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# Detecting and measuring BEPS by MNEs in Italy: A micro approach

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# Detecting and Measuring BEPS by MNEs in Italy: A Micro Approach

**Abstract**

Aggressive Tax Planning (ATP) is a set of practices aimed at exploiting mismatches and loopholes in the international tax framework in order to reduce the overall tax burden of multinational enterprises (MNEs). The measurement of Base Erosion and Profit Shifting (BEPS) is relevant for monitoring the phenomenon and for informing policies aimed at contrasting it, but also for assessing related illicit financial flows and adjusting GDP and GNI estimates. This work proposes a bottom-up method relying on the analysis of Italian MNEs micro data. The aim is to identify tax-avoiding MNEs and to adjust their EBIT in order to determine the amount of BEPS. The PS-ROC procedure used to identify ATP and estimate BEPS is composed of two main steps: in the first one tax-avoiding MNEs are identified, in the second an adjustment of the EBIT of those tax-avoiding MNEs is introduced. Results of this pilot study show that about 60 percent of Italian MNEs are likely to use ATP strategies. On average, it is estimated that Italian MNEs under-report about 11.5 percent of their EBIT, which sum to about 32.8 billion euros. These results are also characterized by a significant sectoral pattern, which can be possibly traced back to peculiar features of their specific markets that affect the choice of possible ATP-related strategies.

**JEL classification:** E01 H26 D22 E26

**Keywords:** BEPS, Aggressive tax planning, Multi-national enterprises, Propensity score matching ROC analysis

## 1. Introduction

In the last decades, the free movement of capital and labor, the gradual removal of trade barriers, and the development of communication technologies have increased the integration of markets (in terms of trade and investments) and boosted the formation of global value-chains. This mixture of legal and technological developments enhanced the possibility for Multi-National Enterprises (MNEs) to adjust the geographical allocation of manufacturing bases along the value-chain, shifting their strategies from country-specific to global models in the governance of production processes.

The fast development of ICT, the increasing digitalization and the raising relevance of trade in services strengthened this tendency by further loosening the *technical* constraint in the geographical allocation of production. This opened the possibility for MNEs to use their global strategies also as a lever to minimize the tax burden by identifying and exploiting possible legal arbitrage, mismatches and loopholes in the international tax framework.

The possibility for MNEs to localize production and manage intra-group trade in order to shift profits from high- to low-tax countries raised several issues, ranging from the non-optimal allocation of resources to the reduction in market competition (OECD, 2013). Consequently, Base Erosion and Profit Shifting (BEPS) has become a relevant topic in the international debate, while strategies connected with Aggressive Tax Planning (ATP) are now investigated by national tax authorities and international organizations (e.g. G20, OECD, UN, and European Commission).

Following European Commission (2017), ATP by MNEs is defined as a set of (generally legal) practices aimed at exploiting mismatches and loopholes in the international tax framework in order to reduce the overall tax burden. Generally, ATP strategies uses the geographical allocation of manufacturing plants and financial headquarters in order to adjust the structure of costs and revenues of the MNE group in order to make the bulk of income and profits emerge in low-tax countries.

In parallel with the definition and the understanding of ATP, also the measurement of BEPS has become a relevant issue. Indeed, assessing the relevance of the phenomenon is crucial for several reasons: monitoring and inform policies aimed at contrasting ATP; assessing related illicit financial flows (as claimed by SDGs indicator 16.4); adjusting GDP and GNI in order to have estimates more comparable across countries and over time.

Starting from the seminal work of Hines and Rice (1994), several methods have been proposed with the aim of measuring BEPS coming from ATP by MNEs (see also Dharmapala, 2014). Empirical studies used both macro (Alvarez-Martinez et al., 2018; Acciari *et al.*, 2015; Dharmapala and Riedel, 2013; Heckermeyer and Overesch, 2013) and micro (Reynolds and Wier, 2016; Barrios and d'Andria, 2016; Huizinga and Laeven, 2008) data in order to study how tax differentials affect the distance between reported profits by MNEs and some theoretical measure based on the application of standard production and behavioral models, or the geographical allocation of FDIs. Other studies focused on the definition of reliable indicators for ATP (Jansky and Palansky, 2017).

In this context, micro empirical studies have been severely limited by the lack of complete and reliable worldwide firm-level information (Acciari *et al.*, 2015). In recent years, new databases

(e.g. Bureau Van Dijk) have attempted to overcome this gap, however issues related to microdata availability are far from being completely solved.

This work tries to overcome this problem by proposing a procedure to estimate BEPS in Italy using microdata related to only Italian enterprises. Though this obviously implies the limitation of analyzing MNEs using only a part of the information, it also represents a tool for national statistical institutes and national tax authorities, which could use information that are generally already available.

In particular, the bottom-up method proposed here is based on the analysis of microdata relating to the whole population of Italian firms, and jointly applies propensity score matching and receiver operating characteristics analysis (PS-ROC procedure, hereinafter). The aim is to estimate the amount of the tax base Italian MNEs shift abroad by using ATP strategies. The procedure grounds on a double comparison (between MNEs and non-MNEs and among MNEs themselves) and it is composed of two steps: (1) identification, in which MNEs are classified into tax avoiding or non-tax avoiding; (2) measurement, in which the BEPS from tax avoiding MNEs is estimated.

From a methodological point of view, the PS-ROC procedure uses PS matching in the first type of comparison (between MNEs and non-MNEs), while ROC analysis is used in the second type of comparison (among MNEs), where clustering (tax avoiding and non-tax avoiding MNEs) is determined, and BEPS is assessed. In this context, while PS matching has been already used to cope with BEPS (see for example Finke, 2013), ROC analysis is a new instrument in the exploration of this topic, even if not a novelty in economics (Costa *et al*., 2019).

Using an integrated micro database containing the main information about structural and economical characteristics of Italian firms (MNEs and non-MNEs), the PS-ROC procedure gives a probabilistic estimate as to whether Italian MNEs uses ATP strategies or not, and if they do, what amount of tax base is shifted. This represents a relevant innovation in the measurement of BEPS, which opens the door to the utilization of the procedure in the context of National Accounts and in the measurement of illicit financial flows.

