Measuring profit shifting by MNEs in Italy

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Abstract

This paper presents a new method to estimate the amount of the Base Erosion and Profit Shifting (BEPS) by Multi-National Enterprises (MNEs) at micro level by exploiting only the information on resident business units (MNEs and domestics). The method contributes to the existing literature in two ways. On the one hand, using microdata referred to resident firms allows for overcoming the issue related to the availability and reliability of worldwide firm-level information, which currently represents the main issue in dealing with the estimation of BEPS. On the other hand, point estimates of BEPS at MNE-level opens the room for the application of the results to several domains, ranging from informing specific policies, to adjusting National Accounts and measuring Illicit Financial Flows. The application of the method to the Italian economy shows that about 6 out of 10 MNEs use ATP strategies, generating slightly less than 25.9 billion euros of BEPS, 1.4% of the Italian GDP at current prices in 2019. Moreover, the results also allow for investigating the role of intangible assets in BEPS, confirming the relevance of strategic location of intangibles in tax avoidance.

JEL classification: E01 H26 D22 E26

Keywords: Base erosion and profit shifting, Aggressive tax planning, Multi-national enterprises, Propensity score matching, ROC analysis

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The opinions expressed in this work are the ones of the author himself and do not involve the responsibility of the Italian National Institute of Statistics.
The author thanks Alessandra Agostinelli, Gian Paolo Oneto, Steven McFeely, William Addessi, and the participants in the expert meeting of the Task force for measuring illicit financial flow held at UNCTAD in July 2019, as well as the participants in the Working Group on National Accounts held at OECD in November 2019 for their helpful comments. Furthermore, the author wish to thank also Stefano Costa, Claudio Vicarelli and Davide Zurlo, my coauthors in some preceding papers on the application of the ROC analysis. Finally, the author also thanks the two anonymous referees for theirs suggestions and comments that helped improve the work.

1. Introduction

This paper presents a new method to estimate Base Erosion and Profit Shifting (BEPS) by Multi-National Enterprises (MNEs) at micro level by exploiting only the information on resident business units (MNEs and domestics). The method contributes to the existing literature in two ways. On the one hand, to use microdata referred to only resident business units allows for overcoming the issue related to the availability and reliability of worldwide firm-level information, which currently represents a relevant issue in dealing with the estimation of BEPS. On the other hand, point estimates of BEPS at MNE-level opens the room for the application of the results in several domains, ranging from informing specific policies, to adjusting National Accounts and measuring Illicit Financial Flows (IFFs).

In the last decades, the free movement of capital and labor, the progressive removal of trade barriers, and the development of Information and Communication Technologies (ICT) increased the integration of markets for trade and investments, and boosted the formation of global value-chains. This mixture of legal, technological and organizational developments enhanced the possibility for MNEs to manage the geographical allocation of production processes along (progressively globalized) value-chains.

The fast development of ICT and digitalization, and the increasing relevance of trade in services further increased what Slemrod (2010) defined as *mobility,* loosening technical and cost constraints in the geographical allocation of production processes. This opened the possibility for MNEs to use their global strategies as a lever to minimize their tax burden by identifying and exploiting the mismatches in the international tax framework.

The opportunity for MNEs to localize production processes and the ownership of tangible and intangible assets, and to manage intra-group trade and structure of debt in order to shift profits from high- to low-tax countries has been rising several issues, ranging from the non-optimal allocation of resources to the reduction in market competition (OECD, 2013a, 2013b). Consequently, BEPS has become a relevant topic in the international debate, while Aggressive Tax Planning (ATP) is actually deeply investigated by National Tax Authorities and international bodies (e.g. G20, OECD, UN, and European Commission).

According to the European Commission (2017), ATP refers to 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 of MNEs. In particular, ATP leverages on the geographical allocation of manufacturing plants and financial headquarters with the aim of adjusting the structure of costs and revenues of MNEs in order to make the bulk of income and profits emerge in business units that are resident in low-tax countries.

Alongside the definition and the understanding of ATP, also the measurement of BEPS has become a central topic. Indeed, assessing its magnitude is crucial for a number of reasons, ranging from monitoring the phenomenon and informing policies aimed at tackling it (OECD, 2013b), to measuring the related IFFs (UNCTAD, 2018; GFI, 2019) and adjusting relevant aggregates (e.g., GDP, intangible assets) in National Accounts (Moulton and Van de Ven, 2018; Ahmad, 2018).

Starting from the early 90s, several studies approached the issue of assessing the magnitude of BEPS. In particular, two strands of literature can be acknowledged, respectively based on the

study of the relationship between BEPS and tax differentials among countries, and on the study of the economic structure of MNEs.

The first strand is rooted in the seminal works of Hines and Rice (1994), and Ghruber and Mutti (1991). In this context, econometric models are used to study how tax differentials among countries affect the distance between the profits declared by MNEs and the theoretical profits estimated based on the application of standard production and behavioral models, or on the geographical allocation of Foreign Direct Investments (FDIs).[1] Econometric models use both macro[2] and micro data[3] where, according to Heckermeyer and Overesch (2013), macro analyses tend to overestimate the BEPS-tax differential relationship. In this context, the tax differential-profit gap elasticity may provide indicators about the magnitude of BEPS at national level and may shape the cross-country distribution of the shifted income.[4]

The second strand is rooted in accounting literature, and uses different variants of the formulary apportionment developed by Avi-Yonah (2010) and Fuest *et al.* (2007) to measure the amount of BEPS. Variables such as sales and compensation of employees (or a composite of them) are used to determine if, and to what extent, the income declared by MNEs is coherent with their economic structure. In this context, BEPS can be assessed by exploring possible inconsistencies between the economic structure and the declared income of the units belonging to the same MNE.[5]

In both approaches, the use of microdata in empirical studies has been severely limited by the lack of a complete and reliable worldwide firm-level information (Acciari *et al.*, 2015). Indeed, though new commercial databases (e.g. Bureau Van Dijk) have attempted to fill this informative gap in recent years, issues related to microdata availability and quality are far from being completely solved.

As mentioned, this work presents a method able to provide point MNE-level estimates of BEPS using microdata related to only resident business units (MNEs and domestics).[6] The method thus

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[1] See Dharmapala (2014) and, more recently, Dharmapala (2019) for a survey.

[2] Among others, Dharmapala and Riedel (2013) use macro data in order to measure the sensitivity of the behavior of MNEs with respect to exogenous changes in tax differentials among countries. Acciari *et al.* (2015) use instead the distribution of FDIs to test to what extent the geographical allocation of investments in foreign companies is sensitive to tax differentials. Finally, using a general equilibrium model, Alvarez-Martinez *et al.* (2018) use macro data from a large set of OECD countries in order to estimate the amount of profits that are shifted abroad by MNEs.

[3] Among others, Egger *et al*. (2010) use microdata about European foreign and domestic manufacturing plants to test to what extent their geographical location is connected with strategies aimed at reducing the tax burden. In a similar vein, Huizinga and Laeven (2008) use commercial micro databases to estimate the semi-elasticity of BEPS with respect to tax differentials. More recently, Reynolds and Wier (2016) use microdata about South African corporations to estimate profit and debt shifting, using taxation as explanatory variable in modelling firms behaviors, while Barrios and d'Andria (2016) use worldwide firm-level data to account for BEPS coming from the geographical management of intangibles.

[4] See Clausing (2016) and Dowd *et al.* (2017) for USA.

[5] In particular, Dyreng and Markle (2013) use sales to adjust the income declared by business units belonging to MNEs, Guvenen *et al.* (2017) use an average of sales and compensation of employees for the same goal, while Bruner *et al*. (2018) use the number of workers.

[6] The database will therefore include resident headquarters and affiliates, while excluding non-resident ones. In other words, if a MNE with headquarter in Country A has two affiliates, one in Country A and one in another country, only the headquarter and the affiliate in Country A will be included in the analysis.

permits to overcome the aforesaid informative gap, since data about resident firms are generally available for National Statistical Offices, National Tax Authorities and, though with some administrative burden, for scholars.[7]

From a methodological point of view, the hereby presented PSM-ROC approach moves away from both model-based methods and formulary apportionment. It jointly applies Propensity Score Matching (PSM), which has already been used in the exploration of BEPS (Finke, 2013), and the Receiver Operating Characteristics (ROC) analysis, which has not been used as yet in dealing with this topic, though not constituting an absolute novelty in economics (Costa *et al*., 2019, 2022).[8]

The PSM-ROC method is conceptually based on the idea that ATP strategies tend to produce an "abnormal" set-up of structural (e.g., size, localization, industry) and economic (e.g. value added, costs, profitability) variables of MNEs with respect to a "normal" behavior, where the distance between the normality and the declared set-up can be traced back to a measure of BEPS. In particular, the method exploits the information coming from the interaction between two comparisons: "between" resident MNEs and domestics (which is coped with by using PSM) and "within" resident MNEs (which is dealt with by using ROC).

