Unity is strength? Credit risk in Corporate Networks

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Corporate networks

- 'Network contracts' are special contracts that companies can enter into with their related supplier/clients/partners.
- It is a tentative formalization of the 'network' among companies that should:
  - help (especially) SMEs in their growth and in the capacity of retrieving external financing –> curb asymmetry of information in the face of possible investors or lenders
  - promote innovation also among SMEs (for a review of networks' advantages and limits see Bentivogli et al., 2013).
- The economic literature focuses on the theoretical reasons for networks and on their effects, but there is still limited evidence on the effects of the participation to a network on credit risk/resilience to external shocks.
- In Italy, network contracts have been introduced formally in 2009.

Research question

- What is the impact of belonging to a corporate network on the company's individual default risk, i.e. the risk that the company is not able to meet its loan repayment obligations?

  Belonging to a network could translate into a
  - *network effect*: companies in the network could have common dependence (or, to the contrary, resilience) on sectorial and macroeconomic factors
  - *within-network effect*: possible contagion effects between companies in the network, but also possible commercial and financial advantages of being linked to other firms.
- How to include these effects in a credit scoring model?

Motivation

Investigating the effects of interlinkages between companies generated by corporate networks

- can help banks and other lending institutions to improve default prediction and credit risk assessment;
- support policy makers and regulators in assessing vulnerabilities for risk transmission;
- becomes even more important with the large growth of innovative financial technologies (Fintech) in the credit market such as P2P online lending platforms, which suffer lack of financial and behavioural information typically used in credit risk assessment.

Data

- Dataset of $\simeq$ 11992 Italian SMEs (source: ORBIS) belonging to a corporate network.
- Balance sheet information and key economic and financial ratios for active and defaulted companies from 2015 to 2019.
- Information on the geographic area (region) and the industry to which the companies belong.
- $\simeq$ 5.2% of companies defaulted in the period.
- 76% of the companies belongs to a network.
- A network can include companies belonging to different industries ($\simeq$ 40%) and to different regions ($\simeq$ 20%).

Proposal

A **mixed logit** model where the individual default probability depends on

- an idiosyncratic component (financial ratios)
- sectorial or macroeconomic risk factors, through a random slope common to all companies in the same network
- the number of links the company has through the network, which can be interpreted as a *centrality* measure.

Model

We define the credit score of company i belonging to network j at time t as

$$y_{ijt} = log\left(\frac{PD_{ijt}}{1 - PD_{ijt}}\right) = \beta x_{it} + \gamma_{it} + \phi w_{it}$$

$$\gamma_{it} = \delta_j^s f_{st}^i + \delta_j^g f_{gt}^i$$

where

- PD_{ijt} is the probability that the company defaults in t, given the available information set
- x_{it} is a set of individual financial ratios
- f_{st}^i and f_{gt}^i are risk factors for the industry and the region to which the company belongs, respectively
- w_{it} is the number of companies belonging to the same network as i (degree centrality, see Barabasi, 2015)

Covariates

- Balance sheet ratios (selected through expert judgment and correlation analysis) on last financial year:
  - Logarithm of total assets, that proxies for size of the firm
  - Tangible fixed assets/Total assets (Tangibility)
  - Net income/Total assets (i.e. ROA)
  - Total assets growth rate (with respect to previous year)
  - Long-term debt/Total assets (Leverage)
- Industry-specific and regional risk factors:
  - default rate of the industry to which the company belongs, in $t-1$
  - default rate of the region to which the company belongs, in $t-1$
- Degree centrality

- Estimation of the logit model with no random effects

Variable	Estimate	Standard error	P-value
constant	-5.044	0.056	0.000***
Logarithm of TA	0.058	0.042	0.167
Tangibility	-0.151	0.051	0.003**
ROA	-0.609	0.024	0.000***
TA growth	-0.524	0.056	0.000***
Leverage	-0.053	0.048	0.272
Industry risk	0.128	0.044	0.004**
Regional risk	0.155	0.043	0.000***
Centrality	-0.126	0.048	0.008**

- Estimation of the mixed logit model

Fixed effects:

Variable	Estimate	Standard error	P-value
constant	-5.838	0.173	0.000***
Tangibility	-0.146	0.052	0.006**
ROA	-0.676	0.059	0.000***
TA growth	-0.521	0.059	0.000***
Centrality	-0.336	0.089	0.000***

