Are efficiency measures predictive of firm crisis? Evidence from the Italian agrifood industry

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Contents

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<u>Selected Related Literature</u>

- Audretsch and Mahmood 1995
- Geroski et al. 2010;
- Strotmann 2007
- Josefy et al. 2017;

1. We employ a unique dataset with all agrifood companies failed from 2008 to 2017 in Italy with an associate group of alive companies selected by propensity score method;
2. We compute the impact of infrastructure level on the productivity of companies, an open issue in the literature, by applying an appropriate nonparametric approach without any a-priori assumption;
3. We compare different innovative measures of productivity (whose effect is often ambiguous) including a measure of managerial performance, as well as other covariates used in previous established studies, that might affect the likelihood of firm failure.

Methodology

Methodology

Two-stage approaches → Nonparametric Conditional Efficiency Frontier - Panel Data

- Aim: analyzing the role of context and locatio factor in spurring productivity growth via the analysis of the impact over time of environmental factors (Infrastructure) on efficiency.
- Literature of frontier model with environmental factor:
  → Daraio and Simar (2005)
  → Simar and Wilson (2007, 2011)→ problem with two stage approach
- Separability issue: unit facing different environmental conditions. Environmental variable may influence the production process in two way:
  1. May affect the attainable set: $\Psi^z = \{(x, y)|Z = z, x \text{ can produce } y\}$,
  2. May affect the efficiency distribution
  3. Daraio et al. (2018) propose a test for separability condition

Methodology

- Following **Cazals et al. (2002), Daraio and Simar (2005), Bădin et al. (2012), Mastromarco and Simar (2015):**
  $\rightarrow$ **nonparametric efficiency frontier panel data model with environmental factors**
- According to Mastromarco and Simar (2015), we consider the time T as an additional conditioning variable and, for each time period t, define the attainable set $\Psi_t^z \subset \mathbb{R}_+^{p+q}$ as the support of the conditional probability:

$$H^t_{X,Y|Z}(x, y|z) = Prob(X \leq x, Y \geq y|Z = z, T = t)$$

- Accordingly, the conditional output-oriented technical efficiency of a production plan $(x, y) \in \Psi_t^z$, at time t facing conditions z, is defined in (Daraio and Simar, 2005) as

$$\lambda_t(x, y|z) = \sup\{\lambda|(x, \lambda y) \in \Psi_t^z\} = \sup\{\lambda|S^t_{Y|X,Z}(\lambda y|x, z) > 0\}$$

where $S^t_{Y|X,Z}(y|x, z) = Prob(Y \geq y|X \leq x, Z = z, T = t)$.

Conditional efficiency scores

- $\lambda_{i,t}(X, Y|Z, T)$ taking into account the time dependence in the value added; shift of the frontier; Infrastructure affect the production process.
- $R_O(X_{i,t}, Y_{i,t}|Z_{i,t}) = \frac{\hat{\lambda}^{DEA}(x,y|z)}{\hat{\lambda}^{DEA}(x,y)}$
- Analysis of $R_O(X_{i,t}, Y_{i,t}|Z_{i,t})$ marginally, as a function of Z:

2nd-Stage: regression of the conditional efficiencies

We use, as in **Bădin et al. (2012)**, the flexible location-scale regression model:

$$\lambda_t(X, Y|z) = \mu(z,t) + \sigma(z,t)\epsilon$$

where we assume that $E[\epsilon|z,t] = 0$ and $V[\epsilon|z,t] = 1$.
This model allows us to capture the location $\mu(z,t) = E[\lambda_t(X, Y|Z = z)]$ and the scale effect $\sigma^2(z,t) = V[\lambda_t(X, Y|Z = z)])$. So the idiosyncratic part of the conditional efficiency will be estimated for $i = 1, ..., n$ and $t = 1, ..., s$ by

$$\hat{\epsilon}_{i,t} = \frac{\hat{\lambda}_t(x_{i,t}, y_{i,t}|z_{i,t}) - \hat{\mu}(z_{i,t}, t)}{\hat{\sigma}(z_{i,t}),t)}.$$

We estimate a location scale model for $\hat{\lambda}_t(x_{i,t}, y_{i,t}|z_{i,t})$. So we obtain $\hat{\mu}(z_{i,t}, t)$ by regressing $log\hat{\lambda}_t(x_{i,t}, y_{i,t}|z_{i,t})$ on (t,z) and $\hat{\sigma}^2(z_{i,t}, t)$ by regressing the squared residuals of the preceding regression on (t,z).