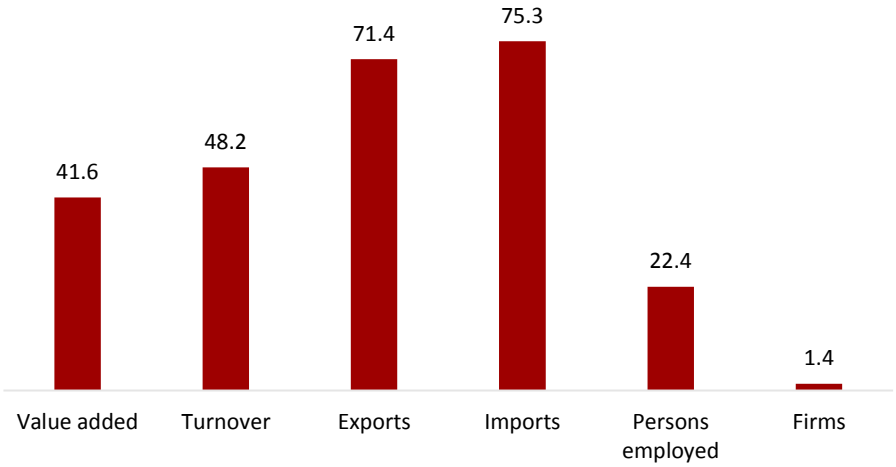
The work is organized as follows. Section 2 briefly describes the role of MNEs in Italy. Section 3 presents the database used for the analysis and the two phases composing the PS-ROC procedure. Section 4 summarizes the results. Section 5 concludes.

## 2. MNEs in Italy

A strong prevalence of very small enterprises characterizes the Italian business system. About half of the 4.4 million firms have less than 2 persons employed, while only about 11.000 have more than 100. This strong concentration towards SMEs of the size distribution does not prevent the Italian business system from being relevantly internationalized. Indeed, about 400.000 enterprises have some type of interaction with international markets (export and/or import). In Europe, only Germany shows higher extensive margins (i.e. incidence of exporters on the total number of firms), while the Italian business system still suffers from the tendency to show low intensive margins (i.e. the export-to-turnover ratio of exporting firms).

In 2016, there were more than 63,000 MNEs in Italy. About 25,000 belong to 11,720 MNE groups with headquartered abroad in 121 countries. Roughly 38,000 belong instead to 8,125 MNE group headquartered in Italy with affiliates in 125 countries.

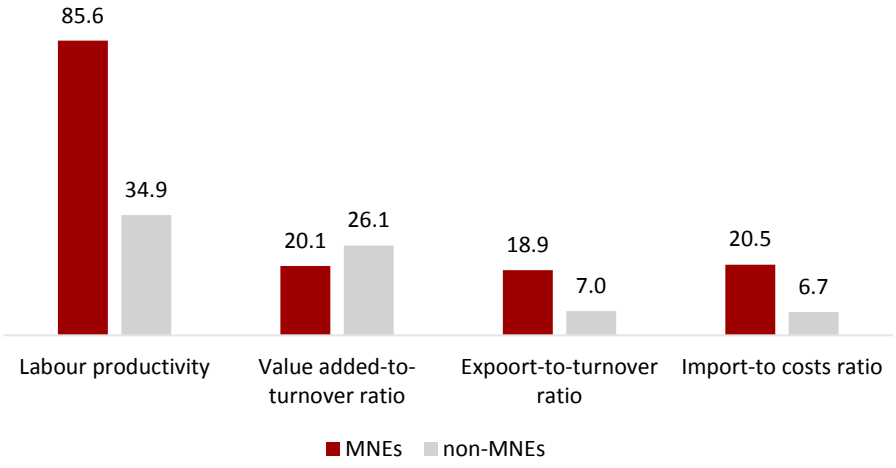
**Figure 1.** Contribution of MNEs in the Italian business system (shares), 2016




*Source: Author's elaboration on Istat data*

As Figure 1 shows, MNEs account for a small share of the total number of Italian enterprises (1.4%). However, their size is above the average and MNEs employ 22.4% of the workforce and generate a sizeable share of value added (41.6%) and turnover (48.3%). Finally, MNEs play a leading role in internationalization of the Italian business system, accounting for 71.4% of exports and 75.3% of imports.

**Figure 2.** MNEs vs. non-MNEs (thousands euro, shares)




*Source: Author's elaboration on Istat data*

Considering some economic and performance indicators (see Figure 2) it is possible to pin down some relevant heterogeneity between the characteristics of MNEs and non-MNEs. Considering the impact of internationalization on the structure of turnover and costs, MNEs obviously show a higher export-to-turnover and import-to-costs ratios with respect to non-MNEs (respectively, 18.9% vs. 7.0%, and 20.5% vs. 6.7%).

MNEs also prove to be strongly more productive than non-MNEs: labor productivity is more than double in MNEs (85.6 vs. 34.9 thousands euros). Instead, the value added-to-turnover ratio is lower in MNEs (20.1%) than in non-MNEs (26.1%). This may obviously depend on the tendency towards a lower degree of vertical integration that somewhat naturally characterizes MNEs. At the same time, it can be also considered as an indirect indicator (say a suspect though without evidence, also considering the higher productivity of MNEs) of the fact that MNEs might tend to increase in their reporting the incidence of costs given the turnover so as to reduce the value added (which is the main component of the tax base).

## 3. The PS-ROC procedure

This section presents the PC-ROC procedure to identify MNEs that put in place ATP strategies in order to erode the tax base in Italy and to measure the related amount of profits. The PS-ROC procedure permits therefore an analysis and estimation of BEPS at micro level. It is based on two conceptual steps: the first one is the comparison of a set of indicators between MNEs and non-MNEs, and the second is the comparison of (another) set of indicators among MNEs.

The first step is carried out through PS matching. This permits to define the most reliable control group of non-MNEs against which the economic behavior of MNEs can be contrasted. The second step is carried out using ROC analysis, which permits to discriminate among tax avoiding and non-tax avoiding MNEs based on the results coming from the first step and on the shape of the set of indicators used to define their behavior. The same model is then used to estimate the amount of BEPS for tax avoiding MNEs.

The two phases of identification and measurement are separately dealt with in paragraphs 3.2 and 3.3, while paragraph 3.1 describes the database used to carry out the analysis.

### 3.1 Database

The PS-ROC procedure is a bottom-up approach, which relies on micro data about enterprises. Starting from 2014, Istat produces the Structural Business Statistics Archive Frame-SBS (Luzi and Monducci, 2016), a database integrating administrative and survey data, which contains economic and structural information for the whole population of about 4.4 million of Italian firms.

In order to build the dataset for the PS-ROC procedure, Frame-SBS has been further integrated with two other databases. The first is COE-TEC, which contains micro information about imports and exports of enterprises by product and country of origin/destination. The second is the ASIA-group archive (the Italian version of the European Group Register), which includes information about the role of Italian firms within MNE groups (with Italian or foreign headquarter).

For each Italian firm (MNEs and non-MNEs), therefore, the final database includes, for each firm, comprehensive structural and economic information, the characteristics of its international trade network and, where relevant, its position within MNE groups. The database contains the whole population of economically relevant Italian enterprises (about 4 million), including about 61 thousand MNEs belonging to the selected industries.

Firms with a value added or turnover lower than or equal to 0 or that have less than 1 person employed were considered as irrelevant for the analysis and were excluded from the population. Moreover, industries whit particular features such as Tobacco, Financial intermediaries, Coke and refined petroleum products were also excluded from the analysis.