Random effects:

Variable	Standard deviation	Correlation
Industry risk	0.583	0.18
Regional risk	0.505	

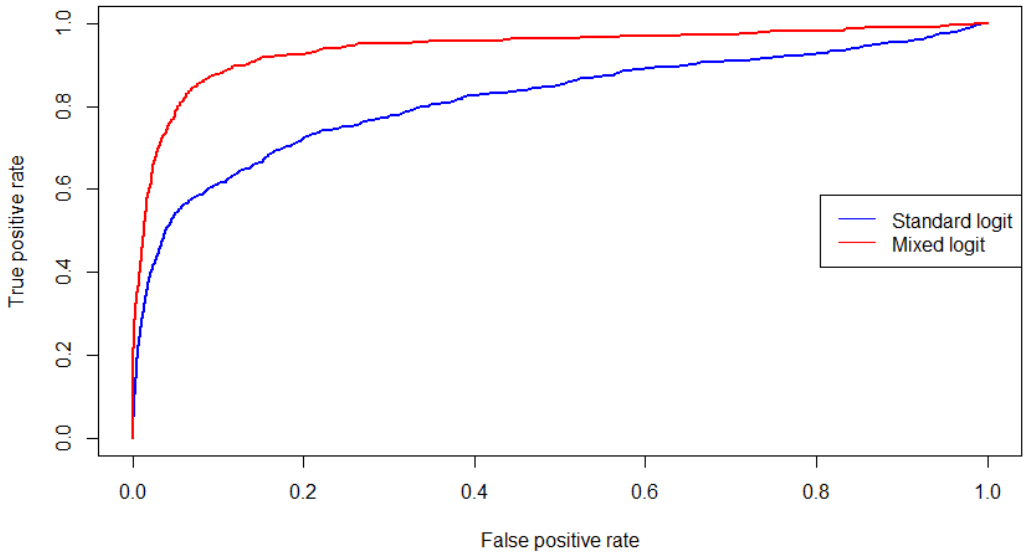

Figure: AUROC of the standard and the mixed logit model

- Substantial increase in predictive accuracy: AUROC from 0.815 to 0.939.

