Modeling Efficiency, Credit Risk and Performance in a Local Banking System

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Objectives

- Analyze the impact of crisis on the banking system  
  - Recession has uniformly affected banks?  
  - To what extent recession impacts on bank efficiency?

- Evaluate the determinants of cost/profit inefficiency  
  - What are the main determinants?  
  - What is the role of environmental features?  
  - Efficiency changes over time?

- Investigate whether determinants differ between bank groups  
  - What are the main features influencing bank heterogeneity?  
  - Size and/or category?
Motivation
Diversification (1/3)

- Over recent years numerous banks around the world have broadened their portfolio to offer non-traditional services.

- Some authors show that the higher volatility of NII outweigh diversification benefits.

- Some banks more oriented to traditional activities could have suffered less than other banks the “subprime and derivative” crisis, but in the future they could be more credit risk exposed.
  - Rossi et al., 2009 JBF, show that although diversification negatively affects cost efficiency, it increases profit efficiency and reduces banks’ realized risk. Moreover diversification seems to have a positive impact on banks’ capitalization.

Motivation
Risk (2/3)

- The recent financial crisis seems to have hit all banks differently in respect to their attitude towards traditional or not traditional banking activities:
  - De Jonghe, JFI 2010: “banks that profitably focus on lending activities contribute more to banking system stability than diversified banks. Retail banks, with a relatively high proportion of core deposits and loans in total assets, have a consistently lower systemic risk exposure”.
  - Wagner, JFI 2010: “even though diversification may reduce each bank’s probability of default, it makes systemic crises more likely”.

- A too high traditional loan growth rate could be an important driver of the riskiness of banks (Foos, Norden and Weber, JBF 2010).
Motivation
Size (3/3)

– There could be difference in banking activities related to its size
  • (DeYoung and Hasan, 1998; Akhigbe and McNulty, 2003)

– bank size, distance, relationship lending …
  • Alessandrini et al. 2009 a, b; Berger and Black, 2010

– … and to its juridical specification
  • (Angelini et al. 1988; Battaglia et al. 2008; Kontolaimou and Tsekouras, 2010).

Literature review (1/4)

Bank business measures:

• Production approach (cfr. Kuussaari and Vesala 1995)
  – output variables are measured in terms of factual quantities (e.g. the number of current accounts or the volume of transactions carried out in a given time period).

  – The loans granted to customers as well as other remunerative assets are usually defined as output variables, produced by the banks by easily identifiable input variables such as work, fixed assets and collection.

• The value added approach (e.g. Resti 1997, Fiordelisi and Molyneux 2006, Fiordelisi, 2007)
  – which has been applied in more recent studies identifies the bank’s output and input variables on the basis of the added value created, regardless of assets and liabilities. Demand deposits are considered as outputs, even though they represent a liability in the balance sheet.
Bank inefficiency determinants:

- Firm specific factors: size, category, capitalization, management
- Environment: GDP, economic structure, socio-demographic condition, local area characteristics
- Market condition: market share, risk share

Some indicators of efficiency determinants

- Diversification index (cfr. Chiorazzo et al., JFSR 2008):
  \[
  INDIV_j = 1 - \left( NETs_j^2 + NHIs_j^2 \right)
  \]

- Local market power (cfr. Alessandrini et al., JBF 2008):
  \[
  HHI_j = \sum_{\rho \neq j} \left( \frac{\text{branches}_\rho}{\text{branches}_j} \right)^2 \cdot \frac{\text{branches}_j}{P_j}
  \]

- Macro provincial non-performance loans index:
  \[
  NPL INDEX = \sum_{i=1}^{n} \frac{\text{branches}_i}{\text{branches}} \cdot \frac{npl_j}{\sum_{j=1}^{m} npl_j}
  \]
Efficiency measurement:

- Cost or Profit frontier functions and inefficiency models

- Traditional approaches:
    - stochastic frontier function
    - simultaneous (one-stage) estimation procedure of inefficiency effects (MLE estimator).
  - Data Envelopment Analysis – DEA (Lowell, 1994)
    - Non-parametric mathematical programming approach to frontier estimation
    - ex-post analysis of the efficiency determinants (two-stage regression)
  - The Metafrontier approach (Battese et al., 2004; O'Donnell et al. 2008)
    - opportunity to handle the presence of a plurality of cost function associated to heterogeneous “units”
    - the metafrontier model is an envelop of individual stochastic frontiers for different groups, each having their own technological, environmental and specific features.

