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On the Horizontal Inequity Effect of the Erosion of the PIT Base: The Case of Italy

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Abstract

This paper deals with the erosion of the personal income tax (PIT) base, a well-known phenomenon that is undermining the redistributive features of the Italian tax system. Several sources of income previously subject to progressive marginal tax rates are now taxed under substitute proportional tax regimes or are entirely exempt from taxation. The existing tax system as of the 2019 tax year is compared with three alternative policy scenarios. First, a comprehensive income tax scheme where all income components are included in the PIT base is examined. Second, a flat-rate personal income tax scheme with a drastic reduction in revenue is considered. Third, a further flat-rate tax scheme with a neutral effect on revenue is simulated. The focus of the comparison is on the unequal tax treatment of close equals. Decomposition approaches to the study of classical horizontal inequity are applied and discussed (van de Ven et al., 2001; Duclos et al., 2003; Urban and Lambert, 2008). The findings show that the erosion of the PIT base has increased the level of horizontal inequity of the tax system only negligibly, and that limited benefits would be obtained if a flat personal income tax were to be adopted.

Keywords: classical horizontal inequity; comprehensive income tax; flat tax; redistribution; microsimulation; IT-EXEMPT
JEL code: D31, H23, H24

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1. Introduction

In the debate about the distinguishing characteristics of the Italian tax system, the erosion of the personal income tax (PIT) base has been widely examined (MEF, 2008; Bises and Scialà, 2014; Stevanato, 2017; Boscolo, 2019a). The gradual exclusion from progressive taxation of various sources of income can be traced back to the introduction of Italian PIT, known as the *Imposta sul reddito delle persone fisiche*. The original provisions of the reform sought to create a PIT scheme with a broad comprehensive tax base (Paladini, 2014). However, once the reform became effective in 1974, it became clear that the scheme deviated from the theoretical framework intended. Capital income and gains, that were initially intended to be included in the PIT base and taxed at progressive marginal tax rates, were excluded and subject to proportional withholding taxes. This first exception may be seen what we could call the theoretical erosion of the PIT base. A further exclusion was allowed in 1987, with the cadastral value of the main residence deemed to constitute taxable income only if its value was greater than an amount equivalent to 1,300 euros[1] and the taxable amount was based on the value in excess of that limit.[2] Over the last twenty years there has been a marked tendency to transfer specific sources of income previously subject to progressive taxation to more favourable tax regimes. Without claiming to be exhaustive and based on the order of the introduction of the various measures, the following is a list of sources of income that have been subject to this phenomenon, which we can define as effective erosion. The 2019 Italian tax system is characterised by the following features.

i) A substitute tax regime is applied to income from self-employment – known as the '*regime forfetario*' – conditional on certain monetary and organisational criteria that tend to restrict the potential beneficiaries to small firms (IRA, 2019). The maximum sales volume to be able to benefit from the regime is 65,000 euros, and taxable income is calculated by reducing earnings first using a cost coefficient, that differs by business sector, and then subtracting social security contributions; the tax liability is calculated by applying a proportional tax rate of 15%.[3]

ii) Productivity bonuses paid to private-sector employees up to a limit of 3,000 euros are taxed at a rate of 10%.

iii) Company welfare schemes are entirely tax-free, with a view to increasing employee well-being through the provision of goods and services.

iv) A proportional tax is applied to rental income from residential properties, known as the '*cedolare secca*', with two different tax rates depending on the type of

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[1] Italian lire converted into present-day euro value.

[2] Since the 2002 tax year, the cadastral value of the main residence has been one of the income sources in PIT gross income, but its value is entirely subtracted by means of a deduction.

[3] In the case of taxpayers meeting certain requirements – that the business was not carried on during the previous three years or was not the continuation of an activity previously carried on in the form of salaried employment – the tax rate is reduced to 5% for the first five business years.

rental agreement between the parties (10% for controlled rents or 21% otherwise). Starting from the 2019 tax year, a substitute proportional tax can also be applied to rental income from shops (at a rate of 21%).

v) Cadastral income from properties at the disposal of the owners and located in a different municipality from that of the main residence are excluded from the PIT base and not subject to taxation at all.

In the light of the above, it is easy to suspect that the gradual subjection to proportional taxation of income sources previously included in the PIT base (and thus taxed progressively) could have a significant impact on the two guiding principles of a fair tax system. Taxpayers with a different ability to pay are supposed to pay different amounts of tax, so that a high-earning taxpayer will pay a higher relative amount of tax than a low-earning taxpayer, and taxpayers in similar circumstances are supposed to pay the same rates of tax. These are respectively the *vertical* and *horizontal equity* principles (Kakwani and Lambert, 1998).