### 3.2 Identification

The identification is composed of three steps. In the first one, for each MNE, a control group of domestic firms is defined using PS matching. In the second, for each pair MNE-control group a comparison in terms of profit share over turnover is used to define a proxy clustering variable, which is used to identify possible "abnormal" behavior by MNEs. Finally, in the third step, ROC analysis is performed to define the final classification between tax avoiding and non-tax avoiding MNEs, starting from the proxy variable and using a set of indicators that are intended to capture the economic and strategic behavior of MNEs.

Conceptually, the identification phase is based on the idea that ATP strategies by MNEs tend to produce an "abnormal" set-up of economic variables with respect to the "normal" behavior of similar enterprises. This is true with respect both to similar non-MNEs that cannot freely manage the geographic allocation of their manufacturing and financial bases, and to other MNEs that do not use ATP strategies. The PS-ROC method uses the information provided by both types of comparison. In particular, PS matching is used to define the most efficient control group of non-MNEs to be compared with the given MNE, while ROC analysis is used to compare MNEs with each other.

Along the first phase of identification, the control group of non-MNEs is defined by using PS matching over a set of variable including territory, economic activity, employment, indicators of internationalization, structure of costs and revenues.[1] In this way, the PS matching algorithm should be able to identify, for each MNE in the database, a control group of domestic firms with the highest degree of similarity in terms of the selected characteristics.

In particular, each control group contains the 10 non-MNEs with the highest level of similarity given the following constraints: (1) being in the same region (NUTS2); (2) operating in the same economic activity (3 digit NACE rev. 2); (3) being included in the same size class (1-2, 2-5, 5-10, 10-20, 20-50, 50-100, 100-250, 250-500, more than 500 person employed).

In the second phase, for each pair MNE-control group, a proxy variable is defined in order to obtain a first tentative clustering between MNEs having a "normal" or an "abnormal" behavior

[1] In particular, 9 variables are used: region (NUTS2); industry (3 digit NACE rev. 2); per-capita turnover; persons employed; share of goods and services on total costs; export-to-turnover ratio; import-to-total costs ratio; share of salaries on total costs; share of services on turnover.

with respect to similar non-MNEs. Notably, this clustering is obtained by imposing the following conditions:

- $Proxy = 1$ (suspect) if EBIT-to-turnover ratio of the given MNE unit is lower than the average of the control group
- $Proxy = 0$ (absence of suspect) if EBIT-to-turnover ratio of the given MNE unit is higher than (or equal to) the average of the control group

In this context, the proxy variable, which reflects a behavioral mismatch between MNEs and their control groups, is interpreted as an indicator of "abnormality" and, thus, as a suspect of tax avoidance.

The third phase is devoted to the second type of comparison: among MNEs. This step also represents a refinement of the analysis, finalized to possibly adjust the clustering provided by the proxy variable. With this aim, ROC analysis is applied to determine to what extent the status signaled by the proxy variable can be reliably confirmed taking into account a set of variables characterising the economic structure, performance and possible ATP levers of MNEs.

ROC analysis has been widely used in in medicine and psychology (Lusted, 1960; Pepe, 2003), in machine learning (Majnik and Bosnic, 2013) and natural science (Peck, 2010). Its application is relatively new to economics, where it has been used to define the export threshold for Italian firms (Costa *et al.*,2019), to test the accuracy of business cycle classification made by the National Bureau of Economic Research (Berge and Jorda 2011), and in the credit risk literature (Khandani *et al.*, 2010). Furthermore, it has also been used to measure under-reporting of SMEs in Italy (Sallusti and Cavalli, 2019).

The methodology is finalized to define a threshold value over the distribution of a classifier able to efficiently cluster observations starting from a binary response variable (Fawcett, 2005).[2] Starting from a standard logit model having an explicative continuous variable, ROC analysis permits to define what is the value of the variable that efficiently classifies observations, given the relative importance assigned to errors (false positives and false negatives).

In this work, the binary variable is the proxy defined along the previous step. The classifier is represented by a composite indicator built from a set of variables relating to: the structure of costs and revenues of MNEs; their performance and internationalization; the tax differential among countries (in which MNE group have headquarters or parents). Furthermore, the composite also includes specific variables connected with the main channels of ATP: R&D, royalties, imports and exports.[3]

The composite indicator is constructed in two steps. In the first, a factor analysis is run on the whole set of selected variables. In the second, the first two factors are aggregated using relative share of explained variance as weight.

For each MNE, the composite indicator will be:

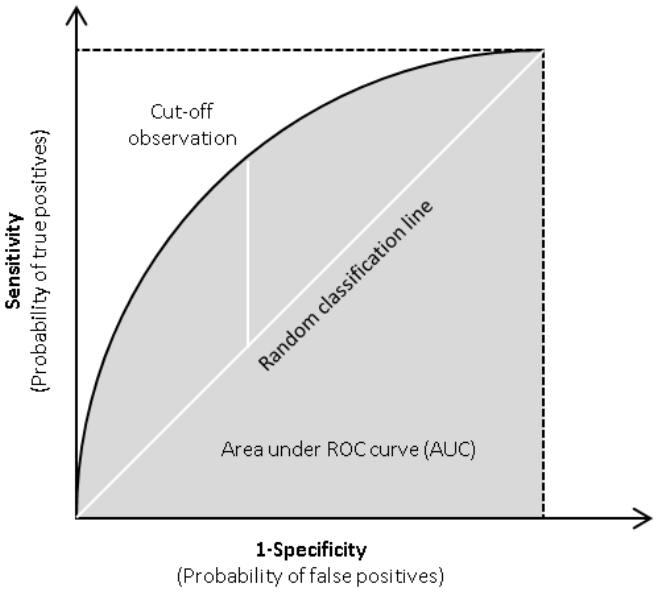
[2] A comprehensive discussion of the methodology is provided in Costa *et al.* (2019) and in Sallusti (2019).
[3] Variables included in the composite indicator are the following: EBIT-to-turnover ratio; Value added-to-turnover ratio; R&D spending with respect to turnover; share of royalties on total costs; share of salaries on total costs; share of services on total costs; export-to-turnover ratio; import-to-total cost ratio; average differential in income taxation among (related) countries.

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

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.

The composite indicator calculated in Equation [1] is then used as explicative variable in a logit model having as dependent the proxy of "suspect". Starting from the estimates provided by the logit, the ROC curve in Figure 1 can be obtained. The ROC curve represents the distribution of observation in the space of sensitivity (the probability of true positives) and the reciprocal of specificity (the probability of false positives) resulting from the model. The area under ROC curve (AUC) measures the goodness of fit of the logit, implicitly representing the extent to which it (and, in turn, the classifier) is able to cluster observations better than a random classification (represented by the 45° line).