Data and sample coverage

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<td>15</td>
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<td>32</td>
<td>35</td>
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<td>29</td>
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<tr>
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<td>114</td>
<td>118</td>
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<td>502</td>
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<tr>
<td>Minors</td>
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<td>494</td>
<td>521</td>
<td>515</td>
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<td>Total unbalanced sample</td>
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<td>655</td>
<td>692</td>
<td>686</td>
<td>120</td>
<td>2,406</td>
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<tr>
<td>Total balanced sample</td>
<td>607</td>
<td>607</td>
<td>607</td>
<td>607</td>
<td>1,821</td>
<td>84.66%</td>
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</tbody>
</table>

Sources:

- Bilbank dataset provided by the Italian Banking Association, A.B.I.
- Bank of Italy information on local macro NPL conditions and bank branch locations.
- ISTAT information on provincial population distribution.
Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td><strong>Profit (Cost) (in thousand Euro)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost (TC)</td>
<td>1,821</td>
<td>65,113</td>
<td>326,124</td>
<td>-4,205</td>
<td>6,180,000</td>
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<tr>
<td>Total profit (TP)</td>
<td>1,821</td>
<td>30,816</td>
<td>152,239</td>
<td>-608,080</td>
<td>2,643,000</td>
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<tr>
<td><strong>Output Quantities (in thousand Euro)</strong></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Loans (L)</td>
<td>1,821</td>
<td>2,194,457</td>
<td>10,000,000</td>
<td>0</td>
<td>207,000,000</td>
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<td>Demand deposits (DD)</td>
<td>1,821</td>
<td>1,094,788</td>
<td>4,952,635</td>
<td>0</td>
<td>95,400,000</td>
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<td>Non-interest income (NII)</td>
<td>1,821</td>
<td>42,013</td>
<td>246,583</td>
<td>-575,765</td>
<td>4,823,807</td>
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<td>Equity (E)</td>
<td>1,821</td>
<td>352,649</td>
<td>2,531,713</td>
<td>2,604</td>
<td>51,000,000</td>
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<td><strong>Input prices</strong></td>
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<tr>
<td>Price of funds (w1)</td>
<td>1,819</td>
<td>0.025</td>
<td>0.008</td>
<td>0.000</td>
<td>0.087</td>
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<td>Price of head capital (w2)</td>
<td>1,811</td>
<td>5.945</td>
<td>24.790</td>
<td>0.077</td>
<td>18.387</td>
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<td>Price of labor (w3)</td>
<td>1,821</td>
<td>0.014</td>
<td>0.008</td>
<td>0.000</td>
<td>0.143</td>
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<td><strong>Efficiency variables</strong></td>
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<td></td>
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<tr>
<td>Banking business structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income diversification (INDIV)</td>
<td>1,796</td>
<td>0.301</td>
<td>0.099</td>
<td>0.000</td>
<td>0.550</td>
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<td>Asset diversification (ASDIV)</td>
<td>1,821</td>
<td>0.340</td>
<td>0.186</td>
<td>0.013</td>
<td>1.000</td>
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<td>In Total assets (SIZE)</td>
<td>1,821</td>
<td>5.701</td>
<td>0.737</td>
<td>3.711</td>
<td>8.633</td>
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<td>Cost income (CI)</td>
<td>1,821</td>
<td>0.693</td>
<td>1.947</td>
<td>0.433</td>
<td>0.847</td>
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<tr>
<td>Equity/Assets (EQUITY RATIO)</td>
<td>1,821</td>
<td>0.119</td>
<td>0.064</td>
<td>0.012</td>
<td>0.906</td>
</tr>
<tr>
<td><strong>Micro risk conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Loan loss provision/Total credit loans (LLP)</td>
<td>1,816</td>
<td>0.125</td>
<td>4.564</td>
<td>0.900</td>
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<tr>
<td>Non performing loans/Total credit loans (NPL)</td>
<td>1,816</td>
<td>0.013</td>
<td>0.014</td>
<td>0.115</td>
<td></td>
</tr>
<tr>
<td>Past due loans/Total credit loans (PDL)</td>
<td>1,816</td>
<td>0.009</td>
<td>0.014</td>
<td>0.276</td>
<td></td>
</tr>
<tr>
<td>Relationship lending</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Loans/Employee (LPER in thousand Euro)</td>
<td>1,820</td>
<td>4,261.166</td>
<td>51,185.710</td>
<td>0</td>
<td>2,178,539</td>
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<tr>
<td>Local banking structure</td>
<td></td>
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<tr>
<td>HHI</td>
<td>1,807</td>
<td>0.002</td>
<td>0.009</td>
<td>0.002</td>
<td>9.070</td>
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<tr>
<td>NPL INDEX</td>
<td>1,816</td>
<td>5.010</td>
<td>15.717</td>
<td>0.329</td>
<td>10.0</td>
</tr>
</tbody>
</table>

