Measuring BEPS: MNEs vs. comparable non-MNEs method

*Italian case study - Practice*

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Building up the dataset

• The database for the analysis is composed of three informative sources:
  
  • The archive **Frame-SBS**, which includes the information about the structure and economic variables for the whole set of 4.4 millions of firms
  
  • The archive **COE-TEC** (Integrated International Trade Database), which includes the information about imports and exports (by product and origin/destination country) for the whole set of firms
  
  • The archive **ASIA-Groups** (Italian version of European EGR), which includes the information about firms involved in domestic and foreign groups

• For each unit in the business system, the final database reports comprehensive information about:
  
  • The economic and organizational structure
  • The characteristics of its inclusion in the network of international trade
  • If applies, the positioning within MNE groups
Building up the dataset

- Frame-SBS contains about 4.3 million units for 2019
- COE-TEC contains about 4.3 million units for 2019 (165515 are internationalised, i.e. positive values of imports and/or exports)
- Asia-Groups contains 233092 units
- Some limitation is applied to the dataset (i.e. exclusion of units with 0 workers, value added lower than 0, missing relevant variables, sectors with peculiar characteristics such as tobacco, financial auxiliaries, coke and refineries)
- The final dataset contains 3829908 observation
<table>
<thead>
<tr>
<th>Unit ID</th>
<th>NACE</th>
<th>Workers</th>
<th>Size class</th>
<th>Value added</th>
<th>Turn-over</th>
<th>Salaries</th>
<th>Intermediate costs</th>
<th>Costs for goods</th>
<th>Costs for services</th>
<th>Costs for royalties</th>
<th>Costs for R&amp;D</th>
<th>Costs from sub-contracting</th>
<th>EBIT</th>
<th>Value of imports</th>
<th>Value of exports</th>
<th>Group ID</th>
<th>Type of group</th>
<th>Nationality of headquarters</th>
<th>Nationality of units</th>
</tr>
</thead>
</table>
Overview of the method by step

- MNE vs. comparable non-MNE method is composed by three phases:

  1. The **identification** of the either BEPS generating (outward IFFs) or BEPS collecting (inward IFFs) nature of the country (OECD’s dashboard approach of BEPS indicators)

  2. The **selection** of tax avoiding (TA) units among MNEs
     - Italian MNEs are evaluated in order to define if they are suspected of tax avoiding behaviour based on the comparison between MNEs and a control group consisting of (comparable) non-MNEs

  3. The **correction** of profits for TA MNEs
     - The EBIT-to-turnover ratio of TA units is adjusted exploiting the selection model in order to compare the economic results of TA MNEs vs. the one of non-TA MNEs
The phase of selection is composed of three steps:

- **Control group definition**

  For each MNE unit, a control group of domestic firms is defined using propensity score matching.

- **Between comparison (MNEs vs. non-MNEs)**

  For each pair MNE unit-control group, a comparison in terms of profit share is used to define a proxy variable, which stresses possible abnormal behaviours by MNEs.

- **Within comparison (among MNEs)**

  ROC analysis is used to define the final clustering between tax avoiding (TA) and non tax-avoiding (NTA) units starting from the proxy variable.
Selection - Definition of control groups

Definition of confounding variables for PS matching analysis

• $v_1$ = Turnover / Workers
• $v_2$ = Number of workers
• $v_3$ = Costs for goods / Total intermediate costs
• $v_4$ = Value of exports / Turnover
• $v_5$ = Value of imports / Total costs
• $v_6$ = Salaries / (Salaries + Total intermediate costs)
• $v_7$ = Costs for services / Total intermediate costs
• $vv$ = EBIT / Turnover

See Table DB PS indicators
Selection - Definition of control groups

Propensity score matching analysis

- PS Model to define matching probabilities
  
  \[ \text{treat(treated='1')} = v1 \ v2 \ v3 \ v4 \ v5 \ v6 \ v7 \ \text{NUTS2} \]  
  \[ \text{(Logit model to define matching probabilities)} \]

- Matching method and number of similar
  
  match method = greedy \((k = 5)\)

- Binding characteristics
  
  Exact (NACE3 size class NUTS2)
Definition of the proxy of suspect

• Prospensity score matching allows to define a control group of domestic firms for each MNE unit

• For each pair MNE unit-control group, a **proxy of suspect** of TA is given by the following condition:
  
  • **Proxy = 1**

  if ebit-to-turnover ratio for the MNE unit is lower than the average of the control group

  • **Proxy = 0**

  if ebit-to-turnover ratio for the MNE unit is greater or equal to the average of the control group
Selection - Within comparison