**Figure 3.** The ROC curve




Starting from the ROC curve, it is possible to define a cut-off observation that efficiently discriminates the status of the others based on the following condition:

$$\overline{Cut} = h * Sensitivity - (1 - h) * (1 - Specificity) \qquad [2]$$

where $h$ and $(1-h)$ represent the relative weights to manage the trade-off between true and false positives. The value of the cut-off is therefore affected by the shape of the ROC curve (represented by sensitivity and specificity) and by the relative weight assigned in the trade-off between true and false positives. In particular, $h > 0.5$ would correspond to a "liberal" selection, which assigns positive classification even in the presence of weak evidence. Conversely, $h < 0.5$ would correspond to a "conservative" selection, which assigns positive classifications only in presence of strong evidence.

In this work, $h$ is set equal to 0.5. This corresponds to a "neutral" selection, which also makes Equation [2] equal to the Youden's (1950) $J$-index.[4] By applying Equation [2] to the results of the logit model with the composite $I_i$ as explicative and the proxy as dependent, a cut-off observation can be determined, which represents the threshold observation (i.e. the MNE starting from which the others can be clustered).

Once the threshold observation is identified (for each industry), under the obvious assumption that the composite indicator is monotone with respect to the proxy, the value of its composite indicator can be interpreted as the threshold value ($\bar{I}$) above or below which observation can be clustered: MNEs will be classified as tax avoiding if $I_i < \bar{I}$, while they are classified as non-tax avoiding if $I_i \geq \bar{I}$.

The PS-ROC procedure, therefore, yields a final classification where MNEs can be categorized into tax avoiding or non-tax avoiding, taking into account the comparison of MNEs with both similar non-MNEs and other MNEs. In particular, while PS matching permits to highlight (and interpret) the difference between MNEs and non-MNEs based on their general economic structure, the ROC analysis permits to identify (and interpret) the difference among MNEs, also taking into account variables related to potential ATP strategies (i.e. royalties, R&D, imports and exports, tax differentials). This way, along the second type of comparison (ROC analysis), the procedure is also used to "adjust" the results obtained along the first type of comparison (PS matching), considering specific indicators for MNEs.

### 3.3 Measurement

Once MNEs are classified as tax avoiding and non-tax avoiding, the second step of the PS-ROC procedure is designed to assess the amount of BEPS. In particular, the aim of the measurement phase is to determine the amount of EBIT (which is equal to value added if the labor income is given) that is concealed using ATP strategies.[5]

In general, measuring BEPS of tax avoiding MNEs can be performed by means of two strategies. The first, which can be called "horizontal", involves assessing BEPS by analyzing the distribution of profits among MNEs included in the same MNE group. In this way, measurement is based on possible incoherence in the geographical allocation of profits. The second, which can be called "vertical", involves assessing BEPS by analyzing the coherence between the given MNE and

[4] See Costa *et al*. (2019) for a deeper discussion.

[5] The conceptual correspondence of EBIT and value added under the condition of fixed amount of salaries is relevant if one is willing to use the estimates in the context of the measurement of GDP and GNI in national accounts.

others MNEs in the same country (and industry). In this context, the measurement would be based on the "distance" between tax avoiding and non-tax avoiding MNEs.

Both methods have advantages and disadvantages and can also be used contextually. However, while the latter approach (vertical) utilizes the same dataset as the identification phase (i.e. data about firms in the given country, being MNEs or not), the former approach (horizontal) uses data regarding all the firms involved in a given MNE group (i.e. data about firms in all countries in which a given MNE group operates).

Even if existing databases provide information about firms operating worldwide (e.g. Bureau Van Dijk), two main problems still make their use problematic. Indeed, information is only available for corporations (which have the obligation of publishing their balance sheets), where a great (and increasing) number of MNEs are unincorporated enterprises. Furthermore, even if the information is present, the selection of variables does not provide a comprehensive description of the economic structure and performance of firms.

Therefore, in this work, a "vertical" strategy has been chosen to measure BEPS. In particular, BEPS is assessed by exploiting the findings of the application of the ROC analysis in the identification phase. Conceptually, the measurement of BEPS is obtained by adjusting the EBIT of tax avoiding MNEs for the amount needed to bring them on the threshold defined by the ROC analysis, thus implicitly changing their status from tax avoiding to non-tax avoiding.

In particular, for each tax avoiding MNE (in a given industry), the following condition must hold:

$$\bar{I} > \omega_1 F_{1,i} + \omega_2 F_{2,i} \qquad [3]$$

$F_{1,i}$ and $F_{2,i}$ are factors for the $i$-th firm extracted in the identification phase starting from the set of $x_{j,i}$ variables in the following form:

$$F_{1,i} = \sum_j \gamma_{j,1} x_{j,i} \qquad [4a]$$

$$F_{2,i} = \sum_j \gamma_{j,2} x_{j,i} \qquad [4b]$$

The measurement of BEPS is carried out by increasing the EBIT-to-turnover ratio (indicator $x_h$,) so as to obtain that:

$$\bar{I} = \alpha F_{1,i} + \beta F_{2,i} \qquad [5]$$

Using some algebra, the adjustment condition which permits to measure BEPS for the $i$-th tax avoiding MNE is the following:

$$\tilde{x}_{h,i} = \frac{\bar{I} - (\omega_1 \sum_{-h} \gamma_{-h,1} x_{-h,1} + \omega_2 \sum_{-h} \gamma_{-h,2} x_{-h,2})}{\omega_1 \gamma_{h,1} + \omega_2 \gamma_{h,2}} \qquad [6]$$

where $\tilde{x}_{h,i}$ is the adjusted value of the EBIT-to-turnover ratio coherent with the threshold to shift from tax avoiding to non-tax avoiding status.

Finally, the amount of EBIT connected with BEPS is calculated, for each tax avoiding MNE, as:

$$BEPS_i = \left(\tilde{x}_{h,i} - x_{j,i}\right) * Turnover_{\ i} \qquad [7]$$

Equation [6] implies that the magnitude of the adjustment (i.e. the amount of BEPS) depends on three elements. The first is the level of the threshold $\bar{I}$, which represents the contextual conditions, at sectoral level, in which the given tax avoiding MNE operates. Indeed, the difference between $\bar{I}$ and the value of the composite indicator for the $i$-th MNE ($I_i$) can be interpreted as a proxy of the deviation of the tax avoiding MNE with respect to the minimum requirement to be included in non-tax avoiding class. In this context, obviously, the greater the distance, the higher the amount of the adjustment. The second element is the second part of the numerator ($\omega_1 \sum_{-h} \gamma_{-h,1} x_{-h,1} + \omega_2 \sum_{-h} \gamma_{-h,2} x_{-h,2}$), which incorporates the relevance of the effect of the other (than EBIT-to-turnover ratio) variables in the distance between the composite indicator and the threshold. The greater their influence, the lower will be, *ceteris paribus*, the amount of correction. The third element is the denominator ($\omega_1 \gamma_{h,1} + \omega_2 \gamma_{h,2}$), which represents the influence of the EBIT-to-turnover ratio. In this case, the higher the response, the lower the amount of the adjustment needed.