The proposed model

**The cost approach**

- We estimate efficiency levels by specifying the translog functional form for the cost function

\[
\ln c_i = \alpha + \sum_k \beta_k \ln q_{i,k} + \sum_p \beta_p \ln p_{i,p} + \sum_{j \neq k} \beta_{jk} \ln q_{i,j} \ln q_{i,k} + \sum_{j \neq p} \beta_{jp} \ln p_{i,j} \ln p_{i,p} + \\
\sum_k \sum_p \beta_{0k} \ln q_{i,k} \ln p_{i,p} + \beta_t \ln E_i + (V_i + U_i)
\]

- Where:
  - C: total cost
  - Q is a vector of three outputs which are defined at the bank level:
    1. Total loans; 2. Retail deposits; 3. Fee-based financial services (i.e. non-interest income)
  - P is a vector of three market prices for inputs:
    1. The wage rate for labor; 2. the price for borrowed price of funds; 3. the price of physical capital.
  - E: Equity capital defined at the bank level to control (in a rough fashion) for the potential increased cost of funds due to financial risk.
  - U assumed \(N(u, \sigma^2u)\) and \(V\) is the error term.
The proposed model

*The determinant of cost inefficiency*

- The proposed efficiency model is:

\[
\mu_t = \delta_0 + \delta_{HHI} \ln HHI + \delta_{IN} \ln INDIV + \delta_{ASD} \ln ASDIV + \delta_{SIZE} \ln SIZE + \\
+ \delta_{CI} \ln CI + \delta_{ER} \ln EQUITY \text{ RATIO} + \delta_{LLP} \ln LLP + \delta_{NPL} \ln NPL + \\
+ \delta_{PDL} \ln PDL + \delta_{NPLINDEX} \ln NPL \text{ INDEX} + \delta_{LPR} \ln LPR + \delta_t
\]

Where:

- HHI: defined at provincial level
- INDIV: income diversification
- ASDIV: asset diversification
- SIZE: Ln total asset
- CI: cost income
- ER: EQUITY RATIO: Equity/Total Asset
- LLP: Loan loss provision/Total NPL:
- PDL: Past due loans/Total credit loans
- NPL INDEX
- LPR: Loans/Employees
- \( t \): trend

---

The proposed model

*Group frontiers*

- Bank grouped by:
  - Size:
    - Large and medium banks > 9 billions
    - Small banks 1.3 – 9 billions
    - Minor banks < 1.3 billions
  - Juridical category:
    - Mutual banks
    - Cooperative banks
    - Saving banks
    - Other listed banks
## Preliminary results (1/2)

### Parameter estimates of the inefficiency models: bank groups by SIZE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FULL</th>
<th>LARGE</th>
<th>SMALL</th>
<th>MINOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln_HHI</td>
<td>-0.28*</td>
<td>-0.03**</td>
<td>-0.05*</td>
<td>-0.16</td>
</tr>
<tr>
<td>ln_NPL_Index</td>
<td>0.19*</td>
<td>0.06*</td>
<td>0.00</td>
<td>0.14*</td>
</tr>
<tr>
<td>ln_INDIV</td>
<td>-0.82*</td>
<td>-0.67*</td>
<td>-0.17*</td>
<td>-0.70*</td>
</tr>
<tr>
<td>ln_ASDIV</td>
<td>1.31*</td>
<td>0.31*</td>
<td>0.26</td>
<td>1.35*</td>
</tr>
<tr>
<td>ln_SIZE</td>
<td>0.50*</td>
<td>-0.04</td>
<td>0.33*</td>
<td>0.33*</td>
</tr>
<tr>
<td>ln_LPER</td>
<td>-0.23*</td>
<td>0.08</td>
<td>0.05</td>
<td>-0.33*</td>
</tr>
<tr>
<td>ln_LLP</td>
<td>0.01*</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02*</td>
</tr>
<tr>
<td>ln_NPL</td>
<td>0.04*</td>
<td>0.07*</td>
<td>0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td>ln_PDL</td>
<td>0.09*</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.08*</td>
</tr>
<tr>
<td>ln_EQUITY RATIO</td>
<td>-0.47*</td>
<td>-0.02</td>
<td>-0.31*</td>
<td>-0.33*</td>
</tr>
<tr>
<td>ln_CI</td>
<td>0.34*</td>
<td>0.64*</td>
<td>0.60*</td>
<td>0.69*</td>
</tr>
<tr>
<td>t</td>
<td>-0.21*</td>
<td>-0.08*</td>
<td>-0.10*</td>
<td>-0.26*</td>
</tr>
</tbody>
</table>