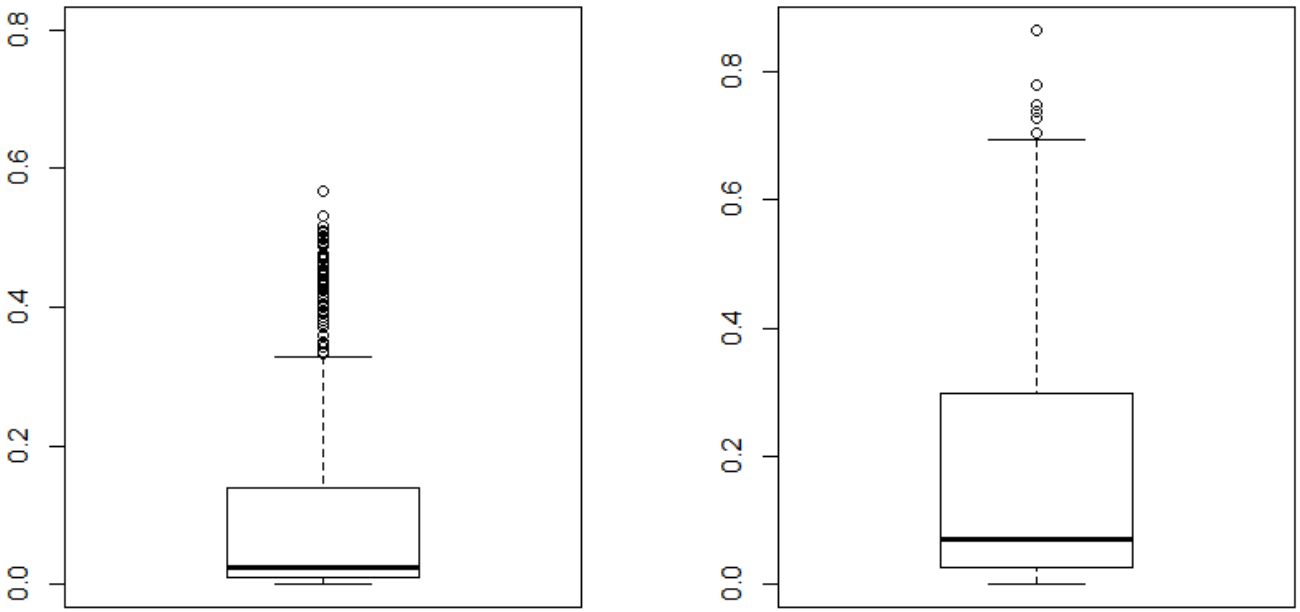

Figure: Distribution of PD estimated for defaulted companies by the standard logit model (left) and by the mixed logit model (right).

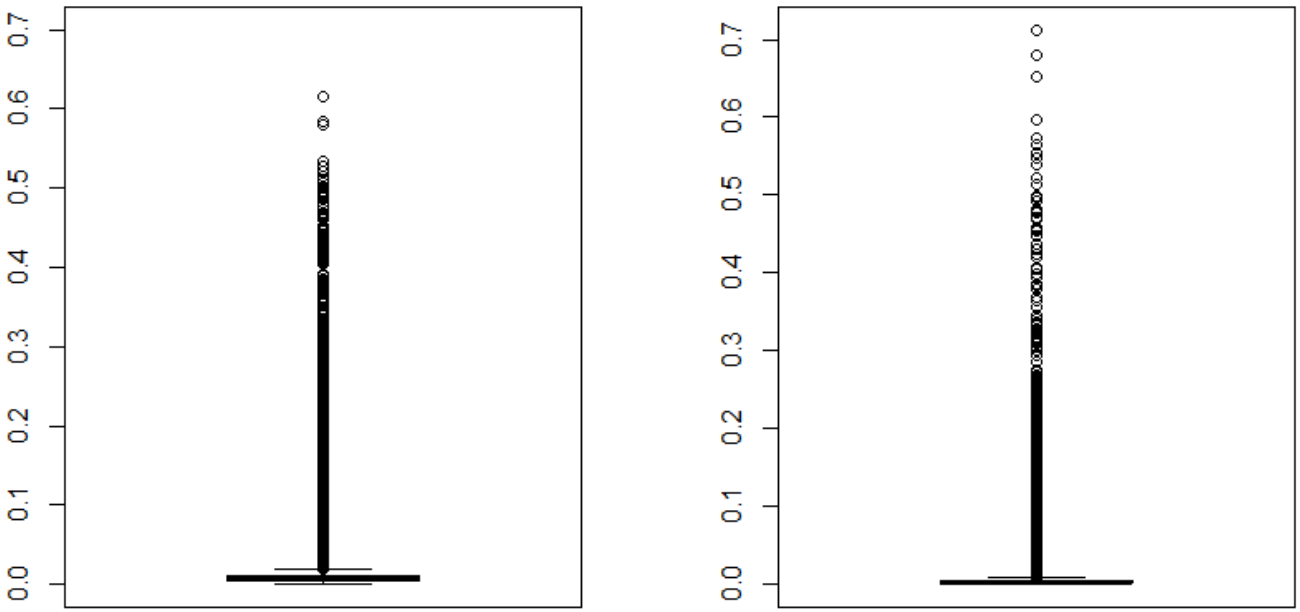

Figure: Distribution of PD estimated for non-defaulted companies by the standard logit model (left) and by the mixed logit model (right).