Moreover, the estimates of BEPS for the $i$-th tax avoiding MNE will depend on both sectoral and individual characteristics, where the individual characteristics are summarized by the relative relevance of the EBIT-to-turnover ratio and of the other variables in the composite indicator. This confirms that the PS-ROC procedure permits to measure BEPS by taking into account not only sectoral and general meso and macro elements, but also the individual economic structure of a given MNE.

**4. Results**

The PS-ROC procedure has been applied to the Italian business system, analyzing 61,243 MNEs in 2016. Results are shown in Table 1. Overall, tax avoiding units represents the 60.4% of the total of Italian MNEs (7th column). The ROC analysis tends to reduce by 8 points the incidence of tax avoidance with respect to the proxy defined by the PS matching (68.4%). In particular, the share of MNEs that is included in the same class stepping from the proxy to the clustering of the ROC analysis (the sum of 3rd and 6th columns) is over 80% on average, while in 5.4% of cases ROC analysis worsens the position of MNEs (from non-tax avoiding to tax avoiding) and in 13.5% of cases the symmetrical situation applies.

Results also show a strong sectoral heterogeneity. The incidence of tax avoiding units ranges from 43.3% in Real estate activities to 78.8% in Informatics. No evident differences between manufacturing and services emerge: industries with low and high incidence of ATP characterize both macro-sectors.

**Table 1.** Results of the PS-ROC procedure by industry, 2016

| Industry | Units | Identification (%) | | | | | | Adjustment (mln euro and %) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TA proxy | TA proxy vs. TA ROC | | | | TA ROC | Original EBIT | Adjusted EBIT | Correction | Incidence of correction | Incidence of TA |
| | | | YY | NY | YN | NN | | | | | | |
| Mining and quarrying | 157 | 75.8 | 63.7 | 0.6 | 12.1 | 23.6 | 64.3 | 137 | 158 | 20 | 14.8 | 12.9 |
| Food and beverage | 1640 | 64.0 | 47.2 | 7.3 | 16.8 | 28.8 | 54.5 | 10225 | 11990 | 1765 | 17.3 | 14.7 |
| Textile | 584 | 68.3 | 55.1 | 5.7 | 13.2 | 26.0 | 60.8 | 1824 | 1987 | 163 | 8.9 | 8.2 |
| Wearing apparel | 578 | 67.5 | 53.1 | 7.3 | 14.4 | 25.3 | 60.4 | 2853 | 3058 | 205 | 7.2 | 6.7 |
| Leather | 482 | 68.9 | 59.5 | 11.6 | 9.3 | 19.5 | 71.2 | 2887 | 3222 | 335 | 11.6 | 10.4 |
| Wood, Paper and print | 1248 | 64.7 | 48.0 | 6.4 | 16.7 | 28.8 | 54.4 | 3827 | 4246 | 419 | 11.0 | 9.9 |
| Chemical and pharmaceutics | 967 | 58.5 | 46.2 | 6.8 | 12.3 | 34.6 | 53.1 | 13525 | 15166 | 1640 | 12.1 | 10.8 |
| Rubber and plastic | 935 | 69.7 | 56.0 | 3.9 | 13.7 | 26.4 | 59.9 | 4874 | 5725 | 851 | 17.5 | 14.9 |
| Non-metallic minerals | 780 | 67.8 | 55.3 | 4.2 | 12.6 | 27.9 | 59.5 | 3827 | 3998 | 171 | 4.5 | 4.3 |
| Metals | 2680 | 67.4 | 55.7 | 8.4 | 11.6 | 24.2 | 64.1 | 10055 | 12174 | 2118 | 21.1 | 17.4 |
| Electronics | 1286 | 70.7 | 61.2 | 6.6 | 9.5 | 22.7 | 67.8 | 10403 | 11217 | 815 | 7.8 | 7.3 |
| Machinery | 2602 | 62.0 | 52.9 | 4.9 | 9.1 | 33.1 | 57.8 | 17596 | 18342 | 747 | 4.2 | 4.1 |
| Automotive | 540 | 66.1 | 51.7 | 6.3 | 14.4 | 27.6 | 58.0 | 12968 | 14237 | 1269 | 9.8 | 8.9 |
| Other manufacturing and repair | 1901 | 73.3 | 59.2 | 5.4 | 14.2 | 21.3 | 64.6 | 4396 | 4902 | 506 | 11.5 | 10.3 |
| Energy, water and waste | 2433 | 58.2 | 53.1 | 7.4 | 5.1 | 34.4 | 60.5 | 22427 | 30347 | 7920 | 35.3 | 26.1 |
| Construction | 4653 | 71.7 | 58.9 | 2.3 | 12.8 | 26.0 | 61.2 | 5772 | 6318 | 546 | 9.5 | 8.6 |
| Wholesale and retail trade | 13335 | 69.9 | 51.2 | 6.6 | 18.7 | 23.6 | 57.7 | 33262 | 40473 | 7211 | 21.7 | 17.8 |
| Transportation and logistics | 2048 | 70.8 | 61.3 | 5.5 | 9.5 | 23.6 | 66.8 | 24703 | 26171 | 1468 | 5.9 | 5.6 |
| Hotel and restaurants | 2685 | 64.5 | 54.3 | 4.8 | 10.2 | 30.7 | 59.1 | 3814 | 4069 | 254 | 6.7 | 6.2 |
| Telecommunications | 729 | 72.8 | 63.0 | 2.9 | 9.9 | 24.3 | 65.8 | 20680 | 21182 | 502 | 2.4 | 2.4 |
| Informatics | 2142 | 80.6 | 73.1 | 5.7 | 7.5 | 13.7 | 78.8 | 11261 | 11945 | 685 | 6.1 | 5.7 |
| Real estate | 7897 | 56.8 | 40.3 | 3.0 | 16.5 | 40.2 | 43.4 | 3882 | 4274 | 393 | 10.1 | 9.2 |
| Business services | 6492 | 79.8 | 68.9 | 5.8 | 10.9 | 14.5 | 74.6 | 22028 | 24301 | 2274 | 10.3 | 9.4 |
| Personal services | 2449 | 74.2 | 63.8 | 4.5 | 10.5 | 21.2 | 68.3 | 5849 | 6418 | 570 | 9.7 | 8.9 |
| **Total** | **61243** | **68.4** | **55.0** | **5.4** | **13.5** | **26.1** | **60.4** | **253073** | **285920** | **32846** | **13.0** | **11.5** |

*Source: Author's elaboration on Istat data*

MNEs considered in the analysis declare roughly 253 billion euros of EBIT (8th column). According to the procedure, BEPS connected with ATP strategies amounts to 32.8 billion euros (10th column), representing the 11.5% of the final value of EBIT (about 285 billion euros) and the 13.0% of the declared value (respectively, 11th and 12th columns). Also in this case, industries show different level of incidence, ranging from the 26.1% in Energy, water and waste to 2.4% in Telecommunications. These results show that ATP strategies are widely used by Italian MNEs. Even if the incidence of eroded tax base is lower with respect to the average incidence of non-observed economy related to the fiscal behavior of non-MNEs (Istat, 2018), the total amount of BEPS is relevant, accounting for about 2% of the Italian GDP.

