirical strategy | Definition of the composite

- ROC analysis supports only one covariate. The composite used in the ROC analysis is obtained as a linear combination of the five pillars as follows:

$$C_i = \alpha_1 ES_i + \alpha_2 P_i + \alpha_3 IO_i + \alpha_4 EO_i + \alpha_5 ID_i$$

where weights are the estimated coefficient of the following logit:

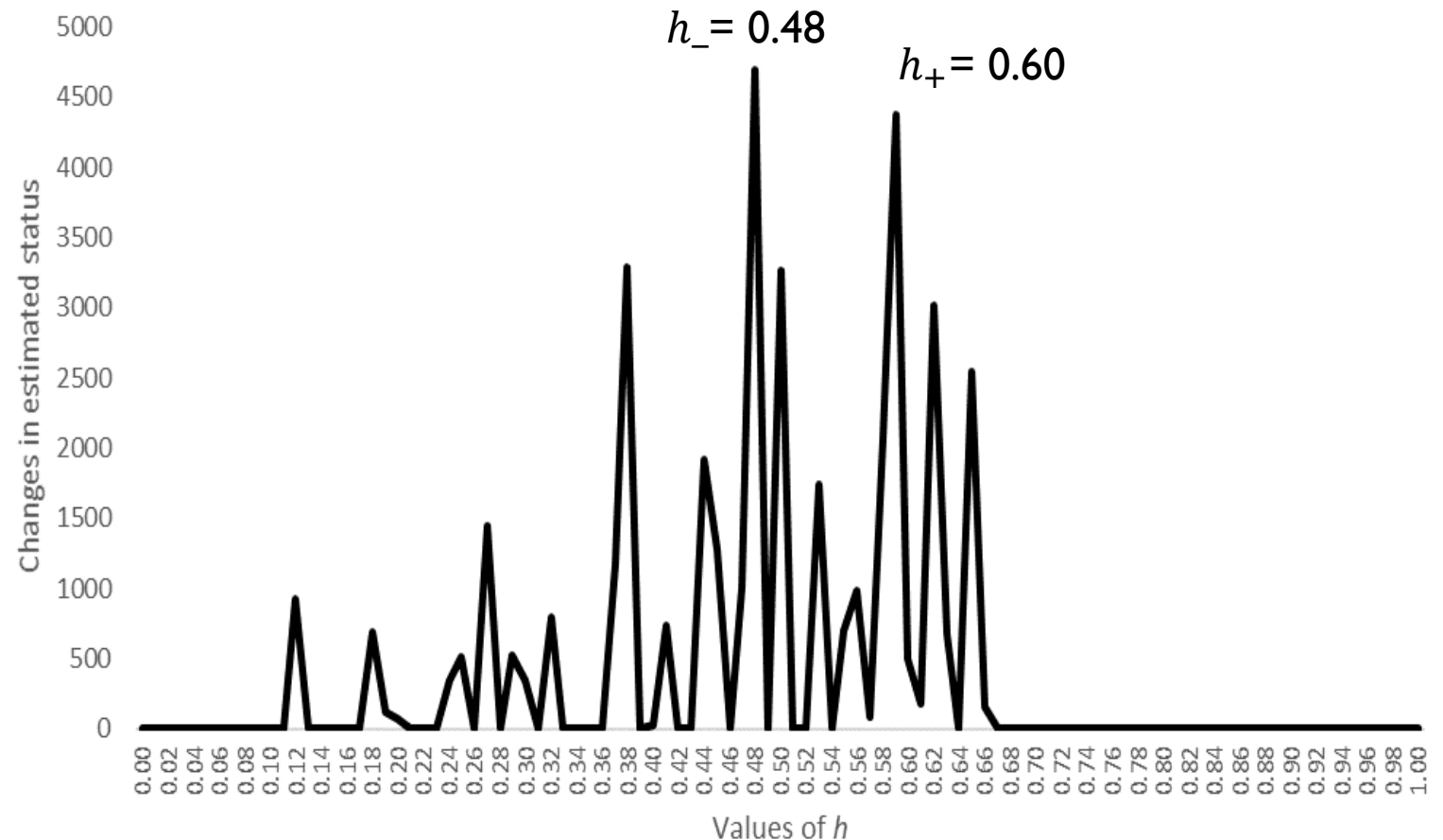
$$\begin{aligned} & \text{Prob}(\text{Solidity}_i = 1 | ES_i, P_i, IO_i, EO_i, ID_i, nace_i, geo_i, liq_i, diff_i) = \\ & \Lambda(\alpha_1 ES_i + \alpha_2 P_i + \alpha_3 IO_i + \alpha_4 EO_i + \alpha_5 ID_i + \alpha_6 nace_i + \alpha_7 geo_i + \alpha_8 liq_i + \alpha_9 diff_i) \end{aligned}$$