Take the case of two single persons, one of whom is an employee and the other is self-employed and so can opt for the more favourable tax regime on self-employment income. For the sake of simplicity, let us suppose that taxable income from employment after social insurance contributions is the only income for both these individuals and amounts to 50,000 euros a year. Suppose again that personal income tax is calculated by simply applying the marginal tax rates applicable in 2019,[4] excluding deductions and tax credits. In this simplified scenario, the employee would be liable to an effective tax rate (30.6%) that is twice that of the self-employed worker, whose marginal tax rate equals the effective tax rate (15%). This example shows the lack of horizontal equity when proportional regimes replace the application of the progressive principle to specific income sources. A lack of vertical equity would also be evident in the case of an employee earning 15,000 euros, leading to the absurd situation in which the tax system differentiates according to the taxpayers' ability to pay, but regressively: in this case the effective tax rate would be 23%.

Evidence of the magnitude of the horizontal effect in the Italian income tax system has previously been provided by Pellegrino and Vernizzi (2011). Their results were dependent on the decomposition methodology and on the choice of the optimal bandwidth in which comparable individuals are identified. For the 2006 (2007) tax year and taking the individual as the unit of analysis, the absolute horizontal effect of Urban and Lambert (2008) was estimated to be 0.05% (0.09%) of the PIT redistributive effect when the optimal bandwidth is chosen by maximising the ratio of the vertical effect to the redistributive effect – the criterion adopted by van de Ven et al. (2001). The magnitude of the horizontal effect was found to be slightly greater using alternative decomposition methodologies but never greater than 0.9% (1.2%) for the 2006 (2007) tax year.

This paper aims to shed light on the horizontal equity issues associated with the gradual exclusion of certain income sources from progressive taxation in Italy. By means of microsimulation techniques, the existing tax system in the 2019 tax year

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[4] The PIT brackets and relative tax rates are as follows (value in euros): 1) up to 15,000: 23%; 2) 15,001-28,000: 27%; 3) 28,001-55,000: 38%; 4) 55,001-75,000: 41%; 5) over 75,000: 43%.

(hereinafter EX) is compared with three alternative policy scenarios. First, income sources excluded from the PIT base are simulated and then reincluded, defining what for the sake of simplicity we can call the *comprehensive income tax* scheme (hereinafter CIT). Second, a flat-rate personal income tax scheme with a drastic reduction in revenue is simulated (hereinafter FLAT). Third, a further flat-rate tax scheme with a neutral effect on revenue is evaluated (hereinafter NFLAT). This microsimulation exercise makes possible not just an assessment of the horizontal inequity effects resulting from the effective erosion of the PIT base, but also a quantification of how horizontally unfair the existing tax system is when compared to a tax system that, *ipso facto*, should limit inequality between similar taxpayers to minimal levels. The comparison between the different tax systems makes use of four decomposition methodologies designed for the study of *classical horizontal inequity* (van de Ven et al., 2001; Duclos et al., 2003; Urban and Lambert, 2008), where close equal groups are taken as the basis for the measurement.

The remainder of the paper is structured as follows. Section 2 outlines the data, the policy scenarios simulated and the IT-EXEMPT microsimulation model, a static microsimulation model for the analysis of exemptions from progressive taxation. Section 3 describes the decomposition approaches adopted to measure classical horizontal inequity. Section 4 discusses the redistributive features of the Italian tax system by focusing on the contribution of PIT components and proportional taxes to income redistribution. Section 5 presents the results, with particular emphasis on the horizontal effects of the existing tax system and alternative policy scenarios simulated. Section 6 focuses on the policy implications arising from the research findings. Finally, Section 7 concludes the paper.

2. IT-EXEMPT: a static microsimulation model for the study of sources of income exempt from progressive taxation

The substitution of progressive taxation with proportional tax regimes gives rise to a series of difficulties when it comes to their simulation. Tax exemptions are often granted to a small number of taxpayers, who may not be properly represented in sample survey data. As a result, their precise replication may require the adjustment of sample weights to aggregate administrative data. Furthermore, not all the information needed for the simulation is collected. In the following, the features of IT-EXEMPT are briefly presented.

The starting point of the analysis is the choice of the data source. The model is developed using the Survey on Household Income and Wealth (SHIW) published by the Bank of Italy for the 2016 tax year. Deductions and tax credits are assigned to taxpayers before launching the algorithm for the conversion of total income from net to gross amounts (Albarea et al., 2015). A hypothetical value of total gross income was assigned to all taxpayers, $Y^H = (Y - T)(1 + 0.23)$, that is the total net income collected in SHIW multiplied by a factor that equalises Y^H to the total gross income from aggregate tax returns, Y^A. In the simulation of the 2016 tax-benefit system, the algorithm identifies iteratively the value of total gross income that makes the simulated value of total net income equal to that in SHIW, $(Y - T)^S = (Y - T)$, by adding (subtracting) one income unit to (from) Y^H at the end of each round if $(Y - T)^S$ is higher (lower) than $(Y - T)$. The procedure stops when all taxpayers satisfy the condition or when the difference between $(Y - T)^S$ and $(Y - T)$ is minimised (Immervoll and O'Donoghue, 2001).