Steps in within comparison

• Definition of variables

From structural and performance characteristics of MNEs it selects the variables of interests in capturing the behavior of MNEs

• Factor Analysis

From x0-x8 variables it selects two factors

• Definition of composite indicator

From factors it defines the composite to be used in the logit model of the ROC analysis

• ROC analysis

It allows to define the final classification between Tax Avoiding (TA) and non-Tax Avoiding (nonTA) MNEs
Selection - Within comparison

**Definition of variables** (inverse relationships with proxy, the higher the values the lower the probability of TA)

- $x_0 = \frac{\text{EBIT}}{\text{Turnover}}$
- $x_1 = \frac{\text{Value added}}{\text{Turnover}}$
- $x_2 = \frac{\text{Costs on R&D}}{\text{Total intermediate costs}}$
- $x_3 = 1 - \left( \frac{\text{Costs on royalties}}{\text{Turnover}} \right)$
- $x_4 = 1 - \frac{\text{Value of imports}}{\text{Total intermediate costs}}$
- $x_5 = 1 - \frac{\text{Tax framework (by Country, differential)}}{}
- $x_6 = \frac{\text{Salaries}}{\text{Turnover}}$
- $x_7 = 1 - \frac{\text{Cost for services}}{\text{Turnover}}$
- $x_8 = \frac{\text{Value of exports}}{\text{Turnover}}$

See Table DB ROC indicators
Factor analysis and the definition of the composite indicator

- \( x_0 \) - \( x_8 \) variables are firstly standardized in order to avoid scale effects

- From factor analysis, the first two auto-rotated factors are retained and the composite is defined as follows

\[ I_i = \omega_1 \left( \sum_j \gamma_{j,1} x_{j,i} \right) + \omega_2 \left( \sum_j \gamma_{j,2} x_{j,i} \right) \]

where, \( \gamma_{j,1} \) and \( \gamma_{j,2} \) are the loadings of the \( j \)-th variable in factors 1 and 2, \( x_{j,i} \) is the value of the \( j \)-th variable for the \( i \)-th observation, and \( \omega_1 \) and \( \omega_2 \) are weights in term of explained variance

<table>
<thead>
<tr>
<th></th>
<th>Factor1</th>
<th>Factor2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x_0 )</td>
<td>0.043</td>
<td>0.518</td>
</tr>
<tr>
<td>( x_1 )</td>
<td>0.057</td>
<td>0.519</td>
</tr>
<tr>
<td>( x_2 )</td>
<td>-0.086</td>
<td>0.025</td>
</tr>
<tr>
<td>( x_3 )</td>
<td>0.452</td>
<td>-0.063</td>
</tr>
<tr>
<td>( x_4 )</td>
<td>-0.043</td>
<td>0.178</td>
</tr>
<tr>
<td>( x_5 )</td>
<td>-0.011</td>
<td>0.050</td>
</tr>
<tr>
<td>( x_6 )</td>
<td>0.195</td>
<td>-0.002</td>
</tr>
<tr>
<td>( x_7 )</td>
<td>0.465</td>
<td>-0.049</td>
</tr>
<tr>
<td>( x_8 )</td>
<td>-0.063</td>
<td>0.118</td>
</tr>
</tbody>
</table>

| Explained variance | 2.098 | 1.688 |
**Selection - Within comparison**

**ROC analysis**

- Using the proxy of suspect and the composite indicator, the following logit model can be run:

\[
\text{Prob} (\text{Proxy} = 1|C)_i = \Lambda(\alpha C)_i
\]

### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimate</th>
<th>Standard error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>-2.4225</td>
<td>0.2075</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

### Goodness of fit

<table>
<thead>
<tr>
<th>Percentuale concordi</th>
<th>82.4</th>
<th>D di Somers</th>
<th>0.648</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentuale discordi</td>
<td>17.6</td>
<td>Gamma</td>
<td>0.648</td>
</tr>
</tbody>
</table>
• The ROC analysis can be traced back to classification problems in which classifiers can give the four possible outcomes shown in the **confusion matrix**. The efficiency of the classifier can be measured using two metrics:

- **Sensitivity** measures the ability of the classifier to detect true positives, i.e. \( \frac{TP}{TP + FN} \);

- **Specificity** measures the ability of the classifier to detect true negatives, i.e. \( \frac{TN}{TN + FP} \), where it is usually considered in its reciprocal expression (1-Specificity), which measures the correct detection of false positives.