Using a bottom-up strategy to estimate BEPS allows an ex-post analysis of the characteristics of Italian MNEs according to their final status with respect to ATP.

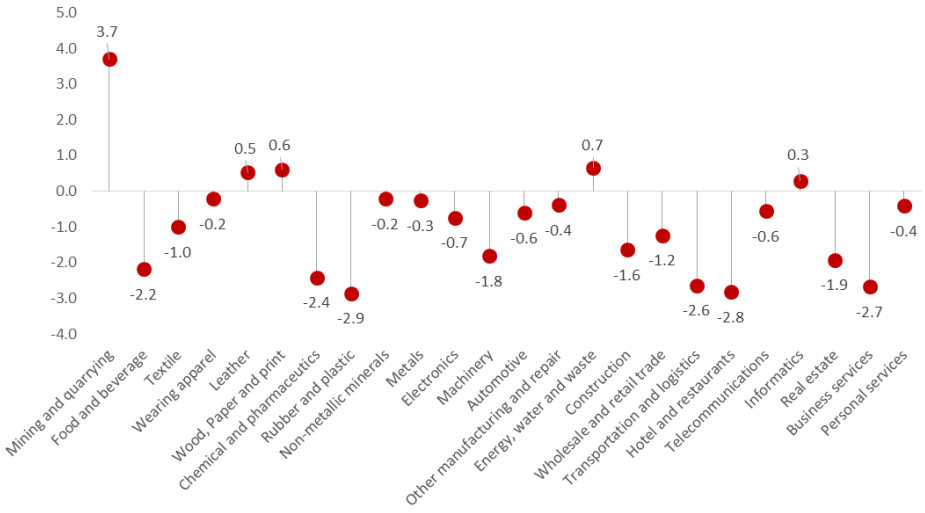
**Table 2.** Characteristics of MNEs by final status, 2016

| Industry | Non tax avoiding MNEs | | | | | | | Tax avoiding MNEs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Persons employed (Number) | Value added (Mln euro) | Turnover (Mln euro) | EBIT (Mln euro) | value added per worker (Thousands euro) | Value adde to turnover ratio (Percentage) | EBIT to turnover ratio (Percentage) | Persons employed (Number) | Value added (Mln euro) | Turnover (Mln euro) | EBIT (Mln euro) | value added per worker (Thousands euro) | Value adde to turnover ratio (Percentage) | EBIT to turnover ratio (Percentage) |
| Mining and quarrying | 27.0 | 2.5 | 8.1 | 2.0 | 93.9 | 31.3 | 24.7 | 10.9 | 0.7 | 2.8 | 0.3 | 63.6 | 24.6 | 8.9 |
| Food and beverage | 92.9 | 10.3 | 44.2 | 10.0 | 111.1 | 23.3 | 22.5 | 49.1 | 4.0 | 34.1 | 3.1 | 81.9 | 11.8 | 9.1 |
| Textile | 105.4 | 7.4 | 24.3 | 7.1 | 70.3 | 30.5 | 29.3 | 26.6 | 1.6 | 8.3 | 0.6 | 58.6 | 18.8 | 6.7 |
| Wearing apparel | 153.5 | 11.4 | 49.4 | 11.2 | 74.5 | 23.2 | 22.8 | 34.4 | 1.6 | 10.0 | 0.8 | 46.9 | 16.1 | 7.9 |
| Leather | 149.0 | 17.9 | 62.9 | 17.6 | 120.2 | 28.5 | 28.0 | 34.4 | 2.1 | 13.8 | 1.3 | 62.3 | 15.5 | 9.3 |
| Wood, Paper and print | 67.2 | 5.8 | 22.5 | 5.6 | 85.7 | 25.6 | 24.9 | 28.4 | 1.7 | 8.9 | 0.9 | 59.4 | 18.9 | 10.5 |
| Chemical and pharmaceutics | 193.4 | 25.8 | 86.4 | 24.9 | 133.3 | 29.9 | 28.9 | 60.9 | 5.8 | 50.9 | 4.3 | 94.4 | 11.3 | 8.4 |
| Rubber and plastic | 136.1 | 10.8 | 37.9 | 10.4 | 79.2 | 28.4 | 27.3 | 38.2 | 3.2 | 17.4 | 1.8 | 83.3 | 18.3 | 10.2 |
| Non-metallic minerals | 139.4 | 11.6 | 37.2 | 11.3 | 83.0 | 31.1 | 30.5 | 25.5 | 1.3 | 6.9 | 0.5 | 50.8 | 18.7 | 7.5 |
| Metals | 93.1 | 7.4 | 26.7 | 7.2 | 79.7 | 27.7 | 26.9 | 50.4 | 2.9 | 21.0 | 1.8 | 57.8 | 13.9 | 8.7 |
| Electronics | 273.2 | 22.1 | 76.5 | 21.8 | 81.0 | 28.9 | 28.5 | 42.4 | 2.8 | 13.6 | 1.6 | 67.0 | 20.8 | 11.4 |
| Machinery | 173.6 | 15.4 | 55.7 | 15.0 | 88.7 | 27.6 | 26.9 | 33.0 | 2.3 | 9.1 | 0.7 | 70.7 | 25.5 | 8.1 |
| Automotive | 565.9 | 49.4 | 212.2 | 49.2 | 87.2 | 23.3 | 23.2 | 188.1 | 7.0 | 110.4 | 5.7 | 37.3 | 6.4 | 5.2 |
| Other manufacturing and repair | 77.6 | 5.6 | 18.0 | 5.4 | 72.1 | 31.0 | 30.2 | 23.9 | 1.4 | 5.9 | 0.6 | 59.7 | 24.2 | 10.0 |
| Energy, water and waste | 23.6 | 7.1 | 11.2 | 7.1 | 302.1 | 63.7 | 63.0 | 53.8 | 11.0 | 79.3 | 10.6 | 203.7 | 13.8 | 13.4 |
| Construction | 29.9 | 2.6 | 7.8 | 2.5 | 87.7 | 33.7 | 32.0 | 14.1 | 0.8 | 6.1 | 0.4 | 59.8 | 13.8 | 7.3 |
| Wholesale and retail trade | 57.4 | 4.7 | 23.9 | 4.2 | 81.2 | 19.5 | 17.7 | 25.6 | 1.7 | 32.4 | 1.2 | 65.6 | 5.2 | 3.8 |
| Transportation and logistics | 306.5 | 33.9 | 69.2 | 33.3 | 110.6 | 49.0 | 48.1 | 40.2 | 2.4 | 20.4 | 1.5 | 58.7 | 11.5 | 7.5 |
| Hotel and restaurants | 87.9 | 3.0 | 7.0 | 2.9 | 34.1 | 43.0 | 41.1 | 19.6 | 0.7 | 2.4 | 0.4 | 35.2 | 28.9 | 17.6 |
| Telecommunications | 420.4 | 81.0 | 177.2 | 80.4 | 192.8 | 45.7 | 45.4 | 23.5 | 2.1 | 16.9 | 1.3 | 88.3 | 12.3 | 8.0 |
| Informatics | 244.5 | 22.7 | 47.0 | 22.5 | 92.6 | 48.1 | 47.8 | 16.5 | 1.4 | 3.9 | 0.6 | 85.6 | 35.9 | 15.7 |
| Real estate | 2.4 | 0.7 | 1.0 | 0.7 | 296.2 | 69.3 | 67.6 | 1.8 | 0.3 | 1.1 | 0.2 | 150.8 | 25.8 | 21.7 |
| Business services | 219.5 | 11.1 | 18.9 | 10.8 | 50.5 | 58.6 | 57.3 | 16.8 | 1.5 | 7.0 | 0.9 | 86.7 | 20.8 | 12.3 |
| Personal services | 81.4 | 6.5 | 13.0 | 6.4 | 80.5 | 50.2 | 49.3 | 15.1 | 1.0 | 5.0 | 0.5 | 65.9 | 19.8 | 10.3 |
| **Total** | **94.9** | **8.5** | **26.4** | **8.3** | **89.8** | **32.2** | **31.2** | **26.4** | **2.0** | **18.0** | **1.4** | **77.5** | **11.4** | **7.9** |