Before the reweighting procedure, proportional tax regimes and tax-free income sources were fully simulated. For the proportional tax on rental income and the substitute tax regime for income from self-employment, the group of potential taxpayers was first simulated exploiting the information available in SHIW and then restricted to match as far as possible the real value in the administrative data. This was necessary because the pool of taxpayers under examination turned out to be considerably larger than the true value after simulation. A thousand random draws for each category of taxpayers divided by macro area were carried out in order to choose the best-fitting sub-sample population. The draw that minimises the gap between the total number of simulated taxpayers and the external total is the one used to select the taxpayers.

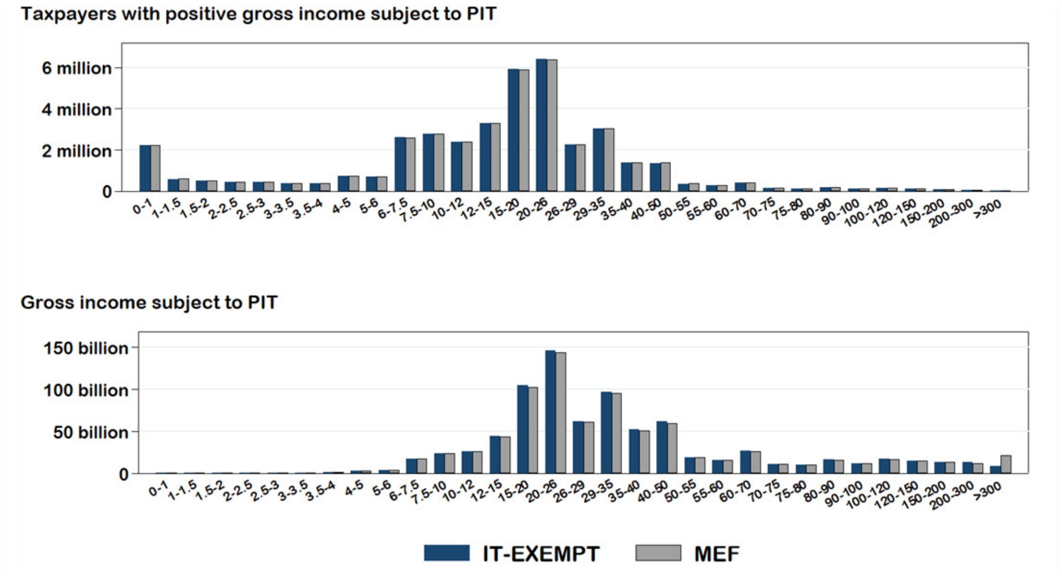
Individual sample weights were reweighted in order to better represent specific categories of taxpayers, such as those with income sources exempt from progressive taxation, those with tax-free income components, those with tax expenditures, and taxpayers ranked by non-decreasing groups of gross income subject to PIT. The adjustment made use of the wealth of information at the individual level made publicly available by the Italian Ministry of the Economy and Finance (MEF) in the form of aggregate data from tax returns. With the external total of the exact number of taxpayers benefitting from one of the many proportional tax regimes, it is possible to calculate for the corresponding sample group the exact proportion of the taxpaying population. A more detailed explanation of the reweighting procedure adopted is given in Pacifico (2014).

A further step consists in the macroeconomic validation of the model. Total values of income components and taxes are compared with the equivalent administrative totals in order to estimate the extent to which the simulated tax system represents a good approximation of the actual system. For this purpose, taxpayers with positive income and total gross income by groups of gross income subject to PIT are shown in Figure 1. The simulated totals correspond almost perfectly with the true totals except for the wealthiest income group (taxpayers who declared more than 300,000 euros), for which total gross income is substantially underestimated. This reflects the usual difficulties encountered in studies of top-income earners when employing sample survey data (Alvaredo and Pisano, 2010). The representativeness of the results is also confirmed by the adherence of the PIT incidence curve to administrative statistics (see Figure 2).

Gross income values and expenditure related to tax credits and deductions were then adjusted using the Consumer Price Index for the 2019 tax year. The replication of the existing tax system for the same year and alternative scenarios represents the last step needed. Compared with the 2016 tax year, the simulated tax system for 2019 is characterised by an extension of the *cedolare secca* to shops and a broadening of the substitute tax regime for income from self-employment. No less importantly, a further legislative change extended the retirement income tax credit granted to taxpayers over 75 years of age to all retired taxpayers.