Survival Analysis

In the second phase of this study, a COX proportional Hazard Regression is conducted on the statistical units, i.e. firms included in the dataset.

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The dependent variable is directly measured by the firm survival, computed on the basis of the firm exit date from the market, due to its inability to survive (e.g., Agarwal and Sarkar 2002; Klepper 2002).

Cox model

The Cox model specifies the hazard of firm exit as:

$$h_i(t) = h_0 exp(\beta^t x)$$

where $h_0(t)$ is the unknown baseline hazard function, x denotes the vector of covariates expected to shift the hazard of exit proportionally in each year, and β is a vector of parameters to be estimated **(Hosmer and Lemeshow 1999)**.

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This analytic method has been used by **Audretsch and Mahmood (1995)** to analyze new firm survival and, for example, by **Boyer and Blazy (2014)** in their analysis of survival of micro-startups. In addition, the findings of **Cader and Leatherman (2011)** provide strong support for the use of Cox hazard models for firm survival analysis.

Empirical Application

Data sources

Dataset	356 agrifood firms located in Italy, divided by Province
Period	2009 / 2018
Output	Added value
Inputs	Labour defined by the number of workers
	Capital stock defined by the material assets
Env. Variable	Indicator of infrastructure at province level

Data source: data are sourced from AIDA. The extraction was conducted selecting the activity code manufacture of agri food industry in line with Nace Rev.2, adopted by a large part of scientific literature.

Matching procedure

The sample is constituted by the total of firms dissolved during the period 2009/2018, in Italy, belonging to sector 10 of Nace Rev. 2 and non-dissolved firms, identified through the propensity score matching on the basis of the following observable characteristics:

- Revenues in 2009 (first year of the analysis);
- Province;
- Sector code;

Non-dissolved firms have been considered **right-censored.**

Infrastructure index

The level of competitiveness and attractiveness of a territory is determined by the adequacy of the economic and social infrastructures present in the reference areas:

- road and railway network;
- ports and airports;
- energy and environmental systems and networks;
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A PCA was carried out using the correlation matrix and in order to neutralize the effects of the different territorial dimension, the endowment indicator must be related to a similar indicator of potential demand (e.g. Population, surface or an actual demand indicator).

Full frontier

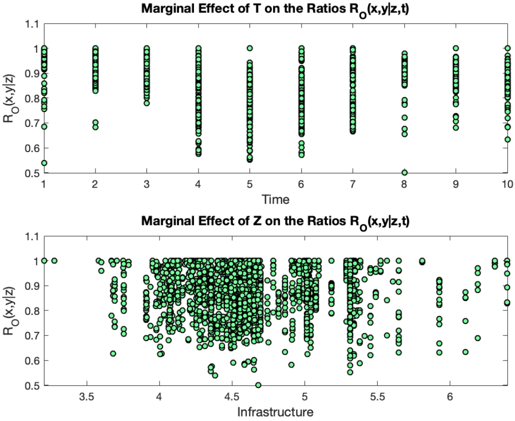

Figure: Full ratios $\hat{R}_0(x, y|z, t)$ as a marginal function of time and infrastructure for full frontier