- Once the status (i.e. the economic solidity) and the classifier (i.e. the composite) are defined, the ROC analysis can be carried out starting from the following logit:

$$\text{Prob}(\text{Solidity} = 1 | C)_i = \Lambda(\alpha C)_i$$

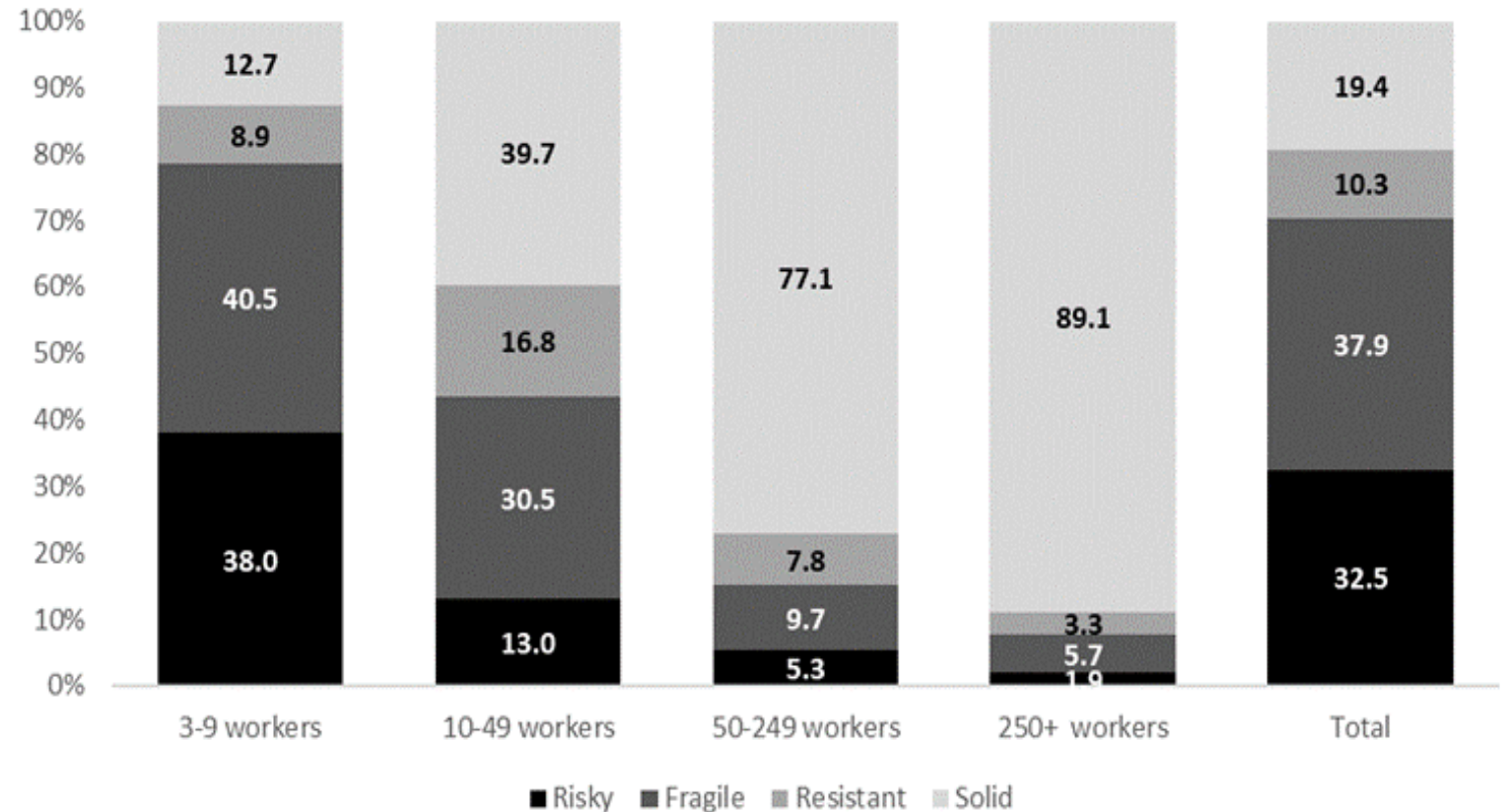
Empirical strategy | Definition of cut-offs