In the following, the simulated policy scenarios are examined. The reference distribution common to all the scenarios is gross income subject to PIT or substitute tax regimes with the addition of tax-free sources of income previously subject to progressive marginal tax rates and the ‘80 euro’ bonus.[5] CIT includes in the PIT base the list of income components taxed at a proportional rate or entirely tax-free under EX (see the list in the introduction, which we referred to as effective erosion), while keeping constant the remaining features of the tax system. In contrast, in FLAT a tax rate of 15% is applied to gross household income subject to PIT jointly with a deduction granted at the level of the household,[6] while keeping the proportional taxes and tax-free income components as simulated under EX. Once PIT liabilities were computed, the average household tax rate was assigned to each family member with positive income to determine individual liabilities. The tax system represented in FLAT is the initial proposal made by the League party during its recent term of office (2018-2019), which is the most radical proposal on personal income taxation to be put forward in the Italian scenario. The aim of the simulation is not to legitimise the proposed reform, but simply to offer the chance to assess an alternative tax system intended to reduce horizontal inequity effects as much as possible. Among all flat tax proposals, the one simulated in FLAT is characterised by the lowest PIT tax rate, thus minimising the distance from tax rates applied in substitute tax regimes and tax-free sources of income (which may be thought of as components with a zero tax rate). Finally, NFLAT maintains the same features as FLAT except for the tax rate applicable to income subject to the current PIT, set at 24.8% so as to ensure the same level of revenue simulated in EX.

Figure 1 – Taxpayers and gross income subject to PIT by income group for the 2016 tax year: values on the horizontal axis in thousands of euros



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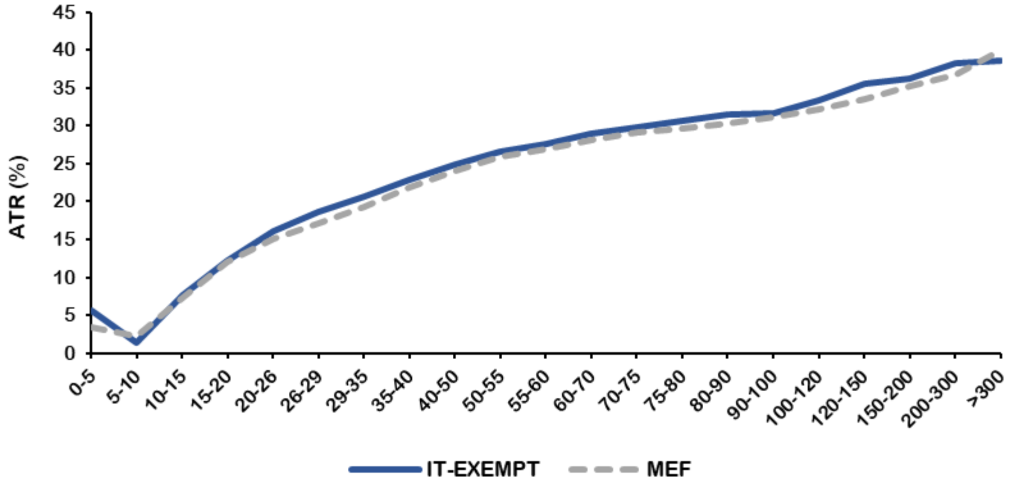
[5] A sum of 80 euros per month granted to employees with income from employment ranging from 8,174 to 26,600 euros and positive net PIT.

[6] To determine the amount of the deduction, a value of 3,000 euros was assigned to all family members if gross household income is less than 35,000 euros; with household income ranging between 35,000 and 50,000 euros, a value of 3,000 euros was granted for each dependent member; for income higher than 50,000 euros, the deduction was set to zero.

Figure 2 – Average PIT rate by income group for the 2016 tax year: values on the horizontal axis in thousands of euros



3. The measurement of horizontal inequity[7]

For the classicist, in the sense intended by Dardadoni and Lambert (2001), to distinguish between practitioners and researchers making use of tools for the investigation of horizontal inequity other than copula functions, the two measurement concepts in the literature on the subject – the *reranking approach* on the one hand and the *classical horizontal inequity approach* on the other – are somehow bonded together. Let the pre-tax income vector be $x = \{2, 5, 5, 7\}$ and the resulting post-tax income vector be $y = \{1, 3, 6, 5\}$. In this simple example, the existence of unequal treatment of equals signals the manifestation of reranking, a finding which is quite common in empirical studies with large samples. The couple of exact equals ends up showing a different level of post-tax income, which as a result leads to the reordering of units, since the third unit in x has a higher disposable income than the fourth one after state intervention. However, reranking can also be the result of unequal treatment of unequals, as the unequal treatment of equals can lead to no reranking when those below and those above do not overlap with the pre-tax equal units. A further conceptual link between classical horizontal inequity and reranking might be revealed by breaking down the overall process of redistribution in each of the tax instruments contributing to it, when pre-tax unequal units become equal following the payment of an initial tax and then turn out to be treated unequally because of the application of another tax.