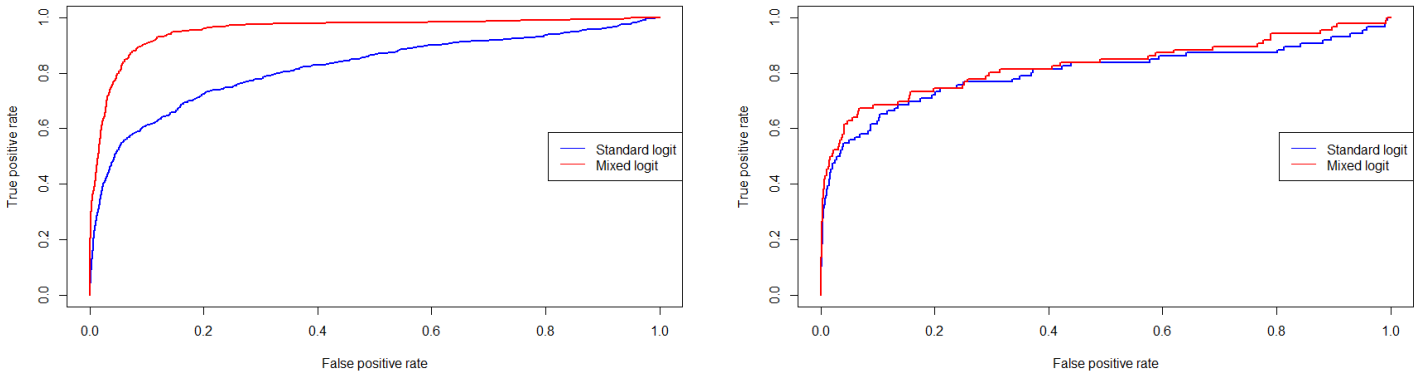

Figure: AUROC of the standard and the mixed logit model for the companies belonging (left) and not belonging (right) to a network.

Results

Accuracy

	All companies		Companies in network		No network	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Standard logit	0.663	0.853	0.642	0.871	0.767	0.736
Mixed logit	0.897	0.875	0.921	0.884	0.744	0.787

- The model including random effects is more sensitive for companies both belonging and not belonging to a corporate network.
- For companies belonging to a network, the model specificity is also higher.

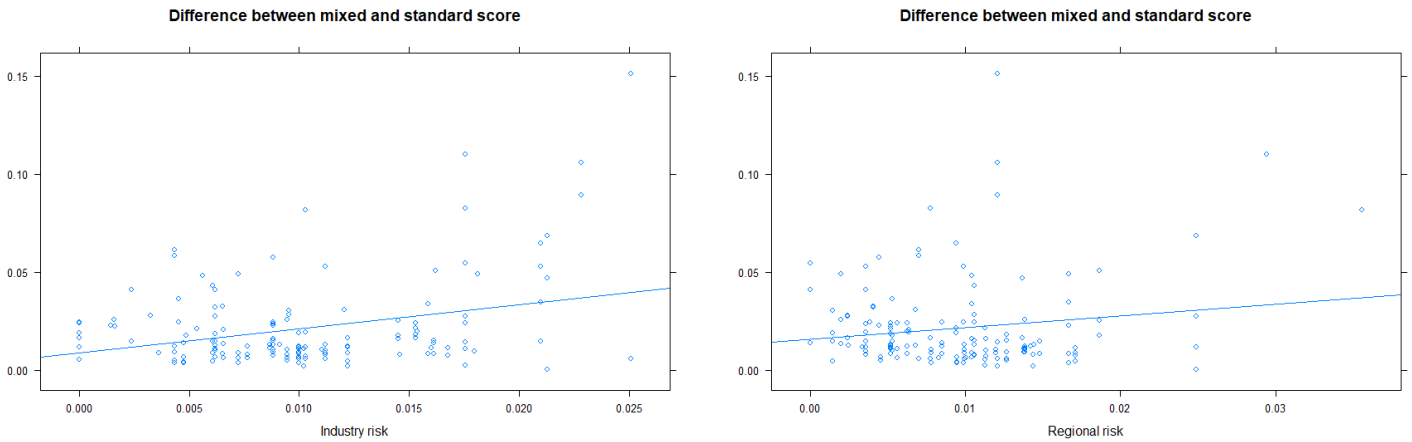

Figure: Relationship between the difference in the score attributed by the mixed and the standard logit model and the industry (left) and regional (right) risk, for the defaulted companies.

Conclusions...so far

- Corporate networks have a significant impact on companies' probability of default.
- On average, being linked with a higher number of companies decreases credit riskiness.
- Considering the network effect as a variance component leads to a considerable increase in predictive accuracy.
- Industry-specific and regional risk factors give a substantial contribution to model sensitivity and specificity when using network-level random slopes.

Work in progress

- Analysing the impact of exogenous or latent risk factors.
- Considering further links between companies belonging to the network (commercial and financial relationships).
- Differentiate according to corporate size and role in the network.
- Including possible interactions between networks in the same geographic area.