The application of the PSM-ROC method to the Italian economy shows that about 6 out of 10 MNEs use ATP strategies, generating slightly less than 25.9 billion euros of BEPS (1.4% of the Italian GDP at current prices in 2019). Results also show strong sectoral heterogeneity, where construction has the highest level of BEPS and motor vehicles the lowest one. Finally, considering the country of headquarters, Italian MNEs generate 64.1% of the whole amount of BEPS, while MNEs with headquarter in other relevant EU countries account for 20.5% of BEPS.

The rest of the work is organized as follows. Section 2 presents the PSM-ROC method. Section 3 shows the results of its application to the Italian business system. Section 4 concludes.

2. PSM-ROC method

This section presents the PSM-ROC method, which is composed of two stages: the classification of MNEs into tax avoiding and non-tax avoiding, and the measurement of the related amount of BEPS.

The classification of MNEs (see Section 2.1) is based on the idea that ATP strategies tend to produce an "abnormal" set-up of economic variables of MNEs. This abnormality is pinned down by sequentially comparing resident MNEs with both similar domestic units ("between" comparison) and among each other ("within" comparison).

In turns, the measurement (see Section 2.2) is based on the idea that the amount of BEPS is connected with the distance of tax avoiding MNEs from the threshold of "normality" based on which they have been classified. In this context, estimates of BEPS are obtained, for each tax

[7] For example, Italian National Statistical Office (Istat) allows scholars and researchers to access microdata by using a secure platform for accessing data.

[8] Indeed, ROC analysis has been used to define the export threshold for Italian firms (Costa *et al.*, 2019, 2022), in the credit risk literature (Khandani et al., 2010), and to measure under-reporting of small and medium firms in Italy (Sallusti and Cavalli, 2019).

avoiding MNE, by calculating the amount of profits that they should have had to declare in order to being classified as non-tax avoiding.

2.1 Classification

The classification of MNEs into tax avoiding and non-tax avoiding is obtained in two steps, which deal with "between" and "within" comparisons respectively.

The "between" comparison allows to identify (and interpret) the difference between the behavior of MNEs and the one of the most similar group of domestic units, thus defining a proxy of "suspect" that provides a first clustering of MNEs. In particular, the proxy for "abnormal" behaviors is obtained by comparing the EBIT-to-turnover ratio of each MNE with the average one calculated over a control group of domestics, which is defined by using PSM.

The "within" comparison allows to identify (and interpret) the difference among (tax avoiding and non-tax avoiding) MNEs, thus providing the final classification. In particular, starting from the proxy of "suspect" derived in the "between" comparison, and analyzing only MNEs, ROC analysis is performed to define the final clustering by comparing MNEs based on a set of indicators that are intended to capture their specific economic and strategic behaviors as well as possible ATP levers/drivers (i.e. royalties, R&D, trade, tax differentials).

The "between" comparison uses PSM to define, for each resident MNE, the control group of domestic units characterized by the highest level of similarity in terms of a set of confounding variables that should reconstruct the economic and strategic behavior of business units (e.g., economic activity, employment, internationalization, structure of costs and revenues).[9]

In order to mitigate possible distortions coming from the fact that confounding variables might not capture all sources of heterogeneity between MNEs and domestics (e.g. economies of scale, technology, organizational set-up), the model also controls for economic activity and size class.[10]

Furthermore, to obtain full coverage of MNEs in the comparison with domestics, PSM procedure should be sequentially applied by setting up control groups characterized by decreasing size (see also Section 3.2). Where MNEs were still uncovered – i.e. for the given MNE a control group constituted by at least one domestic unit is not found – the control group should be set to contain, for each uncovered MNE, all the domestic units in the same industry and size class.

For each MNE-control group pair (including industry/size average), a proxy of "suspect" is defined to obtain a first clustering in which each MNE is classified based on its "normal" or "abnormal" behavior with respect to domestic units. Notably, this first clustering is obtained by imposing the following conditions:

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[9] In particular, in the application of the method to Italian data (see Section 3) 7 variables are used: per-capita turnover; workers; share of goods total intermediate costs; export-to-turnover ratio; import-to-total intermediate costs ratio; share of salaries on total costs; revenues from services on turnover.

[10] The economic activity should cover the effect of technology and the technology-related economies of scale. Size class should cover organizational set-up and the size-related economies of scale. In particular, in the application of the method presented in Section 3, the economic activity is defined in terms of 2-digits NACE rev. 2, while the size class are 1-2, 2-5, 5-10, 10-20, 20-50, 50-100, 100-250, 250-500, more than 500 workers.

- $Proxy = 1$ (suspect) if the EBIT-to-turnover ratio of the given MNE is lower than the average of the control group
- $Proxy = 0$ (no suspect) if the EBIT-to-turnover ratio of the given MNE is higher than (or equal to) the average of the control group.[11]

This proxy of "suspect" represents the starting point of the "within" comparison, carried out with ROC analysis, where MNEs are compared to each other in order to define the final classification.[12]

According to Fawcett (2005), the Receiving Operating Characteristic (ROC) analysis permits to define a threshold value over the distribution of a classifier able to efficiently cluster observations starting from a binary response variable.[13] Considering a standard logit model having a binary dependent and a continuous explanatory, ROC analysis permits to define the value of the explanatory that efficiently classifies observations, given the relative importance assigned to classification errors.

In this work, the binary variable is represented by the proxy of "suspect" defined along the "between" comparison. The explanatory (classifier) is a composite indicator built from a set of characteristics relating to the economic structure, performance and strategic behaviors of MNEs. Furthermore, this composite also includes ATP-specific levers/drivers such as R&D, royalties, tax differentials among countries in which MNEs have headquarters, parents or affiliates, and the structure of imports and exports.[14]

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[11] Averages within the control groups are obtained by weighting the values of each unit in the control group by using matching weights. In the case of Industry/Size control group, weights are obtained considering the value added of business units.

[12] Performing a double comparison instead of using only one of them comes from the need for interacting their results in order to obtain a less distorted classification and a more reliable measurement. This is connected with two main motivations. On the one hand, if only the "between" comparison was used, the classification of MNEs and the measure of BEPS might be affected by two sources of distortions: possible loose matching between MNEs and domestics in control groups; the impossibility to consider specific variables capturing ATP strategies and ATP levers/drivers of MNEs (i.e., they are hardly significant in domestic units). In this context, the "within" comparison performed by ROC analysis should reduce the incidence of both rooms for distortion. Indeed, it allows for considering MNE-specific behaviors (see footnote 14), while the related classification should also correct distortions coming from loose matching in the proxy derived along the "between" stage (see Table 4). On the other hand, in order to perform the ROC, a starting prior for the clustering (the proxy of "suspect") is needed. In this context, to define this prior along the "between" comparison should avoid some conceptual endogeneity, which might emerge if the suspect of tax avoidance would be derived by directly comparing MNEs to each other (i.e., the behavioral model to define the proxy and the final classification would be the same).

[13] A comprehensive discussion of the methodology is provided in Costa *et al*. (2019, 2022).

[14] In the application of the method to Italian data (see Section 3), variables included in the composite indicator are: EBIT / Turnover; Value added / Turnover; R&D spending/Costs for services; 1 - (costs for royalties / Total intermediate costs); 1 - (Wages / Turnover); 1 - (Costs for services / Turnover); Exports / Turnover; 1 - (Imports / Total intermediate costs; Average differential in income taxation among (related) countries. In particular, variables are defined to have an inverse relationships with respect to the probability of being tax avoiding. No variables capturing the financial structure of MNEs have been included because of the lack of this type of information. Indeed, as in Italy only corporations have the obligation of publishing their financial statements, this information is largely unavailable for unincorporated enterprises, which account for a relevant (and increasing) share of MNEs. This prevented from including the global allocation of debts and interests in the model.