Horizontal inequity in taxation was first operationalised in the literature through *utility reranking*. Several authors have suggested such an approach because of the inherent difficulties in identifying exact equals in sample survey data (Feldstein, 1976; Atkinson, 1980; Plotnick, 1981; Kakwani, 1984). Due to sample size

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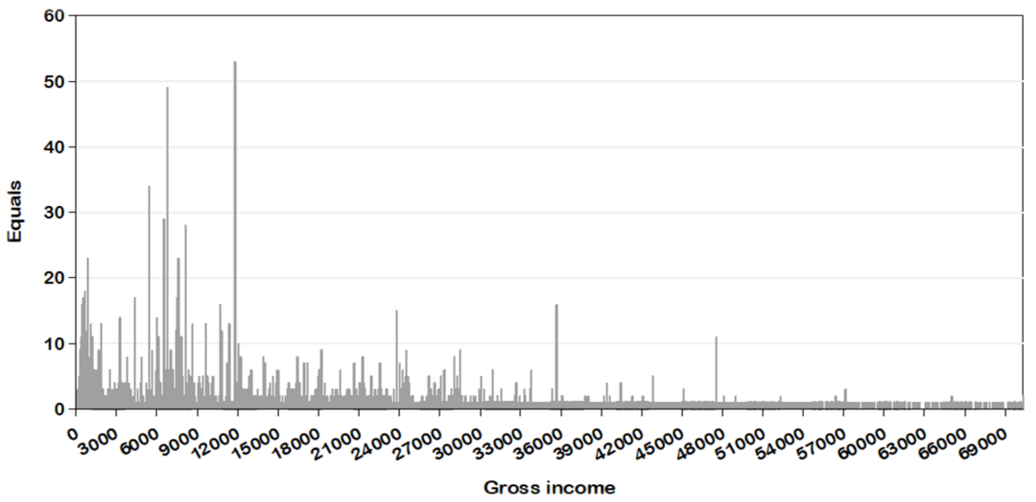
[7] Several decomposition approaches for the study of horizontal inequity were applied in this study, although they do not represent the entire spectrum of methodologies proposed in the literature. In this connection, mention should be made of the use of copula function approaches based on the horizontal inequity concept of Dardanoni and Lambert (2001). Bø et al. (2012) and Díaz-Caro and Onrubia (2019) provided the first applications of this measurement framework.

limitations, equals are often rare and not well distributed along the income distribution. In Figure 3, the number of taxpayers with positive income falling into groups of exact equals is given for the 2016 tax year using SHIW data. In addition to the scarcity of cases registered, it may be noted that equals tend to be concentrated in the left-hand tail of the reference distribution. Among 9,654 income levels corresponding to as many groups, only 782 (8.1%) contain more than one individual.

Figure 3 – Exact equals in SHIW 2016: values in euros on the horizontal axis



NOTE: No exact equals were found in the sample with gross income greater than 70,310 euros.

As in Kakwani (1984), the net redistributive effect of a tax system can be defined as:

$$[1]\quad RE = VE - R = \left(G_Y - C_{Y-T,Y}\right) - \left(G_{Y-T} - C_{Y-T,Y}\right)$$

where *VE* stands for the vertical effect and it is given by the difference between the pre-tax Gini index and the concentration index of post-tax income (referred to as the Reynolds-Smolensky index), while the horizontal effect, expressed with the *R* of reranking, is equal to the difference between the post-tax Gini index and the concentration index.

This framework was extended in the work of Aronson et al. (1994) shedding light on the concept of classical horizontal inequity. By dividing the population into groups of exact equals – that is, individuals or households with an identical level of gross income – it is argued that RE can be broken down into three aggregates:

$$\begin{aligned}[2]\quad RE = G_Y - G_{Y-T} &= G_Y - \left(G_{Y-T_e} + G^{W}_{Y-T} + R^{AP}_{Y-T}\right)\\ &= \left(G_Y - G_{Y-T_e}\right) - \sum_{i=1}^{k}\left[\left(\alpha_{i,}\beta_{i,Y-T}\right) G_{i,Y-T}\right] - R^{AP}_{Y-T}\\ &= VE^{AJL} - HE^{AJL} - R^{AJL}\end{aligned}$$