*Source: Author's elaboration on Istat data*

In general, tax avoiding MNEs are smaller (94.9 vs. 26.4 employed persons on average) and less productive (89.9 vs. 77.5 thousands euro) than non-tax avoiding ones. They also generate higher turnover (26.4 vs. 18.0 million euro on average), value added (8.5 vs. 2.0 million euro) and, particularly, EBIT (8.3 vs 1.4 million euro). Consequently, tax avoiding MNEs are characterized by lower levels of value added-to-turnover ratio (11.4% vs. 32.2% on average) and EBIT-to-turnover ratio (7.9% vs. 31.2%).

**Figure 4.** Differential in average income taxation between non-tax avoiding and tax avoiding MNEs, 2016

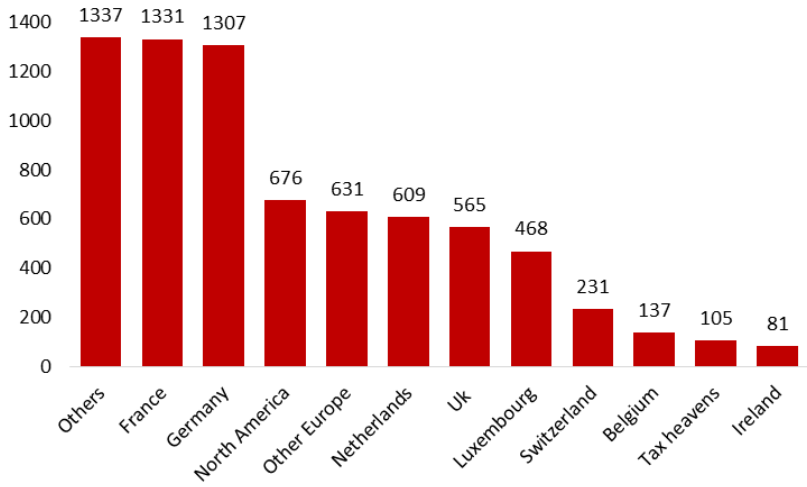



*Source: Author's elaboration on Istat data*

The possibility to investigate MNEs at micro level also facilitates a comparison between the average income tax faced by MNEs according to the country in which they are headquartered

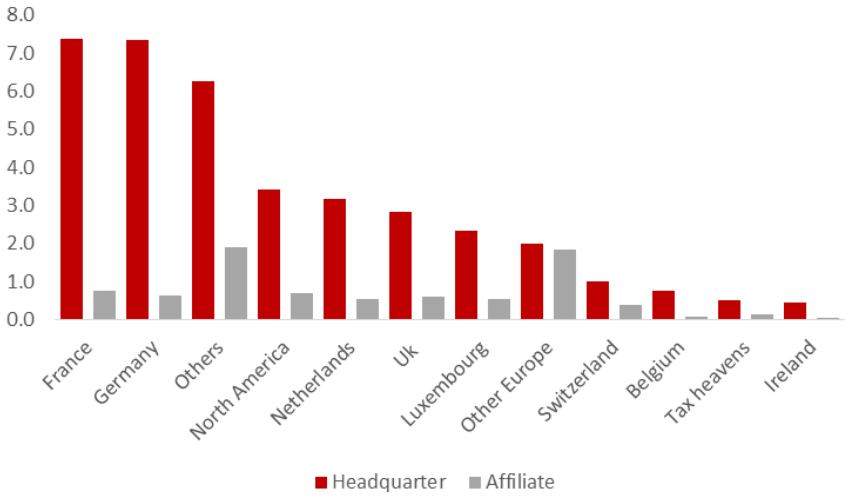
or have affiliates. Figure 4 shows the differential in the average tax income characterizing tax avoiding and non-tax avoiding MNEs. In particular, results confirm the hypothesis that tax avoidance is linked to the exploitation of mismatches in the international taxation framework: tax avoiding MNEs have a negative differential in almost all industries. This implies that the geographical allocation of production allows MNEs to pay lower average income taxation. Tax differentials are however small in amount with a maximum value of 2.9 points in rubber and plastic.

**Figure 5.** Total adjustment for MNE by country, in billion euros, 2016




*Source: Author's elaboration on Istat data*

**Figure 6.** Share of adjustment for MNEs by localization of headquarters and affiliates, 2016




*Source: Author's elaboration on Istat data*

Figure 5 presents the geographical allocation of the adjustment in terms of EBIT considering the country in which the headquarter of the given MNE group is based. Excluding the case in which the final headquarter is located in Italy, which accounts for about 90% of the total amount, about 1.3 billion euro are related to MNEs having headquarter in Germany and France, while The Netherlands (609 million euro), UK (565) and Luxembourg (468) show lower relevance.

Figure 6 also includes the location of affiliates of the Italian MNEs in determining the share of the total amount of BEPS related to foreign countries. Headquarters shows a higher relevance for all countries (or geographical zone). Not surprisingly, however, the relevance of affiliates is relatively higher for other European countries and other countries (in which MNEs have manufacturing bases characterized by lower production costs), while in tax heavens, Ireland and Belgium the role of the location of affiliates is negligible.