For each stratum, the composite indicator for the i-th MNE (I_i) is built by using a factor analysis on the whole set of the selected characteristics, and then aggregating the first two factors using the relative share of explained variance as weight:

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

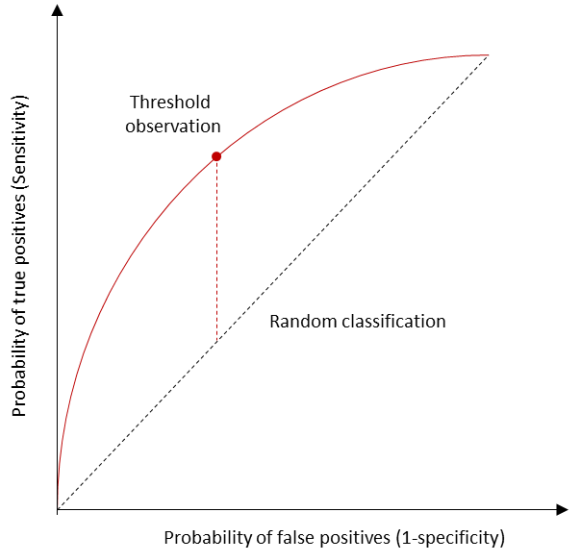
where $\gamma_{j,1}$ and $\gamma_{j,2}$ are the loadings of the j-th variable in factors 1 and 2, $x_{j,i}$ is the value of the j-th variable for the i-th observation, and ω_1 and ω_2 are weights in term of explained variance.

For each stratum, the composite indicator calculated in Equation [1] is then used as explanatory variable in a logit model having as dependent the proxy of "suspect":

$$Prob\ (Proxy_i = 1|\ I_i) = \Lambda(\ \alpha I_i) \qquad [2]$$

where Λ is the cumulative distribution of the logistic function.[15]

Figure 1. The ROC curve



Starting from the estimates of the logit in Equation [2], the ROC curve in Figure 1 can be obtained. The ROC curve represents the distribution of the observations (MNEs in this case) in the space of the probability of true positives (defined as *sensitivity*) and the probability of false positives (defined as the reciprocal of *specificity*) resulting from the model.

[15] In the application of the method presented in Section 3, strata of analysis are represented by the economic activities reported in Table 1. Weights used for each stratum are reported in Table 3, as well as the estimated (negative) parameters and relative standard errors in the logit in Equation [2]. Finally, Table 3 also shows, for all strata, the AUC, which represents the goodness of fit of the model.

Along the ROC curve, the threshold observation efficiently discriminating the status of the others can be identified starting from the following condition:

$$\overline{Cut} = h * Sensitivity - (1 - h) * (1 - Specificity) \qquad [3]$$

where h and $(1 - h)$ represent the weights assigned to manage the trade-off between true and false positives along the distribution of probability.

Consequently, the identification of the cut-off depends on two elements. On the one hand, it is affected by the shape of the ROC curve (its area over the 45° line is also a measure of the goodness of fit of the model). On the other hand, it is affected by the relative weight assigned to sensitivity and (the inverse of) specificity.

In this work, h is set equal to 0.5, i.e. the same weight is assigned to the importance of detecting true positives and avoiding false positives.[16] In this case, Equation [3] corresponds to Youden's (1950) J-index, which determines the threshold observation by maximizing the vertical distance between the 45° line and the curve (i.e. the bullet in Figure 1).

By applying the J-index to the results of the logit with the composite I_i as explanatory and the proxy of "suspect" as dependent, a cut-off can be identified, 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 stratum, under the obvious assumption that the composite indicator is monotone with respect to the proxy of "suspect", the value of its composite indicator can be interpreted as the threshold ($\bar{I}$) above or below which other MNEs can be classified.[17] Specifically, when the composite is inversely related to the dependent, MNEs are considered as tax avoiding if $I_i < \bar{I}$, while they are considered as non-tax avoiding if $I_i \geq \bar{I}$.

2.2 Measurement

The measurement stage aims at providing, for each MNE classified as tax avoiding along the classification stage, a point estimate of the related BEPS: the amount of EBIT (which is equal to the value added if the labor cost is given)[18] that is shifted using ATP strategies.

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[16] See Costa *et al*. (2019) for an in depth analysis. In particular, $h > 0.5$ would correspond to assigning positive classifications even in presence of weak evidence, while $h < 0.5$ would correspond to assigning positive classifications only in presence of strong evidence. In the case of this work, $h = 0.5$, i.e. a "neutral" hypothesis, seems to be the more suitable choice, since there is not strong *a priori* about the "right" evidence with which MNEs have to be classified as tax avoiding or not. The choice of different values of h might be useful if, for example, the method would be used for audit purposes (where auditors might be interested in increasing the efficiency of controls by reducing the value of h, so as to submit to audit only MNEs with a higher evidence of tax avoidance).

[17] The threshold value $\bar{I}$ for each stratum in the application of the method is reported in Table 3.

[18] The conceptual correspondence of EBIT and value added under the condition of fixed amount of labor costs is relevant if one is willing to use the estimates in the context of the measurement of Gross Domestic Product and Gross National Income in National Accounts.

The measurement of BEPS is performed by exploiting the findings of the ROC analysis along the classification. In particular, it is assessed based on the "distance" of tax avoiding MNEs from the threshold defined by the ROC.[19]

This strategy of measurement also permits to exploit the same information used in the classification, thus overcoming the issue related to the constraint represented by the availability and reliability of data related to foreign business units belonging to resident MNEs.[20]

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, thus implicitly changing their status from tax avoiding to non-tax avoiding. In other words, for each tax avoiding MNE, BEPS is calculated as the difference between the amount of profits that they should have declared in order to be classified as non-tax avoiding and the one they actually declared.

In a given stratum, recalling Equation [1], the following condition holds for i-th tax avoiding MNE:[21]

$$\bar{I} > \omega_1\left(\sum_j \gamma_{j,1} x_{j,i}\right) + \omega_2\left(\sum_j \gamma_{j,2} x_{j,i}\right) \qquad [4]$$

The measurement of BEPS is carried out by increasing the EBIT-to-turnover ratio (x_h), being the others variables unchanged (x_{-h}), such that:

$$\omega_1\left(\sum_j \gamma_{j,1} x_{j,i}\right) + \omega_2\left(\sum_j \gamma_{j,2} x_{j,i}\right) = \bar{I} \qquad [5]$$

[19] This approach can be traced back to a "vertical" strategy, in which BEPS is assessed by analyzing possible inconsistencies between the given MNE and others MNEs in the same country. Alternatively, the measurement could be approached by using a "horizontal" strategy, in which BEPS is assessed by analyzing possible inconsistencies in the geographical distribution of profits among units (resident or not in the country) belonging to the same MNE. Both methods have pros and cons, and potentially they may be used contextually. However, while the "vertical" strategy uses in the measurement the same dataset as in the identification (i.e. data about resident units), the "horizontal" strategy would use data relating to all the business units belonging to the given MNE (i.e. firms in all countries in which the MNE operates).

[20] USA and Canada have the possibility to access data of foreign business units belonging to MNE with headquarter in the USA and Canada. In this case, horizontal strategies could be used at least to test the existence of BEPS related to the use of foreign affiliates by US or Canadian MNEs. However, a "horizontal" measurement of BEPS related to the use of US or Canadian affiliates to foreign MNEs would be still problematic. Furthermore, even if existing databases provide information about firms operating worldwide (e.g. Bureau Van Dijk), two main issues still make their use problematic. Indeed, information is only available for corporations, where a great (and increasing) number of units belonging to MNEs are unincorporated enterprises. Even if the information is present, the selection of variables does not provide a comprehensive description of the economic structure and performance of firms.

[21] This condition comes from the inverse relationships between the composite indicator and the probability of being non-tax avoiding (see also footnote 14).

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

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

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

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

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

Equation [7] implies that the magnitude of the adjustment (i.e. the amount of BEPS) depends on three factors. The first one is the level of the threshold $\bar{I}$, which represents the contextual conditions 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 "normality", i.e. the minimum requirements to be included in the non-tax avoiding class in its stratum. In this context, obviously, the greater the distance, the higher the amount of the adjustment.

The second is represented by the rest 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 (x_{-h}) in the distance between the composite indicator and the threshold. The greater their influence, the lower, *ceteris paribus*, the amount of the adjustment.

The third is the denominator ($\omega_1 \gamma_{h,1} + \omega_2 \gamma_{h,2}$), which represents the influence of the EBIT-to-turnover ratio (x_h). In this case, the higher the response, the lower the amount of the adjustment.[22]

2.3 Sensitivity analysis

The method presented in Sections 2.1 and 2.2 permits to classify MNEs into tax avoiding and non-tax avoiding and to measure the relative amount of BEPS. However, point MNE-level estimates provided by the ROC might be affected by possible statistical errors in modelling the economic and/or strategic behaviors of MNEs.

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

Indeed, different factors could lower the capability of the ROC analysis to capture tax avoidance and, consequently, the amount of BEPS. Variables used to build-up factors might have counter-intuitive behaviors. Furthermore, the composite indicator might fail in providing a strong differentiation among MNEs, thus decreasing the capability of the ROC analysis in determining a clear cut-off for the classification.

In order to consider possible errors and to measure their relevance, a sensitivity check for benchmark results should be performed. In this context, standard errors for the logit in Equation [2] might be used to modulate the threshold $\bar{I}$ in order to generate lower and upper bounds for benchmark estimates in both classification and measurement.