In our notation, VE^{AJL} represents the vertical effect of the tax system and can be obtained by subtracting the Gini index of post-tax income with average liabilities for each *i-th* group of equals – which is also defined as the between-group component of the post-tax Gini index, G_{Y-T_e} – from the pre-tax Gini index. Then HE^{AJL} captures within-group inequality (G^{W}_{Y-T}), which is understood for present purposes as unequal treatment of equals and is given by the sum of the product of the population share, the income share and the post-tax Gini index for each *i-th* group. At the same time, R^{AJL}, the residual that is obtained when breaking down post-tax income in the context of exact equals, is identified with the Atkinson-Plotnik index (R^{AP}_{Y-T}). Following van de Ven et al. (2001), the decomposition in [2] can be adapted to close equal groups:

$$
\begin{aligned}
[3]\quad RE &= VE^{VCL} - HE^{VCL} - R^{VCL} \\
&= \left(G_{Y_e} - G_{Y-T_e}\right) \\
&\quad - \left(\sum_{i=1}^{k}\left[\left(\alpha_i\, \beta_{i,Y-T}\right) G_{i,Y-T}\right] - \sum_{i=1}^{k}\left[\left(\alpha_i\, \beta_{i,Y}\right) G_{i,Y}\right]\right) \\
&\quad - \left(R^{AP}_{Y-T} - R^{AP}_{Y}\right)
\end{aligned}
$$

where G_{Y_e} is the pre-tax Gini index with gross income on average at each *i-th* group – the between-group component of the pre-tax Gini index. The second term in round brackets stands for the within-group components of the pre-tax Gini index as seen earlier, and R^{AP}_{Y} (R^{AP}_{Y-T}) is the residual that is obtained when breaking down pre-tax income (post-tax income). The decomposition in [3] supposes the absence of within- and entire-group reranking ($R^{AP}_{Y} \cong 0$), which leads to the equality $R^{VCL} = R^{AJL}$.

A further adaptation of [2] to close equal groups is offered by Urban and Lambert (2008). The decomposition that follows differs from [3] except for the reranking term ($R^{AJL-UL} = R^{VCL} = R^{AJL}$):

$$
\begin{aligned}
[4]\quad RE &= VE^{AJL-UL} - HE^{AJL-UL} - R^{AJL-UL} \\
&= \left(G_Y - C_{Y-T_e,Y-T_e^1\to Y^2}\right) - \left(C_{Y-T,Y-T_e^1\to Y-T^2} - C_{Y-T_e,Y-T_e^1\to Y^2}\right) \\
&\quad - R^{AP}_{Y-T}
\end{aligned}
$$

where $C_{Y-T_e,Y-T_e^1\to Y^2}$ is the concentration index of post-tax means ordered first by non-decreasing values of post-tax means and then by non-decreasing values of pre-tax income among taxpayers with the same value of post-tax mean ($Y - T_e$);

$C_{Y-T,Y-T_e^1 \to Y-T^2}$ is the concentration index of post-tax income ranked by non-decreasing values of post-tax means and post-tax income.[8]

Urban and Lambert go even further, suggesting a new decomposition approach for the study of classical horizontal inequity that takes account of all possible rerankings:

$$
\begin{aligned}
[5]\quad RE = VE^{UL} - HE^{UL} - R^{UL} &= VE^{UL} - HE^{UL} - (R^{AP}_{Y-T} + R_{WG} + R_{EG}) = \\
&= \left(G_Y - C_{Y-T_e,Y^1 \to Y-T^2}\right) - \left(C_{Y,Y^1 \to Y-T^2} - C_{Y-T_e,Y^1 \to Y-T^2}\right) \\
&- \left[\left(G_{Y-T} - C_{Y-T,Y^1 \to Y-T^2}\right) + \left(C_{Y-T,Y_e^1 \to Y-T^2} - C_{Y-T,Y^1 \to Y-T^2}\right)\right. \\
&+ \left.\left(C_{Y,Y^1 \to Y-T^2} - C_{Y-T,Y_e^1 \to Y-T^2}\right)\right]
\end{aligned}
$$

where R^{UL}, which is equal to the reranking effect as in [1], is made up of three components: the reranking of unequals (R^{AP}_{Y-T}) as in [2], [3] and [4]; the within-group reranking (R_{WG}) which takes place when individuals are in a different after-tax position to the before-tax ordering in the specific group's income distribution; and the entire-group reranking (R_{EG}) capturing the reordering of post-tax means.[9] The differences between [4] and [5] can be better grasped by examining the formulas below:

$$
[6]\quad VE^{UL} = VE^{AJL-UL} + R_{EG} \qquad HE^{UL} = HE^{AJL-UL} - R_{WG}
$$