## 5. Conclusion

This work proposes a method to measure BEPS for Italian MNEs based on a bottom-up approach that uses Istat's firm-level database. The PS-ROC procedure use propensity score matching and ROC analysis to provide, for each Italian MNE, information about its status (tax avoiding or not) and, where relavant, the total amount of BEPS.

This approach represents a relevant step beyond in the existing literature devoted to the empirical study of BEPS. Indeed, the PS-ROC procedure opens the door to the possibility of analyzing the fiscal behavior of MNEs and measuring the corresponding amount of BEPS using information related to domestic enterprises (MNEs and non-MNEs), thus overcoming the constraint represented by the lack of complete and reliable worldwide microdata.

Results show that ATP is relevant in Italy. A great number of Italian MNEs uses global strategies as a lever to shift profits outside Italy to reduce the tax burden. Using the PS-ROC procedure roughly 60% of Italian MNEs (more than 36,000 units) were identified as tax avoiding. The total amount of profits shifted by tax avoiding MNEs is estimated to be more than 32 billion euros, representing about 2% of Italian GDP.

The possibility to estimate BEPS at firm-level also opens the door to the utilization of these results in a number of contexts. Besides monitoring the macro dimension of the phenomenon (as other approaches also permit), micro results can also be used to inform policies aimed at contrasting ATP and BEPS, to analyze and estimate related illicit financial flows, and to improve exhaustiveness of relevant aggregates of national accounts (e.g. GDP and GNI).

Having results at firm-level allows to inform contrast policies based on more detailed information about the characteristics, levers, and indicators connected with ATP strategies. Indeed, they can strongly differ according to sectoral and individual features of MNEs that cannot be observed using macro, top-down, approaches.

The measurement of illicit financial flows has become a relevant point in the international agenda, being also included in SDGs indicators by the UN. By definition, ATP is a relevant source of cross-border financial flows, and the possibility to estimate the magnitude of BEPS at firm-level can be an important element in the measurement of the related illicit financial flows.

The exhaustiveness of national account aggregates is a relevant issue in order to guarantee the comparability of the economic performance of countries, both cross-section and over time. This is particularly true for the European Union, which bases cohesion and regional policies, and taxation on macro-economic indicators derived from the European System of Accounts. Non-observed phenomena are a hot issue in this context, as they might involves incompleteness and/or distortion in measurement. The possibility of estimating BEPS at firm-level allows these estimates to be included in the system of national accounts without affecting the procedures by which they are compiled.

This work is experimental. It obviously suffers from some limitations. The main shortcoming relates to the fact that information about unincorporated firms, though present, is incomplete. This limits the analysis as some MNEs are excluded from the study. The second issue relates to the information on the financial statements of MNEs (which includes information about both the stock of R&D and the structure of debt). Here, the problem is mainly associated to unincorporated enterprises, which are not obliged by Italian law to provide these data publicly. In this context, any possibility to broaden the firm-level information would largely improve the reliability of the results obtained by the PS-ROC procedure, also allowing for carrying out the analysis to a lower level of disaggregation (above all in terms of economic activity and region).

**References**


Acciari P., Tomarelli F., Limosani L., Benedetti L. (2015) Measurement of base erosion and profit shifting phenomena through the analysis of FDI stock. *Italian Ministry of Economy and Finance Working paper* 3/2015

Alvarez-Martinez M.T., Barrios S., d'Andria D., Gesualdo M., Nicodeme G., Pycroft J. (2018) How large is the corporate tax base erosion and profit shifting? A general equilibrium model. *CEsifo working papers* 6870/2018

Barrios S., d'Andria D. (2016) Estimating corporate profit shifting with firm-level panel data: time trends and industrial heterogeneity. *JRC working papers on taxation and structural reforms* N.7/2016

Berge, T.J., Jorda O. (2011) Evaluating the classification of economic activity into recessions and expansions. *American Economic Journal: Macroeconomics* 3: 246–277.

Costa S., Sallusti F., Vicarelli C., Zurlo D. (2019) Over the ROC methodology: productivity, economic size and firms' export thresholds. *Review of International Economics* 00: 1-26

Crivelli E., De Mooji R., Keen M. (2015) Base erosion, profit shifting and developing countries. *IMF working paper* 15/118

Dharmapala D. (2014) What do we know about base erosion and profit shifting? A review of the empirical literature. *Coase-Sandor Institute for Law and Economics working paper* N. 702

Dharmapala D., Riedel N. (2013) Earning shocks and tax-motivated income shifting: evidence from European multinationals. *Journal of Public Economics* 95:95-107

Fawcett T. (2005) An introduction to ROC analysis, *Pattern Recognition Letters* 27: 861-874

Finke K. (2013) Tax Avoidance of German Multinationals and Implications for Tax Revenue: Evidence From a Propensity Score Matching Approach. Mimeo

Heckermeyer J.H., Overesch M. (2013) Multinationals' profit response to tax differentials: effect size and shifting channels. *ZEW Discussion Paper* N. 13-045

Hines J.R., Rice E.M. (1994) Fiscal paradise: foreign tax heavens and American business. *Quarterly Journal of Economics* 109: 149-182

Huizinga H., Laeven L. (2008) International profit shifting within European Multinationals. *Journal of Public Economics* 92: 1164-1182

Istat (2018) L'economia non osservata nei conti nazionali. Comunicato stampa.

Jansky P., Palansky M. (2017) Estimating the scale of profit shifting and tax revenue losses related to foreign direct investments. *IES working paper* N. 25/2017

Khandani A.E., Kim A.J., Lo, A.W. (2010) Consumer credit-risk models via machine-learning algorithms. *Journal of Banking and Finance* 34(11): 2767–2787.

Lusted L.B. (1960) Logical analysis in roentgen diagnosis: memorial *fund* lecture. *Radiology* 74(2): 178–93.

Majnik M., Bosnić Z. (2013) ROC analysis of classifiers in machine learning: a survey. *Intelligent data analysis* 17: 531-558

OECD (2013a) Addressing base erosion and profit shifting. OECD publishing. Paris

OECD (2013b) Action plan on base erosion and profit shifting. OECD publishing. Paris

Reynolds H., Wier L. (2016) Estimating profit shifting in South Africa using firm-level tax returns. *WIDER working paper* N.128/2016

Sallusti F., Cavalli L. (2019) Detecting under-reporting of value added and VAT fraud in National Accounts. Paper presented at the IMF Global Statistical Forum. Washington DC

Warnock D.G., Peck C. (2010) A roadmap for biomarker qualification". *Nature Biotechnology* 28: 444–445

Youden W.J. (1950) Index for rating diagnostic tests. *Cancer* 3: 32–35