In particular, being α the estimated coefficient of I_i in the logit in Equation [2] and se the relative standard error, the lower bound for $\bar{I}$ in the given stratum might be determined as follows:

$$\bar{I}_{lower} = \bar{I} * \frac{\alpha - se}{\alpha}, where\ \bar{I} < 0 \qquad [8a]$$

$$\bar{I}_{lower} = \bar{I} * \left(1 - \frac{\alpha - se}{\alpha}\right), where\ \bar{I} > 0 \qquad [8b]$$

Symmetrically, the upper bound in the given stratum might be obtained as follows:

$$\bar{I}_{upper} = \bar{I} * \frac{\alpha + se}{\alpha}, where\ \bar{I} > 0 \qquad [9a]$$

$$\bar{I}_{upper} = \bar{I} * \left(1 - \frac{\alpha + se}{\alpha}\right), where\ \bar{I} < 0 \qquad [9b]$$

Consequently, in the given stratum, three different classifications should be obtained by comparing the value of the composite of each MNE (I_i) with $\bar{I}_{lower} < \bar{I} < \bar{I}_{upper}$, this involving a different number of tax avoiding MNEs. In turns, following Equation [7], the application of these different thresholds should involve different estimates of BEPS, where $BEPS_{lower} < BEPS < BEPS_{upper}$.

3. Application of PSM-ROC method to the Italian business system

This section presents the application of the PSM-ROC method to the Italian business system. In particular, Section 3.1 describes the dataset used along the analysis, Section 3.2 shows the results of the classification stage, Section 3.3 presents the results of the measurement stage, while, finally, Section 3.4 deals with the sensitivity check.

3.1 Data

The database used along the work integrates three informative sources produced by the Italian National Statistical Office (Istat). The first one is the Frame-SBS (Luzi and Monducci, 2016), an archive that integrates administrative and survey data, and contains economic (i.e. balance

sheets items) and structural (e.g. industry, size, age) information for the whole population of about 4.3 million of Italian firms. The second is the TEC (Trade by Enterprise Characteristics) database, an archive that contains information on the value of imports and exports of Italian business units by product and country of origin/destination. The third is the ASIA-group register (the Italian version of the European Group Register), which includes information on the role of resident business units within MNEs (with Italian or foreign headquarter).

For each Italian business unit (belonging or not to MNEs), and referring to 2019, this integrated database includes comprehensive structural and economic information, the characteristics of its international trade network and, where relevant, its position within MNEs.

Starting from this original database some further processing has been done. On the one hand, the information on business units belonging to the same MNE has been consolidated, thus reconstructing the "resident" portion of MNEs. On the other hand, in order to include in the analysis only relevant units, domestics with a value added or turnover lower than – or equal to – 0, or employing less than 1 worker, were ruled out.[23]

The final database contains around 3.6 million of business units, where 45,241 of them belong to 18,511 MNEs. In particular, 8,315 MNEs (around 45%) have headquarters located in Italy with affiliates in more than 120 countries, while 10,232 MNEs (around 55%) have headquarters located abroad in more than 100 countries.

Table 1. Descriptive statistics of the dataset

Industry	Nace Rev.2 codes	Units			Value added			Turnover			Workers			EBIT		
		% on total economy	*% of MNES in industry*	*% of non-MNEs in industry*	*% on total economy*	*% of MNES in industry*	*% of non-MNEs in industry*	*% on total economy*	*% of MNES in industry*	*% of non-MNEs in industry*	*% on total economy*	*% of MNES in industry*	*% of non-MNEs in industry*	*% on total economy*	*% of MNES in industry*	*% of non-MNEs in industry*
Food and beverage	10, 11	1.3	0.9	99.1	3.3	44.5	55.5	4.5	46.5	53.5	2.8	27.4	72.6	3.2	45.0	55.0
Textile, wearing apparel and leather	13, 14, 15	1.3	1.3	98.7	2.8	42.5	57.5	2.5	49.7	50.3	2.7	26.2	73.8	2.5	44.1	55.9
Wood, paper and print	16, 17, 18	1.0	0.6	99.4	2.2	49.7	50.3	2.2	58.1	41.9	1.6	26.4	73.6	2.3	55.3	44.7
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	from 20 to 23	0.8	4.0	96.0	5.2	63.6	36.4	4.8	65.1	34.9	3.1	49.9	50.1	4.8	63.6	36.4
Metals and metal products	24, 25	1.7	1.4	98.6	4.9	32.8	67.2	4.6	42.3	57.7	4.1	24.2	75.8	4.1	32.0	68.0
Electric apparel, electronics and machinery	26, 27, 28	0.8	6.7	93.3	6.5	61.7	38.3	5.9	66.4	33.6	4.5	55.6	44.4	5.1	57.7	42.3
Motor vehicles	29, 30	0.1	7.9	92.1	2.2	80.4	19.6	2.0	76.4	23.6	1.2	70.7	29.3	2.0	83.6	16.4
Other manufacturing	31, 32, 33	2.1	0.8	99.2	2.7	33.9	66.1	2.2	41.0	59.0	2.6	19.9	80.1	2.4	33.1	66.9
Energy, water and waste	from 35 to 39	0.5	3.0	97.0	3.4	36.4	63.6	3.8	46.7	53.3	1.7	20.9	79.1	4.3	42.1	57.9
Construction	41, 42, 43	12.1	0.2	99.8	7.1	14.5	85.5	5.7	23.3	76.7	8.3	7.4	92.6	7.1	12.5	87.5
Trade, transportation, accomodation and restaurants	from 45 to 56	36.2	0.5	99.5	31.3	34.2	65.8	42.5	37.3	62.7	36.1	17.4	82.6	30.8	33.2	66.8
Other business services	from 58 to 82	26.3	0.5	99.5	21.5	48.3	51.7	15.5	62.4	37.6	20.4	27.3	72.7	24.1	44.5	55.5
Personal services	from 85 to 96	15.8	0.1	99.9	7.0	16.9	83.1	3.7	21.8	78.2	10.8	9.6	90.4	7.4	9.3	90.7
Total (Percentage)		**100.0**	**0.5**	**99.5**	**100.0**	**39.8**	**60.2**	**100.0**	**45.5**	**54.5**	**100.0**	**22.2**	**77.8**	**100.0**	**37.8**	**62.2**
Total (MLN euro, x1000 workers)		**3649558**	**18511**	**3631047**	**791535**	**314360**	**475272**	**3083425**	**1403004**	**1680421**	**15217**	**3381**	**11835**	**380431**	**143886**	**236545**

Source: Author's elaborations on Istat data, 2019

Table 1 shows the composition of the final database considering some relevant characteristics, also reporting the strata of analysis in terms of industry. MNEs represents only 0.5% of the total number of units, even if their incidence rises up to 7.9% in motor vehicles and 6.7% in electronics, electric equipment and machinery. Despite their low impact in terms of number,

[23] The Frame-SBS also excludes firms operating in agriculture and financial services (financial intermediaries and insurance companies) as well as those included in Public Administration. Furthermore, from the database also firms operating in refined petroleum products and tobacco were excluded because of their very low number.

MNEs account for 39.8% of total value added (about 314 billion euros), 45.5% of turnover (around 1,400 billion euros), 22.2% of the workforce (roughly 3.4 million of workers), 37.8% of EBIT (143 billion euros).

As compared to domestic units, MNEs show a higher nominal productivity (93 vs. 40 thousands euros of value added per worker), a lower degree of vertical integration (0.22 vs. 0.28 in the value added-to-turnover ratio), and a lower profitability in terms of EBIT-to-turnover ratio (0.10 vs. 0.14). Furthermore, MNEs are confirmed to be by large more open to international trade, in terms of both import and export intensity.[24]

In this context, the generalized lower degree of profitability that characterizes MNEs with respect to domestics can be considered as an indirect indicator (say a suspect though without evidence, also taking into account the higher productivity of MNEs) of tax avoidance. Indeed, even if this may be connected with the lower degree of vertical integration of MNEs, it may also indicate that MNEs tend to report a higher incidence of costs given the turnover in order to reduce the value added and, in turns, ceteris paribus, operative margins and profits.

3.2 Classification

Along the "between" comparison of MNEs and domestics, PSM uses 7 confounding variables (see footnote 9), while controlling for economic activity and size class (see footnote 10). PSM are set in order to sequentially search for control groups containing 5 or 3 or 1 unit(s) for each MNE, while for uncovered MNEs, Industry-Size class averages are used (see footnote 10 for the level of breakdown).