Preliminary Results

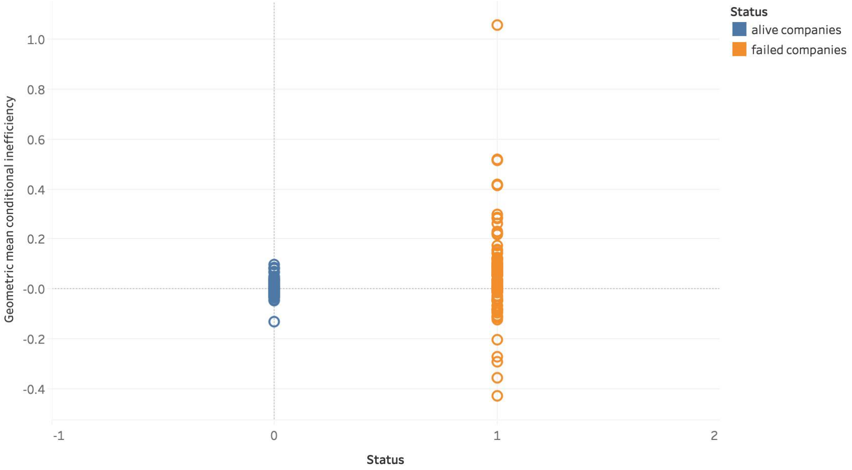

Figure: Geometric mean of conditional inefficiency rate

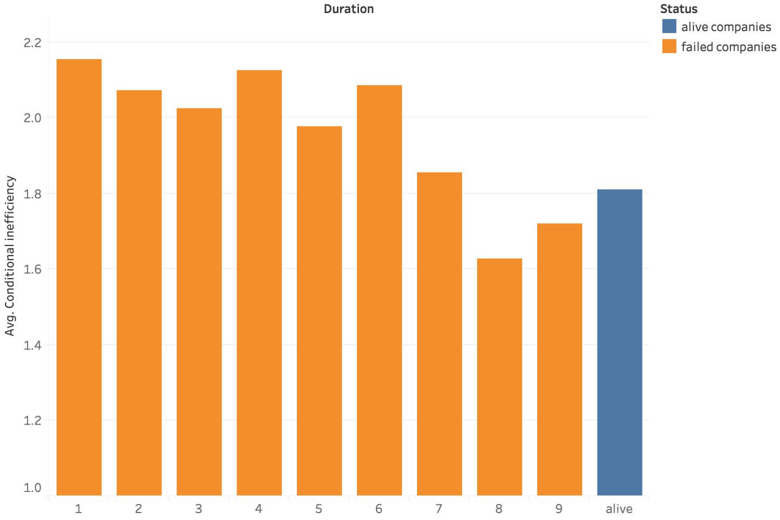

Figure: Average conditional inefficiency by duration

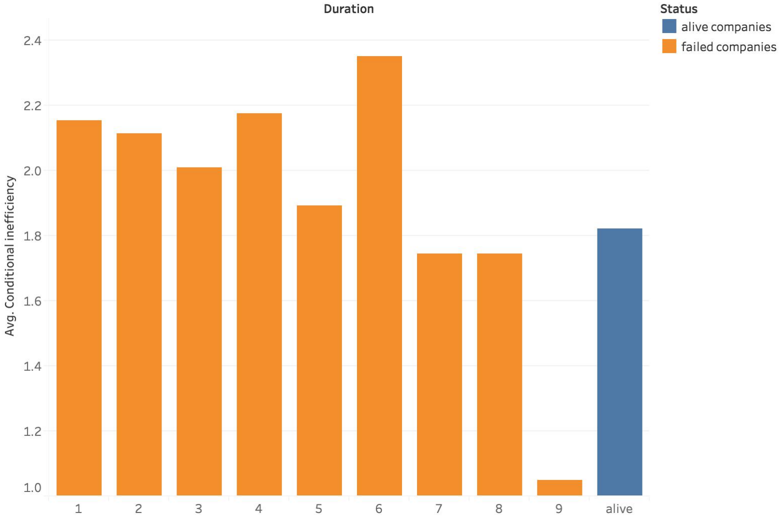

Figure: Average conditional inefficiency by duration, at last year of life of companies.