*p-value 0.05; ** p-value 0.10

Ce_group: 0.83 0.85 0.82 0.85
CE_pool: 0.83 0.74 0.78 0.86

LR test of one-sided err: 2,195 212 333 1,284
LR test: 868

## Preliminary results (2/2)

### Parameter estimates of the inefficiency models: bank groups by CATEGORY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FULL</th>
<th>MUTUAL BANKS</th>
<th>OTHER LISTED BANKS</th>
<th>COOPERATIVE and SAVING BANKS</th>
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<tbody>
<tr>
<td>ln_HHI</td>
<td>-0.28*</td>
<td>0.00*</td>
<td>-0.40*</td>
<td>-0.01</td>
</tr>
<tr>
<td>ln_NPL_Index</td>
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<td>0.01*</td>
<td>0.38*</td>
<td>-0.01</td>
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<td>ln_INDIV</td>
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<td>-0.23*</td>
<td>-0.62*</td>
<td>-0.46*</td>
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<tr>
<td>ln_ASDIV</td>
<td>1.31*</td>
<td>-0.01</td>
<td>0.85*</td>
<td>0.30*</td>
</tr>
<tr>
<td>ln_SIZE</td>
<td>0.50*</td>
<td>0.04*</td>
<td>0.67*</td>
<td>0.05*</td>
</tr>
<tr>
<td>ln_LPER</td>
<td>-0.23*</td>
<td>-0.02*</td>
<td>-0.37*</td>
<td>0.00</td>
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<tr>
<td>ln_LLP</td>
<td>0.01*</td>
<td>0.00</td>
<td>0.05*</td>
<td>0.00</td>
</tr>
<tr>
<td>ln_NPL</td>
<td>0.04*</td>
<td>0.00</td>
<td>0.03</td>
<td>-0.01</td>
</tr>
<tr>
<td>ln_PDL</td>
<td>0.09*</td>
<td>0.01*</td>
<td>0.05*</td>
<td>0.01</td>
</tr>
<tr>
<td>ln_EQUITY RATIO</td>
<td>-0.47*</td>
<td>-0.61*</td>
<td>-0.57*</td>
<td>0.52*</td>
</tr>
<tr>
<td>ln_CI</td>
<td>0.34*</td>
<td>0.50*</td>
<td>0.53*</td>
<td>0.64*</td>
</tr>
<tr>
<td>t</td>
<td>-0.21*</td>
<td>-0.07*</td>
<td>-0.18*</td>
<td>-0.04*</td>
</tr>
</tbody>
</table>

*p-value 0.05; ** p-value 0.10

Ce_group: 0.83 0.70 0.67 0.71
CE_pool: 0.83 0.88 0.88 0.86

LR test of one-sided err: 2,195 1,548 270 332
LR test: 2,977
Conclusions (1/2)

- Strong heterogeneity in bank cost processes with respect to either size or category

  - **Market factors:**
    - HHI is heterogeneous among groups:
      - Generally a more concentrated market implies more efficiency.
      - Not significant in the case of Mutual banks.
    - NPL_Index: the efficiency decreases as the provincial credit risk increases.
      - However not significant in the case of Small banks and in the Cooperative & Saving banks.

  - **Diversification factors:**
    - Income diversification implies greater efficiency. Less important among small banks. More homogenous among categorical groups.
    - Asset diversification (all other assets than loans). Non traditional activities – non traditional intermediation model – decreases efficiency.

  - **Relationship lending factors:**
    - Loan per employee increase efficiency only in the case of minor banks.

  - **Micro default risk:**
    - LLP (proxy of expected loss); NPL, PDL all negatively affect efficiency. Much more significant in the case of past-due loans than the case of non-performing loans.

  - **Firm specific factors:**
    - Size decrease efficiency. Particularly in the case of large listed banks.

Conclusions (2/2)

- Summarizing:
  - INDIV and EQUITY RATIO positively affect CE
  - ASDIVE, SIZE, NPL_INDEX, LLP, NPL, PDL negatively affect CE
  - HHI generally negative. Not significant in the case of MINOR BANKS and opposite sign in the case of MUTUAL BANKS.

- An increase in CE is detected over the analyzed period – TREND

- Large listed banks revel to be the less efficient group
Future research: 

**economic perspective**

- **Economic perspective:**
  - Estimate of the Profit function
  - Analysis of **recession effects** on bank groups (conditioned to availability of data on 2005 and 2009)

- **Methodological perspective:**
  - Define bank groups simultaneously with respect to size and category
  - Use of **Metafrontier approach**
  - Investigate specific determinants (specific firm features, environmental and market variables) of bank CE and Meta Technology Ratio (MTR)

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