Table 2. Coverage by typology of control groups in Propensity Score Matching by industry

Industries	Control group = 5				Control group = 3				Control group = 1				No control group			
	Value added %	Turnover %	Workers %	EBIT %	Value added %	Turnover %	Workers %	EBIT %	Value added %	Turnover %	Workers %	EBIT %	Value added %	Turnover %	Workers %	EBIT %
Food and beverage	90.5	48.4	51.4	45.5	9.5	51.6	48.6	54.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Textile, wearing apparel and leather	91.3	35.8	37.9	44.7	8.7	64.2	62.1	55.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood, paper and print	91.2	20.6	18.8	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	79.4	81.2	63.0
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	81.7	32.5	33.2	36.5	15.1	38.0	36.2	38.4	0.0	0.0	0.0	0.0	3.2	29.5	30.7	25.1
Metals and metal products	91.0	48.5	40.6	53.2	4.0	22.0	21.2	19.6	4.1	12.6	18.3	12.7	0.9	16.8	19.9	14.4
Electric apparel, electronics and machinery	84.9	36.2	34.2	36.8	8.3	15.3	14.4	14.1	1.3	4.9	5.4	5.2	5.4	43.5	46.0	43.9
Motor vehicles	92.2	85.6	83.6	78.5	7.8	14.4	16.4	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other manufacturing	96.7	47.8	48.7	57.4	3.3	52.2	51.3	42.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy, water and waste	99.4	78.6	81.1	76.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	21.4	18.9	23.9
Construction	96.8	41.4	34.1	44.1	3.2	58.6	65.9	55.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trade, transportation, accomodation and restaurants	97.2	65.0	69.7	64.9	2.8	35.0	30.3	35.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other business services	98.9	64.9	66.5	67.9	1.1	35.1	33.5	32.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Personal services	97.1	59.8	66.7	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	40.2	33.3	53.0
Total	**94.6**	**56.2**	**58.4**	**57.3**	**4.1**	**31.2**	**29.8**	**30.2**	**0.3**	**1.0**	**1.3**	**1.2**	**1.0**	**11.5**	**10.5**	**11.4**

Source: Author's elaborations on Istat data, 2019

Table 2 reports the coverage obtained for each typology of control group. Overall, in case of the largest typology (5 domestic for each MNE), the coverage is 94.6% in terms of units, and over 50% for value added, workers and EBIT. Including also MNEs with control groups composed by

[24] See Table A1 in the Appendix for more details.

3 domestics, the coverage is over 85% for all variables. MNEs compared with industry/size average represents 1% of units, 11.5% of value added, 10.5% of workers and 11.4% of EBIT.[25]

Table 3. Weights, thresholds parameters and standard errors in ROC analysis by industry

Industry	Weight of Factor1	Weight of Factor 2	AUC (Area Under the ROC Curve	Coefficient of composite indicator in the related logit	Standard deviation	Threshold value of the composite indicator
	ω_1	ω_2	*Ratio*	α	se	$\bar{I}$
Food and beverage	0.511	0.489	0.888	-3.777	0.439	-0.071
Textile, wearing apparel and leather	0.561	0.439	0.925	-3.469	0.335	0.144
Wood, paper and print	0.560	0.440	0.919	-3.289	0.513	-0.001
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	0.543	0.457	0.878	-2.640	0.195	-0.092
Metals and metal products	0.525	0.475	0.893	-2.562	0.219	0.064
Electric apparel, electronics and machinery	0.559	0.441	0.895	-3.491	0.187	0.034
Motor vehicles	0.651	0.349	0.941	-6.969	0.924	-0.017
Other manufacturing	0.563	0.437	0.881	-1.828	0.241	-0.015
Energy, water and waste	0.607	0.393	0.912	-2.740	0.332	0.253
Construction	0.566	0.434	0.906	-0.746	0.152	0.226
Trade, transportation, accomodation and restaurants	0.571	0.429	0.874	-4.755	0.168	-0.062
Other business services	0.720	0.280	0.888	-6.224	0.262	-0.012
Personal services	0.577	0.423	0.896	-1.940	0.264	-0.002

Source: Author's elaborations on Istat data, 2019

Table 3 reports, for each industry, relevant information on the ROC analysis. In particular, column 1 and 2 show the shares of variance used as weights in computing the composite indicator starting from factors. Column 3 displays the Area Under the ROC Curve (AUC), which represents the extent to which the composite indicator is able to explain the distribution of the proxy (i.e., the fact that in about all industries the AUC is around 0.9 means that models are generally able to capture the status). Finally, column 4 and 5 respectively report the estimated coefficients (all negative as assumed, see footnotes 14 and 21) and the relative standard errors (all very small) of the logit from which the threshold value (reported in column 6) is computed.

The PSM-ROC method has been applied to the Italian business system, analyzing 18,511 MNEs. Table 4 displays the benchmark results for the classification stage. Overall, tax avoiding units represents 57.5% of Italian MNEs (column 6). The incidence of tax avoiding units shows a strong sectoral heterogeneity, ranging from 44.4% in food and beverage to 75.7% in construction. No evident difference between manufacturing and services emerges: industries with low and high incidence of tax avoiding MNEs characterize both macro-sectors.

The ROC analysis ("within" comparison) tends to reduce by roughly 11 percentage points (column 7) the incidence of tax avoidance with respect to the proxy of "suspect" obtained along the "between" comparison (68.4%, column 5). The share of MNEs that are included in the same class stepping from the proxy to the ROC clustering is 75.1% (sum of columns 1 and 4). In 6.9% of cases, ROC worsens the position of MNEs (from non-"suspect" to tax avoiding, column 2),

[25] For control groups equal to 5 units, only 9 domestics are in more than one group, for control groups equal to 3 and 1 units, there are not domestics in more than one group. Considering control groups of all sizes at the same time, 124 domestic units are in control groups in all stage. Overall, 18,325 MNEs are covered by control groups formed by around 89 thousands domestics. Furthermore, Table A2 in the Appendix reports statistics in order to deepen the efficiency of the matching between MNEs and control groups of domestic units.

while in 17.8% of cases the symmetrical situation applies (from "suspect" to non-tax avoiding, column 3). The reduction of the incidence of tax avoidance along the "within" comparison characterizes all industries but energy, water and waste, and construction, in which ROC analysis increases the incidence of tax avoiding MNEs (by 6.4 and 6.0 percentage points respectively).

Table 4. Classification stage, benchmark results by industry

Industries	Suspect confirmed	Non suspect non confirmed	Suspect non confirmed	Non suspect confirmed	Suspect	Tax Avoiding	Difference between proxy and classification
	%	%	%	%	%	%	*Percentage points*
Food and beverage	38.7	5.7	16.9	38.7	55.6	44.4	-11.2
Textile, wearing apparel and leather	61.5	6.6	11.0	20.9	72.5	68.1	-4.4
Wood, paper and print	54.9	7.5	13.7	23.9	68.6	62.4	-6.2
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	40.5	10.8	16.7	32.0	57.2	51.2	-6.0
Metals and metal products	46.6	11.6	15.8	26.0	62.4	58.2	-4.2
Electric apparel, electronics and machinery	48.5	8.7	15.1	27.8	63.5	57.1	-6.4
Motor vehicles	49.0	4.2	18.0	28.8	67.0	53.3	-13.7
Other manufacturing	44.0	8.7	22.0	25.3	66.0	52.7	-13.3
Energy, water and waste	52.9	11.8	5.4	29.9	58.3	64.7	6.4
Construction	61.3	14.4	8.4	15.8	69.8	75.7	6.0
Trade, transportation, accomodation and restaurants	48.9	5.2	20.8	25.1	69.7	54.1	-15.6
Other business services	55.3	4.8	18.6	21.4	73.8	60.1	-13.8
Personal services	46.8	2.1	30.4	20.7	77.2	48.9	-28.3
Total	**50.6**	**6.9**	**17.8**	**24.7**	**68.4**	**57.5**	**-10.9**

Source: Author's elaborations on Istat data, 2019

3.3 Measurement

Table 5 shows the benchmark results of the measurement stage. Italian MNEs declare slightly more than 143 billion euros of EBIT (column 1). According to the method, BEPS amounts to 25.9 billion euros (column 2), representing 1.4% of the Italian GDP at current prices in 2019. The overall incidence of BEPS in terms of EBIT is 15.2% (column 3), about 1.4 million euros per unit (column 4). The incidence of BEPS also shows a strong sectoral heterogeneity, ranging from 46.1% in construction to 4.7% in motor vehicles.

Using a bottom-up strategy to estimate BEPS also permits an ex-post analysis of the characteristics of Italian MNEs according to their final status.