Basically, the vertical effect as proposed in [5] is equal to the vertical effect in [4] with the addition of the entire-group reranking, while the horizontal effect in [5] can be obtained by subtracting the within-group reranking from the horizontal effect in [4]. It is worth mentioning that the horizontal effect in [5] has the drawback of often being negative even for small values of the bandwidth, reflecting the scarcity of exact equals in our sample. Urban and Lambert justify this by pointing out that the concentration curves of $C_{Y,Y^1 \to Y-T^2}$ and $C_{Y-T_e,Y^1 \to Y-T^2}$ may cancel each other out several times, thus leading to small and negative values of HE^{UL}. The solution they suggest is to break down HE^{UL} into two components, the first being the sum

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[8] The formula in [4] can also be expressed with the notation of Pellegrino and Vernizzi (2011). The vertical effect (VE^{AJL-UL}) is given by the difference between the pre-tax Gini index (G_Y) and the sum of the between-group component of the pre-tax Gini index (G_{Y_e}) and the within-group component of the *smoothed* post-tax Gini index, $G^{SW}_{Y-T} = \sum_{i=1}^{k}\left[\left(\alpha_i\, \beta_{i,Y-T_s}\right) G_{i,Y-T_s}\right]$. The term *smoothed* refers to a post-tax income distribution where liabilities are determined by multiplying pre-tax income values by the corresponding bandwidth's average tax rate. Consequently, it diverges from G^{W}_{Y-T}. As far as the horizontal effect (HE^{AJL-UL}) is concerned, it can be obtained by substracting G^{SW}_{Y-T} from the within-group component of the post-tax Gini index, $G^{W}_{Y-T} = \sum_{i=1}^{k}\left[\left(\alpha_i\, \beta_{i,Y-T}\right) G_{i,Y-T}\right]$. HE^{AJL-UL} differs from H^{VCL} for using the same weighting for each of its two within-group components; furthermore, G^{SW}_{Y-T} differs from G^{W}_{Y} in [3].

[9] Still referring to the notation of Pellegrino and Vernizzi (2011), the expressions in [5] are as follows: $VE^{UL} = G_Y - \left(C_{Y-T_e,Y} + G^{SW}_{Y-T}\right)$; $HE^{UL} = C^{W}_{Y-T,Y} - G^{SW}_{Y-T}$; $R^{AP}_{Y-T} = G_{Y-T} + \left(G_{Y-T_e} - G^{W}_{Y-T}\right)$; $R_{WG} = G^{W}_{Y-T} - C^{W}_{Y-T,Y}$; $R_{EG} = G_{Y-T_e} - C_{Y-T_e,Y}$.

of all areas with positive values of HE^{UL} and the second the sum of all areas with negative values of HE^{UL}:

$$[7]\quad HE^{UL-T} = HE^{+} + abs\{HE^{-}\}$$
$$= \sum_{i=1}^{m}\sum_{x=1}^{m}\sum_{y=1}^{k}\left|\left(p_{x[\_n-1]}L_{y}^{C_{Y-T,Y^1\to Y-T^2}} - p_x L_{y[\_n-1]}^{C_{Y-T,Y^1\to Y-T^2}}\right)\right.$$
$$\left.- \left(p_{x[\_n-1]}L_{y}^{C_{Y-T_e,Y^1\to Y-T^2}} - p_x L_{y[\_n-1]}^{C_{Y-T_e,Y^1\to Y-T^2}}\right)\right|_{i}$$

i indicates the close equal groups into which the gross income distribution is divided; p stands for the cumulative values on the horizontal axis of the curve created, while L are the cumulative coordinates of the vertical axis. Thus, HE^{UL} can be turned into a measure of *absolute* classical horizontal inequity by taking the absolute value of negative areas. As Pellegrino and Vernizzi (2011) noted, this modified version of HE^{UL} does not verify specification in [5].

The last of the decomposition approaches discussed here is the *change-in-inequality approach* as in Duclos et al. (2003). Unlike the previous ones, it constitutes a method that combines the Gini coefficient and the Atkinson inequality measure. The advantage of this method lies also in the determination of close-equal groups by means of non-parametric statistical procedures. This approach has not yet found widespread application in practice and, to the best of our knowledge, has never been applied to the Italian context. The redistributive effect is decomposed into three components as seen above:

$$[8]\quad RE^{DJA} = VE^{DJA} - HE^{DJA} - R^{DJA}$$
$$= (I_Y - I^{e}_{Y-T}) - \left(I^{p}_{Y-T} - I^{e}_{Y-T}\right) - \left(I_{Y-T} - I^{p}_{Y\_T}\right)$$