- Once the ROC curve is obtained the four-class taxonomy is obtained in three steps
- To define a first classification using neutral selection ($h_{=}$) so as to obtain two classes (solid and fragile)
- To run hundred ROC (one for each 0.01 step in the value of h)
- Moving from the neutral selection towards both conservative ($h < 0.5$) and liberal selection ($h > 0.5$), to identify the cut-offs in h_{-} and h_{+} corresponding to the higher jumps in firms distributions along sliding h



Results | Taxonomy

- Once the cut-offs are obtained, the four-class taxonomy can be obtained as follows:
 - **Solid:** firms laying over the threshold estimated in correspondence of $h = 0.48$
 - **Resistant:** firms laying over the threshold for $h = 0.50$ and under the threshold for $h = 0.48$
 - **Fragile:** firms under the threshold for $h = 0.50$ and over the threshold for $h = 0.60$
 - **Risky:** firms under the threshold for $h = 0.60$



Results | Descriptive

- Solid firms account for less than 20% of Italian business units and represent the most significant share in terms of employment (54.9%) and value added (76.4%)
- Risky firms account for 32.5% of the total but they play a much less significant role in the economy (14.4% of employment and 4.1% of value added)
- Fragile firms are the relative majority of units (37.9%) and represent 21.9% of total workers and 12.6% of total value added
- Resistant firms account for 10.3% of units, representing 8.7% of total employment and 6.9% of value added
- Manufacturing shows the higher contribution of the overall solidity in terms of units, employment and value added. The condition of firms appears worrying especially in Construction and Other services activities, where 61.7% of firms are Fragile and nearly half (49%) are Risky respectively.

Results | The role of pillars

- For each class, we are able to stress the role of the five pillars in determining the positioning of firms
- For each indicator, his role increases moving towards higher solidity classes, confirming that increasing degrees of solidity are positively associated to the pillars
- A positive status (Resistant or Solid) is associated with above-average economic size, and digitalisation and innovation
- Above the average values of performance, internal and external organization do not guarantee a status of solidity or resistance but it discriminates within smaller and less digitalized firms between a condition of fragility and risk

Pillar	Distance from the average by class (Class/Total average ratio)			
	Risky	Fragile	Resistant	Solid
Economic size	0.510	0.840	1.099	1.567
Performance	0.776	1.016	1.048	1.069
Internal organisation	0.640	1.068	1.128	1.403
External organisation	0.598	1.139	1.173	1.310
Digitalisation and innovation	0.303	0.694	1.480	2.512

Conclusions

- The work uses ROC analysis to define a four-class taxonomy of structural solidity of Italian firms during the pandemic in order to stress the drivers of resilience and solidity
- The analysis considers five pillars accounting for different aspects of firms structure, performance and strategies
- The Italian business system is found to be strongly weakened by the crisis, even if a core of solid firms (mostly medium and large size units) shows a high capability to react
- Fragility and risk are mostly associated with smaller firms, partly independently from sectors-specific factors
- Size, and digitalisation and innovation are found to be the characteristics that mostly impacted in the positioning of firms across the classes of solidity
- Other pillars (performance, and internal and external organization), even if relevant in determining the degree of solidity seem to contribute to a lesser extent to the solidity of firms

thank you.

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