In general, as Table 6 shows, tax avoiding MNEs are smaller (169.5 vs. 200.4 workers per unit on average) and less productive (70.9 vs. 118.3 thousand euro) than non-tax avoiding ones. Furthermore, tax avoiding MNEs also generate higher turnover (77.8 vs. 74.3 million euro) and value added (23.7 vs. 12.0 million euro) per unit, but lower (declared) EBIT (12.6 vs 4.2 million euro) per unit. Consequently, they are characterized by lower average levels of EBIT-to-turnover ratio (0.16 vs. 0.06).

Table 5. Measurement stage, benchmark results by industry

Industries	Declared EBIT	Adjustment	Incidence of adjustment	Adjustment per MNE
	MLN euros	*MLN euros*	*%*	*MLN euros*
Food and beverage	5421.7	1490.0	21.6	3.5
Textile, wearing apparel and leather	4172.4	622.0	13.0	1.0
Wood, paper and print	4824.3	565.1	10.5	2.5
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	11604.4	1974.3	14.5	1.8
Metals and metal products	5035.5	2499.8	33.2	2.8
Electric apparel, electronics and machinery	11117.7	3342.1	23.1	1.7
Motor vehicles	6244.8	309.7	4.7	1.0
Other manufacturing	3055.0	464.4	13.2	0.8
Energy, water and waste	6813.6	5798.3	46.0	11.6
Construction	3395.5	2899.0	46.1	2.7
Trade, transportation, accomodation and restaurants	38865.7	2287.4	5.6	0.4
Other business services	40705.1	3079.7	7.0	0.7
Personal services	2630.4	541.8	17.1	1.0
Total	**143886.1**	**25873.5**	**15.2**	**1.4**

Source: Author's elaborations on Istat data, 2019

Table 6. Comparing tax-avoiding and non-tax avoiding MNEs, benchmark results by industry

Industry	Non Tax Avoiding MNEs						
	Average size	Average Value added	Average Productivity	Average Turover	Value added to Turnover ratio	Average declared EBIT	EBIT to Turnover ratio
	Unit	*x1000 euros*	*x1000 euros*	*x1000 euros*	*Ratio*	*x1000 euros*	*Ratio*
Food and beverage	254.9	29985.6	117.6	126574.4	0.237	15808.6	0.125
Textile, wearing apparel and leather	246.4	28356.8	115.1	99272.4	0.286	15901.0	0.160
Wood, paper and print	376.7	72166.3	191.6	336723.3	0.214	46923.9	0.139
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	258.9	32136.9	124.1	101220.3	0.317	15800.2	0.156
Metals and metal products	130.5	12802.5	98.1	33385.6	0.383	6090.9	0.182
Electric apparel, electronics and	186.6	18226.5	97.7	48072.6	0.379	7894.0	0.164
Motor vehicle	534.5	72074.8	134.8	209147.1	0.345	38211.8	0.183
Other manufacturing	145.4	15957.9	109.8	45660.5	0.349	7921.3	0.173
Energy, water and waste	3.2	4857.0	1503.9	6669.9	0.728	4726.4	0.709
Construction	7.2	1956.3	273.2	4423.2	0.442	1671.0	0.378
Trade, transportation, accomodation	208.5	22374.7	107.3	94900.8	0.236	11722.8	0.124
Other business services	162.2	26537.5	163.6	61661.0	0.430	16309.1	0.264
Personal services	442.3	25578.8	57.8	49978.5	0.512	7193.1	0.144
Total	**200.4**	**23706.8**	**118.3**	**77775.6**	**0.305**	**12651.7**	**0.163**

Industry	Tax Avoiding MNEs						
	Average size	Average Value added	Average Productivity	Average Turover	Value added to Turnover ratio	Average declared EBIT	EBIT to Turnover ratio
	Unit	*x1000 euros*	*x1000 euros*	*x1000 euros*	*Ratio*	*x1000 euros*	*Ratio*
Food and beverage	307.0	24573.1	80.0	189013.4	0.130	9211.2	0.049
Textile, wearing apparel and leather	147.4	9072.3	61.6	47529.7	0.191	2627.1	0.055
Wood, paper and print	239.7	17250.9	72.0	81646.1	0.211	5927.1	0.073
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	166.3	15104.8	90.8	75525.6	0.200	5456.0	0.072
Metals and metal products	200.6	15646.9	78.0	93808.8	0.167	5457.2	0.058
Electric apparel, electronics and machinery	202.7	15003.9	74.0	71774.1	0.209	4077.4	0.057
Motor vehicles	346.0	20790.3	60.1	105386.4	0.197	4788.6	0.045
Other manufacturing	132.7	9708.6	73.1	51316.0	0.189	3007.9	0.059
Energy, water and waste	161.0	27929.2	173.5	164408.3	0.170	18519.5	0.113
Construction	114.2	9447.6	82.7	49252.6	0.192	3662.2	0.074
Trade, transportation, accomodation and restaurants	116.3	6832.4	58.7	69069.8	0.099	1946.2	0.028
Other business services	220.2	13924.9	63.3	73870.9	0.189	4861.0	0.066
Personal services	150.7	9529.5	63.2	44037.6	0.216	2772.7	0.063
Total	**169.5**	**12013.3**	**70.9**	**74328.0**	**0.162**	**4168.0**	**0.056**

Source: Author's elaborations on Istat data, 2019

Finally, results of the benchmark analysis can be broken down according to the location of the headquarters of MNEs. In this context, MNEs with headquarter in Italy generate 16.6 billion euros of BEPS (64.1% of the whole amount), while 5.3 billion euros (20.5%) are related to MNEs with headquarter in other relevant EU countries (mainly, France, Germany and the Netherlands). Finally, MNEs with headquarter in the US and China generate about 1.1 billion euros of BEPS, while 0.6 billion euros are generated by MNEs with headquarter in UK.

Table 7. BEPS by the country of the headquarter, benchmark results

Country of the headquarter	Tax avoiding MNEs		Adjustment	
	Units	*%*	*MLN euro*	*%*
Italy	8315	44.9	16575	64.1
Germany	1678	9.1	1586	6.1
France	1061	5.7	2020	7.8
Spain	420	2.3	87	0.3
Ireland	116	0.6	139	0.5
Luxembourg	591	3.2	505	2.0
The Netherlands	686	3.7	880	3.4
Belgium	187	1.0	95	0.4
UK	1105	6.0	588	2.3
USA	970	5.2	1108	4.3
China	1165	6.3	1149	4.4
Japan	204	1.1	276	1.1
ROW	2013	10.9	864	3.3
Total	**18511**	**100.0**	**25873**	**100.0**

Source: Author's elaborations on Istat data, 2019

3.4 Sensitivity check

According with the strategy presented in Section 2.3, a sensitivity check for the benchmark results presented in Sections 3.2 and 3.3 has been performed. Table 8 shows the results.

Table 8. Sensitivity check for classification and measurement stages by industry

Industry	Classification					Measurement				
	Lower bound	Benchmark	Upper bound	Lower bound / Benchmark	Upper bound / Benchmark	Lower bound	Benchmark	Upper bound	Lower bound / Benchmark	Upper bound / Benchmark
	Units			*Difference %*		*MLN euro*			*Difference %*	
Food and beverage	183	187	226	-2.1	20.9	1469.0	1490.0	1740.3	-1.4	16.8
Textile, wearing apparel and leather	333	414	426	-19.6	2.9	600.3	622.0	657.4	-3.5	5.7
Wood, paper and print	140	141	141	-0.7	0.0	565.0	565.1	566.0	0.0	0.2
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	557	566	652	-1.6	15.2	1932.1	1974.3	2491.3	-2.1	26.2
Metals and metal products	478	512	519	-6.6	1.4	2346.1	2499.8	2513.3	-6.1	0.5
Electric apparel, electronics and machinery	1045	1112	1115	-6.0	0.3	3040.1	3342.1	3360.2	-9.0	0.5
Motor vehicles	162	163	166	-0.6	1.8	297.6	309.7	395.1	-3.9	27.6
Other manufacturing	300	302	308	-0.7	2.0	458.5	464.4	497.0	-1.3	7.0
Energy, water and waste	238	323	336	-26.3	4.0	4621.2	5798.3	5886.8	-20.3	1.5
Construction	784	809	855	-3.1	5.7	2736.7	2899.0	2946.2	-5.6	1.6
Trade, transportation, accomodation and restaurants	3239	3267	3959	-0.9	21.2	2192.6	2287.4	2544.2	-4.1	11.2
Other business services	2587	2593	2689	-0.2	3.7	3037.4	3079.7	4058.9	-1.4	31.8
Personal services	255	256	258	-0.4	0.8	540.9	541.8	539.2	-0.2	-0.5
Total	**10301**	**10645**	**11650**	**-3.2**	**9.4**	**23837.4**	**25873.5**	**28195.9**	**-7.9**	**9.0**

Source: Author's elaborations on Istat data, 2019

For the classification stage, the application of the lower bound to the threshold decreases the incidence of tax avoidance by -3.2% (from 10,645 to 10,301 tax avoiding MNEs), while using the upper bound increases tax avoiding MNEs by 9.4% (from 10,645 to 11,650). In 8 out of the 13

industries considered, both upper and lower bounds results shows differentials lower than 7% with respect to benchmark results. In 3 industries upper bound results are higher by over 10% with respect to the benchmark, while in 2 industries larger differentials are found for the lower bound.