<table>
<thead>
<tr>
<th>Estimated classification</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>True classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>(TP)</td>
<td>(FN)</td>
</tr>
<tr>
<td>0</td>
<td>(FP)</td>
<td>(TN)</td>
</tr>
</tbody>
</table>
Selection - Within comparison

- Considering a logit model having:
  - a binomial dependent reflecting a given status
  - a classifier represented by a single (even composite) indicator

the distribution of probabilities resulting from the logit estimates can be displayed in the space of Sensitivity and 1-Specificity by the ROC curve

- The line of the ROC curve represents the probabilities assigned by the model to each observation in the space of the trade-off between the probability of detecting true or false positives across all possible cut-off points along the values of the classifier
In order to single out, along the ROC curve, the observation that most efficiently discriminates between positives and negatives (Cut), the following equation should be maximized:

\[ \text{Cut} = h \times \text{sensitivity} - (1 - h) \times (1 - \text{specificity}) \]

where \( h \) and \( (1-h) \) represent the relative weights to manage the trade-off between true and false positives.
Selection - Within comparison

ROC analysis

- The logit model generates the following ROC curve (with AUC=0.8119)

\[ \text{Cut} = h \times \text{sensitivity} - (1 - h) \times (1 - \text{specificity}) \]

with \( h = 0.5 \) (neutral selection), the ID of the threshold observation can be obtained:

<table>
<thead>
<tr>
<th>Threshold</th>
<th>ID</th>
<th>Value of the composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>656</td>
<td>0.058488</td>
</tr>
</tbody>
</table>

See Tables AUCs and Coeffs and thresholds.
Classification of MNEs

- The value of the composite of threshold MNE unit \( \bar{S} \) can be used to classify other observation.

In particular:

- If \( I_i \geq \bar{S} \) then the MNE unit is non-TA
- If \( I_i < \bar{S} \) then the MNE unit is TA

<table>
<thead>
<tr>
<th>Status</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Cumulative frequency</th>
<th>Cumulative percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Non-TA</td>
<td>441</td>
<td>39.2</td>
<td>441</td>
</tr>
<tr>
<td>1</td>
<td>TA</td>
<td>683</td>
<td>60.8</td>
<td>1124</td>
</tr>
</tbody>
</table>

See Table Fitting
The correction for BEPS exploits the information provided by the ROC analysis in the selection phase.

Correction – conceptual framework
The correction of profit shifting exploits the information provided by the ROC analysis in the selection phase.

For each TA unit, the following condition applies:

\[ \bar{S} > \alpha F_{1,i} + \beta F_{2,i} \]

where factors are:

\[ F_{1,i} = \sum_j \gamma_{j,1} x_{j,i} \quad \text{and} \quad F_{2,i} = \sum_j \gamma_{j,2} x_{j,i} \]

The procedure assigns to the indicator \( x_1 \), which is the ebit-to-turnover ratio, the value such that, for each TA MNEs, the following condition is obtained:

\[ \bar{S} = \alpha F_{1,i} + \beta F_{2,i} \]
Correction – conceptual framework

• This allows to define the adjustment condition as:

\[ \tilde{x}_{j,i} = \frac{\bar{S} - (\alpha \sum_{-j} \gamma_{-j,1} x_{-j,1} + \beta \sum_{-j} \gamma_{-j,2} x_{-j,2})}{\alpha \gamma_{j,1} + \beta \gamma_{j,2}} \]

where:

• \( \bar{S} \) is the threshold value defined by the ROC analysis on the composite indicator

• \((\alpha \sum_{-j} \gamma_{-j,1} x_{-j,1} + \beta \sum_{-j} \gamma_{-j,2} x_{-j,2})\) represents the effect of the other variables on the value of the composite indicator

• \(\alpha \gamma_{j,1} + \beta \gamma_{j,2}\) represents the weight of the ebit-to-turnover ratio on the value of the composite indicator

• \(\tilde{x}_{j,i}\) is the adjusted value of the ebit-to-turnover ratio in order to bring the TA MNE on the threshold

• The amount of the adjustment is obtained as: \((\tilde{x}_{j,i} - x_{j,i}) \times \text{Turnover}_i\)
Measuring (outward and inward) IFFs

• The amount of the correction is obtained by comparing the EBIT-to-turnover ratio of the two groups of MNEs defined by the model.

• The amount of correction actually represents the measure of IFFs.

• In particular:

  **BEPS generating country**

  \[
  \text{OutwardIFFs}_i = (\tilde{x}_{h,i} - x_{j,i}) \times \text{Turnover}_i
  \]

  where \( \tilde{x}_{h,i} > x_{j,i} \)

  **BEPS collecting country**

  \[
  \text{InwardIFFs}_i = -(\tilde{x}_{h,i} - x_{j,i}) \times \text{Turnover}_i
  \]

  where \( \tilde{x}_{h,i} < x_{j,i} \)

See Table Results, Countries and Descriptives.
Thank you.