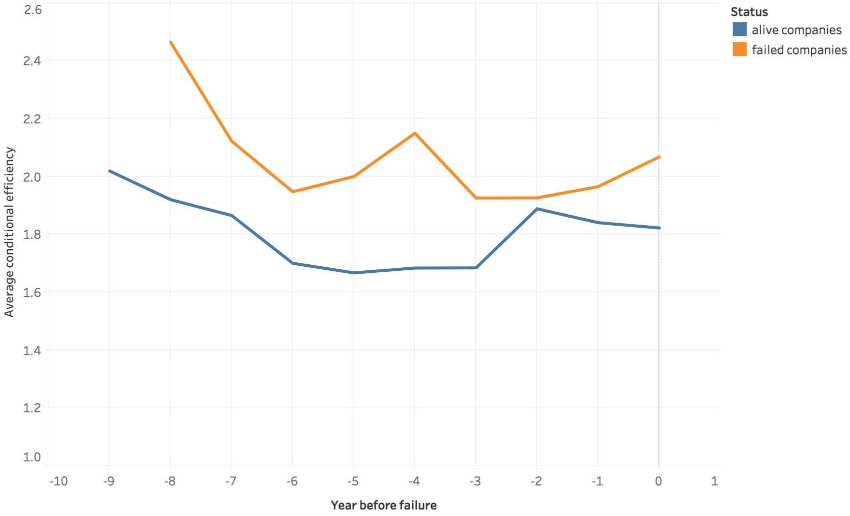

Figure: Average inefficiency registered in the years before the failure

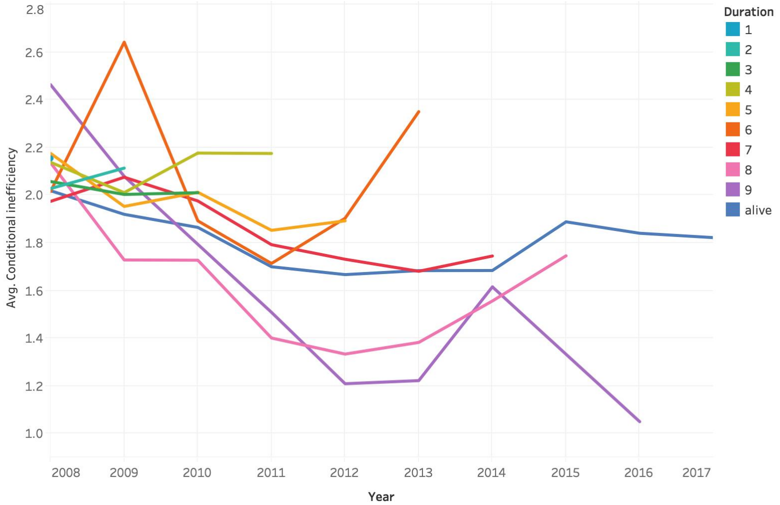

Figure: Average of conditional inefficiencies over the observation period, by duration

Cox model result

The Cox partial likelihood is obtained by using Breslow's estimate of the baseline hazard function. Managerial inefficiency (proxy for management quality), technical inefficiency and conditional inefficiency are greater than 1 and are a measure of inefficiency.
The results corresponding to the three considered measures of efficiency are shown in Equations I,II,III, respectively.
In addition, each equation involves net asset, liquid asset, investment rate and profitability: these variables come from established economic literature on survival analysis.

	MODEL I		MODEL II		MODEL III		MODEL IV	
	coef	HR	coef	HR	coef	HR	coef	HR
Net asset	-4.53e-05	1.00	(-4.47e-05)***	1.00	(-4.44e-05)***	1.00	(-4.38e-05)***	1.00
DEAMANAGERIAL	(1.62e-01)**	1.17	-	-	-	-	-1.122e-01	0.89
DEA	-	-	(3.11e-01)***	1.36	-	-	-	-
ZDEA	-	-	-	-	(3.26e-01)***	1.38	(4.96e-01)*	1.64
Liquid asset	1.65e-02	1.01	2-74e-02	1.03	2.67e-02	1.02	-	-
Investment rate	(-3.90e-02)***	0.96	(-3.89e-02)***	0.96	(-3.87e-02)***	0.96	(-3.85e-02)***	0.96
Profitability	(-1.23e-01)**	0.88	(-1.19e-01)**	0.88	(-1.18e-01)**	0.88	(-1.19e-01)**	0.88
Concordance	0.69	-	0.66	-	0.66	-	0.65	-
Likelihood ratio test	38.55 on 5 df, p=3e-07		41.94 on 5 df, p=6 e-08		42.28 on 5 df, p=5e-08		42.75 on 5 df, p=4 e-08	
Wald test	65.28 on 5 df, p=1e-12		69.73 on 5 df, p=1e-13		70.17 on 5 df, p=9e-14		68.28 on 5 df, p=2e-13	
Score (logrank) test	72.25 on 5 df, p=3e-14		72.36 on 5 df, p=3e-14		73.08 on 5 df, p=2e-14		72.14 on 5 df, p=4e-14	
Global p-value	0.17		0.188		0.102		0.128	
n	2240		2240		2240		2240	
N of events	171		171		171		171	

Table: In this table we show the results of the Hazard model.

Conclusion

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- There is a strong impact of infrastructure on productivity at firm level;
- The empirical evidence shows that inefficiency scores (managerial, technical and conditional) can reliably predict the probability of default.
- The probability of failure was higher for conditionally inefficient companies, as reflected in the measures of both managerial and technical inefficiency. This emphasizes on the role of infrastructure level on productivity and, consequently, on the survival of companies.

Thank you for attention!