For the measurement stage, the application of the lower bound reduces the amount of BEPS by -7.9% (from 25.9 to 23.9 billion euros), while the application of the upper bound to the threshold increases the amount of BEPS by 9.0% (from 25.9 to 28.2 billion euros). In this case, in 4 out of the 13 industries considered, upper bound results exceed the benchmark by more than 10%, while only in 1 industry, lower bound results are lower than the benchmark by more than 10%.

4. The role of intangible assets

Intangibles are relevant assets for MNEs and their production and trade often represents large figures in balance sheets of MNEs. The implicit or explicit distribution of royalty costs among subsidiaries strongly affects the distribution of profits among the different countries in which MNEs operate. In Section 4.1, the role of the location of intangibles in aggressive tax planning is explored, while in Section 4.2, starting from the results presented in Section 3, some stylized facts are shown with the aim of providing an analysis of the relevance of the strategic location of intangibles in Italy.

4.1 Strategic location of intangibles as a lever for BEPS

The link between the management of intangibles in MNEs and tax planning has been established in the late 90s by the work of Grubert and Slemrod (1998), which analized how the location of intangibles had a relevant role in determining profit shifting between the US and Puerto Rico. More recently, Desai and Dharmapala (2006) and Lipsey (2010) pointed out that intangibles are by their nature a relevant lever for tax planning by MNEs. This manly comes from two characteristics of intangibles. On the one hand, being not physical in nature, intangible assets may be easily located in foreign subsidiaries, either by relocating research and development units and patents or by setting up trademark holding companies in low-tax countries. On the other hand, accounting standards leave large room for the overstating intra-group transfer prices of intangibles (by royalty payment) as arms-length values are difficult to assess.

In this context, empirical works largely confirmed the idea that strategic location of intangibles and intra-group trade by royalty payments are used by MNEs to shift profits from high- to low-tax countries. Specifically, Dischinger and Riedel (2011) and Karkinsky and Riedel (2012) found a decreasing relationships between corporate tax rates and the location of intangible assets proxied by patent applications in Europe. Furthermore, Dudar and Voget (2016) pointed out how the relationship between the tax framework and the location of intangibles is strongly linked to the type of asset, where trademark application is found to be more reactive with respect to patents application.

4.2 Stylized facts from Italian economy

This section presents some stylized facts related to the role of the location of intangibles in tax avoidance by Italian MNEs. In particular, two layers of analysis are proposed: the comparison between MNEs and domestics and the comparison within MNEs.

Table 9 shows the MNE vs. domestics (in control groups) comparison in terms of intramuros R&D spending and royalty payments. The first indicator, under the assumption that intangibles are generated by R&D, should approximate the extent to which Italian business units (MNEs and domestics) internally produce intangibles. The second indicator should instead indicate the incidence of intangibles in their structure of costs. As expected, R&D spending is lower in MNEs than in domestics in all industries but Food and beverage and Trade, transportation, accommodation and restaurants. On the other hand, the relevance of royalty payments is by large higher in MNEs than in domestics in all industries. This comparison thus indicates that MNEs are more likely to trade in intangibles rather than producing them internally. Letting aside possible scale economies and comparative advantages, this huge difference may be connected with strategic tax planning.

Table 9. Relevance of royalty payment and intramuros R&D spending for MNEs and control groups by industry

Industry	Royalties	Intramuros R&D spending
	Value of MNE vs. Value of non-MNE in control groups	
Food and beverage	5.07	1.03
Textile, wearing apparel and leather	4.26	0.95
Wood, paper and print	4.43	0.28
Chemical, pharmaceutics, rubber and plastic, and non metalic minerals	2.09	0.98
Metals and metal products	1.51	0.99
Electric apparel, electronics and machinery	3.10	0.85
Motor vehicles	1.66	0.88
Other manufacturing	1.78	0.77
Energy, water and waste	1.03	0.37
Construction	3.24	0.89
Trade, transportation, accomodation and restaurants	2.61	1.03
Other business services	2.04	0.99
Personal services	2.57	0.75
Total	**3.04**	**0.96**

Table 10 provides a comparison of the incidence of royalty payments between tax avoiding and non-tax avoiding MNEs (according to the PSM-ROC method). In general, tax avoiding MNEs show a higher impact of royalty payments with respect to non-tax avoiding MNEs (on average the latter have an incidence lower by about 6% with respect to former). The differential has a relevant sectoral heterogeneity, showing higher values in Chemical, pharmaceutics, rubber and plastic and non-metalic minerals (0.954), in Motor vehicles (0.937), Other manufacturing (0.945), Energy, waste and water (0.947) and Other business services (0.837). These results show that, as expected, strategic location of intangibles may affect industries to a different extent, following the relevance of intangibles in production processes and value-chains. Analyzing a further breakdown of results, higher values of differentials are found for Chemicals and

Pharmaceutics (0.904), and Furniture (0.774) in manufacturing, while in services, differentials are higher in Wholesale and Retail trade (respectively 0.947 and 0.859), Broadcasting (0.910), Software production (0. 754) and Informatics (0.954)

Table 10. Strategic location of intangibles and aggressive tax planning by industry

Industry	Royalty payment
	Value of non tax avoiding MNEs vs. tax avoiding MNEs
Food and beverage	0.987
Textile, wearing apparel and leather	0.978
Wood, paper and print	0.991
Chemical, pharmaceutics, rubber and plastic, and non metalic minerals	0.954
Metals and metal products	0.987
Electric apparel, electronics and machinery	0.964
Motor vehicles	0.937
Other manufacturing	0.945
Energy, water and waste	0.947
Construction	0.996
Trade, transportation, accomodation and restaurants	0.951
Other business services	0.837
Personal services	0.976
Total	**0.941**

Finally, Table 11 shows how the use strategic location of intangibles is heterogeneous also in terms of country of headquarter. Indeed, comparing the overall average incidence of trade in intangibles over the amount of BEPS with country averages a stronger impact of trade in intangibles is found for Ireland (5.7 time the total average), Spain (3.4), Belgium (3.8), and Germany (2.2), while the indicator is below the total average for France (0.6), Japan (0.6) and Italy (0.7).

Table 11. Strategic location of intangibles and aggressive tax planning by country

Country	Difference with respect to total average
Italy	0.749
Germany	2.188
France	0.640
Spain	3.437
Ireland	5.704
Luxembourg	1.293
The Netherlands	1.178
Belgium	3.798
UK	1.580
USA	1.870
China	1.012
Japan	0.630
ROW	1.236

5. Conclusion

This work presents the PSM-ROC method to measure BEPS by MNEs by using only the information on resident business units. The method jointly uses propensity score matching (PSM) and ROC analysis to classify MNEs (between tax avoiding and non-tax avoiding) and to measure the relative amount of BEPS.

From a methodological point of view, the PSM-ROC method represents a novelty and permits a significant step forward in the existing literature devoted to the measurement of BEPS. On the one hand, it provides firm-level point estimates of BEPS, thus permitting to analyze the relationship between the economic (and institutional) context and MNEs' behaviors at micro, instead of at meso or macro level. On the other hand, by using only the information related to resident business units (MNEs and domestics), which is normally available for National Statistical Offices, National Tax Authorities and scholars, it allows for overcoming the constraint represented by the lack of (complete and reliable) worldwide microdata, which affects both model-based and formulary apportionment approaches.

The application of the method to Italian data shows that BEPS is pervasive. A large number of MNEs use global strategies as a lever to shift profits abroad. According to the estimates, slightly less than 60% of Italian MNEs were identified as tax avoiding, while the total amount of shifted profits is estimated to be 25.9 billion euro, accounting for around 1.4% of Italian GDP at current prices in 2019.

To have MNE-level estimates of BEPS opens the door for using these results in a number of domains. Besides monitoring the macro dimension of the phenomenon (as other approaches also permit), MNE-level estimates can also be used to inform policies aimed at combatting the phenomenon, to analyze and estimate related IFFs, and to improve exhaustiveness (and precision) of relevant aggregates of National Accounts (i.e., GDP).

MNE-level estimates should permit to inform policies based on a 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 can be hardly observed by using macro or meso approaches.

The measurement of IFFs has become a relevant topic in the international agenda, being them also included in Sustainable Development Goals by the United Nations. By definition, ATP is a relevant source of cross-border financial flows, and the possibility to estimate the magnitude of BEPS at MNE-level opens the room for measuring IFFs using bottom-up approaches.

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 even more the case in the European Union, which bases cohesion 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 involve incompleteness and/or distortions in the measurement of relevant aggregates. The possibility of estimating BEPS at MNE-level (including the nationality of the headquarter/affiliates) would allow these estimates to be potentially included in the system of national accounts. Furthermore, the possibility of estimating the role of intangibles in determining BEPS may open the room also for adjusting the distribution of intangible assets across business units and countries within MNEs.

Appendix

Table A1 shows the comparison between MNEs and domestic units considering a set of relevant indicators by industry. The database contains around 3.6 million of domestic units, while MNEs are 18,511 (Column 1).

Table A1 Comparison between MNEs and domestics by industry

Industry	Units	Productivity	Vertical integration	Profitability	Openness	Import intensity	Export intensity
		value added / Workers	Value adde / Turnover	EBIT / Turnover	(Exports + Imports) / Turnover	Imports / Total costs	Exports / Turnover
		x1000 euros	*Share*	*Share*	*Share*	*Share*	*Share*
MNEs							
Food and beverage	421	99.2	0.179	0.083	0.385	0.178	0.235
Textile, wearing apparel and leather	608	85.1	0.238	0.107	0.805	0.304	0.566
Wood, paper and print	226	130.2	0.213	0.120	0.204	0.105	0.115
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	1105	110.7	0.266	0.119	0.931	0.498	0.551
Metals and metal products	880	84.4	0.211	0.083	0.711	0.333	0.441
Electric apparel, electronics and machinery	1946	83.7	0.266	0.093	0.676	0.217	0.510
Motor vehicles	306	103.1	0.291	0.133	0.661	0.278	0.438
Other manufacturing	573	91.3	0.260	0.110	0.666	0.194	0.513
Energy, water and waste	499	187.9	0.182	0.126	0.018	0.007	0.012
Construction	1068	86.4	0.199	0.083	0.093	0.047	0.052
Trade, transportation, accomodation and restaurants	6040	88.1	0.173	0.080	0.360	0.271	0.126
Other business services	4316	96.2	0.275	0.137	0.120	0.056	0.076
Personal services	523	59.2	0.377	0.107	0.090	0.052	0.056
Total	**18511**	**93.0**	**0.224**	**0.103**	**0.390**	**0.210**	**0.219**
Domestic units							
Food and beverage	47035	46.8	0.194	0.089	0.237	0.106	0.151
Textile, wearing apparel and leather	47253	40.9	0.318	0.134	0.368	0.162	0.256
Wood, paper and print	37029	47.3	0.299	0.135	0.199	0.135	0.103
Chemichal, pharmaceutics, rubber and plastic, and non metalic minerals	26349	63.3	0.285	0.127	0.333	0.139	0.232
Metals and metal products	60641	55.4	0.317	0.130	0.291	0.135	0.197
Electric apparel, electronics and machinery	27213	65.2	0.326	0.134	0.413	0.085	0.354
Motor vehicles	3583	61.0	0.230	0.084	0.456	0.182	0.318
Other manufacturing	75543	44.2	0.353	0.154	0.245	0.059	0.206
Energy, water and waste	16281	86.7	0.278	0.151	0.013	0.008	0.007
Construction	441590	40.9	0.355	0.176	0.004	0.003	0.002
Trade, transportation, accomodation and restaurants	1316598	35.8	0.198	0.095	0.092	0.069	0.036
Other business services	954529	38.8	0.489	0.283	0.010	0.009	0.005
Personal services	577403	30.9	0.519	0.291	0.003	0.002	0.001
Total	**3631047**	**40.2**	**0.283**	**0.141**	**0.119**	**0.067**	**0.070**

MNEs are generally more productive (column 2) than domestics – 93.0 thousand euros per workers vs. 40.2 on average – where the difference is highest in wood, paper and print (2.7 times), in transportation, trade, accommodation and restaurants, and in other business services (around 2.5 times). Considering the degree of vertical integration (column 3), MNEs show lower values of the indicator – 0.224 vs. 0.283 on average – in all industries but motor vehicles. As for profitability (column 4), domestics have a higher EBIT to turnover ratio – 0.141 vs. 0.103 on average – and the differential is particularly strong in construction, other business services and personal services. Finally, as expected, MNEs show higher values in all the indicators considering international trade. Indeed, MNEs are more open to international markets (column 5) – 0.390 vs. 0.119 on average – particularly in construction and personal services. Moreover, MNEs also show higher import-to-total costs (column 6) and export-to-turnover (column 7) ratios – respectively 0.210 vs. 0.067 and 0.219 vs. 0.070 on average.

Table A2 reports the differences for confounding variables between MNEs and domestics included or not in control groups by industry. The metric used is the MNEs vs. domestics (in control groups or not) ratio for each value of the variables (i.e., values higher than 1 indicate that MNEs have a higher value of the related indicator on average). This should show, on the one hand, the degree of similarity between MNEs and domestics in control groups and, on the other hand, the extent to which the definition of control groups by the PSM procedure improved

the matching with respect to strict MNEs vs. domestics comparison (without considering the similarity).

Table A2 Average differences for confounding variables, MNEs vs. domestics in control groups and MNEs vs. all domestics, by industry

Industry	Per-capita turnover		Workers		Share of goods on total intermediate costs		Exports to turnover ratio		Imports to intermediate costs ratio		Share of salaries on total costs		Revenues from services on turnover	
	MNEs vs. Controls	*MNEs vs. Domestics*	*MNEs vs. Controls*	*MNEs vs. Domestics*	*MNEs vs. Controls*	*MNEs vs. Domestics*	*MNEs vs. Controls*	*MNEs vs. Domestics*	*MNEs vs. Controls*	*MNEs vs. Domestics*	*MNEs vs. Controls*	*MNEs vs. Domestics*	*MNEs vs. Controls*	*MNEs vs. Domestics*
Food and beverage	0.85	0.83	2.65	25.33	0.70	0.70	0.95	1.87	1.02	2.33	0.82	0.63	0.97	0.97
Textile, wearing apparel and leather	0.99	1.80	2.82	2.82	1.16	1.21	1.09	3.03	1.05	3.09	0.83	0.47	0.98	0.86
Wood, paper and print	0.96	3.36	1.63	186.73	1.20	1.18	0.84	1.40	0.85	1.18	0.97	0.50	1.00	0.64
Cemichal, pharmaceutics, rubber and plastic and non metalic minerals	1.01	1.39	1.96	14.86	1.01	1.00	1.11	2.60	1.17	4.47	1.00	0.83	0.98	0.97
Metals and metal products	0.88	1.67	1.50	16.68	0.53	1.16	1.04	2.84	1.18	3.94	0.97	0.63	0.96	0.82
Electric apparel, electronics and machinery	0.81	0.28	1.76	27.41	1.01	1.02	1.03	1.65	1.19	2.98	0.97	0.84	0.96	0.92
Motor vehicles	0.92	1.11	2.70	4.20	1.14	0.80	1.11	1.48	1.35	1.76	0.91	0.58	1.00	1.24
Other manufacturing	0.98	1.91	1.99	77.00	0.76	0.76	0.74	3.50	2.87	4.63	0.88	0.66	0.84	0.84
Energy, water and waste	0.94	1.51	1.70	9.98	0.95	2.14	1.03	3.24	1.11	2.11	0.90	0.36	0.96	0.68
Construction	0.79	0.79	2.42	67.24	0.80	0.80	0.82	32.74	0.72	37.44	1.93	0.64	0.87	1.22
Trade, transportation, accomodation and restaurants	1.00	1.16	1.87	15.89	1.03	0.84	0.88	5.32	0.76	16.71	0.90	0.76	0.69	1.24
Other business services	1.08	2.07	2.39	30.39	0.87	0.87	2.44	26.54	0.78	0.78	0.92	0.75	1.01	0.76
Personal services	0.89	2.55	1.18	37.74	1.22	0.86	2.50	2.50	0.86	17.07	0.96	1.18	0.92	1.03
Total	**0.97**	**1.49**	**2.01**	**29.76**	**0.95**	**0.94**	**1.37**	**10.66**	**0.94**	**10.29**	**0.99**	**0.74**	**0.91**	**1.15**

Results show that the definition of control groups strongly improve the level of similarity for all variables: the differential between MNEs and domestics units lowers when considering control groups for all variables. Moreover, differences between MNEs and control groups, which approximate the goodness of matching, is lower than ∓ 0.10 for all variables but workers (2.01) and export-to-turnover ratio (1.37), for which the differential considering MNEs vs. total domestics comparison would be respectively 29.76 and 10.66.

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