In this case the first bracket stands for the vertical redistributive effect of a tax system that causes no reranking (VE^{DJA}), with I_Y equal to pre-tax income inequality and I^{e}_{Y-T} capturing *expected post-tax income inequality*; the horizontal effect (HE^{DJA}) is given by the difference between I^{p}_{Y-T}, a measure of post-tax income inequality when the pre-tax reranking is preserved, and I^{e}_{Y-T}; and the reranking effect, R^{DJA}, which can be computed by subtracting $I^{p}_{Y\_T}$ from I_{Y-T}, the post-tax income inequality index. In more detail, these inequality measures are based on the use of social evaluation functions and rank-dependent weights. Take the case of I_Y in [9]. The utility of pre-tax income of the *i-th* individual takes the form of Atkinson's (1970) utility function, where ε indicates the ethical parameter of relative risk aversion. As for the rank-dependent weights (w_i^Y), observations were first sorted by pre-tax income levels. fw_i stands for the frequency (sample) weight of the *i-th* individual, while v and $q_{Y,i}$ are respectively the ethical parameter of aversion to rank inequality and the sample estimate of the *i-th* quantile of the cumulative distribution function. It should be noted that when $\varepsilon = 0$, then $HE^{DJA} = 0$ by definition. In the case where $\varepsilon = 0$ and $v = 2$, the decomposition in [8] becomes equal to [1]. Finally, considering the denominator in [9], $\hat{\mu}(Y)$ is pre-tax mean income. An analogous procedure was followed for I_{Y-T}, replacing pre-tax income with post-tax income where necessary and sorting observations by post-tax income levels in the weighting.

$$[9]\quad I_Y = 1 - \frac{\left[(1-\varepsilon)\left(\sum_{i=1}^{k} U(Y_i)\, fw_i\, w_i^Y\right)\right]^{\frac{1}{1-\varepsilon}}}{\hat{\mu}(Y)}$$

$$= 1 - \frac{\left[(1-\varepsilon)\left(\sum_{i=1}^{k}\left(\frac{Y_i^{1-\varepsilon}}{1-\varepsilon}\right) fw_i \left[\left(\sum_{i=1}^{k} fw_i\right)^{-1} v\left(1-q_{Y,i}\right)^{v-1}\right]\right)\right]^{\frac{1}{1-\varepsilon}}}{\left(\sum_{i=1}^{k} fw_i\right)^{-1} \sum_{i=1}^{m}\left(fw_i\, Y_i\right)}$$

$$[10]\quad q_{Y,i} = \left(\sum_{i=1}^{k} fw_i\right)^{-1} \sum_{i=1}^{m}\left(fw_i + fw_{i-1}\right)$$

For the estimate of expected post-income levels ($Y - T^e$), it is necessary to employ curve-fitting methods such as kernel-weighted local polynomial regression (Fan and Gijbels, 1996). Note that the computation of I_{Y-T}^e makes use of the rank-dependent weights in [9].

$$[11]\quad I_{Y-T}^e = 1 - \frac{\left[(1-\varepsilon)\left(\sum_{i=1}^{k} U(Y - T_i^e)\, fw_i\, w_i^Y\right)\right]^{\frac{1}{1-\varepsilon}}}{\hat{\mu}(Y - T_i^e)}$$

Finally, I_{Y-T}^p is computed by simply replacing pre-tax income with post-tax income in the utility function, but using a modified set of weights ($\overline{w}_i^Y$) as described by Urban (2013). The use of the original weights in [9] as initially proposed by Duclos et al. (2003) would lead to biased estimates of the inequality measure. In fact, equal individuals would be weighted differently, although these units have the same ranking if ordered by pre-tax income levels. As a result, the new weights are obtained by taking the average value of w_i^Y by group of equals.

$$[12]\quad I_{Y-T}^p = 1 - \frac{\left[(1-\varepsilon)\left(\sum_{i=1}^{k} U(Y - T_i)\, fw_i\, \overline{w}_i^Y\right)\right]^{\frac{1}{1-\varepsilon}}}{\hat{\mu}(Y - T_i)}$$

4. Empirical description of the Italian tax system as of 2019

In the following, income/revenue aggregates and common measures for the analysis of income redistribution and progressivity in each simulated scenario are compared and discussed. An in-depth examination is carried out with the aim of understanding the determinants of income redistribution under EX. The contribution of each tax instrument to redistribution is calculated employing the method used in Onrubia et al. (2014) [hereinafter O14], and then compared with contributions that are measured with the method in Kristjánsson (2013) [hereinafter K13]. The two decomposition approaches are extensively examined in Appendix A. This allows us to describe the redistributive features of the Italian tax system by showing what contributes most to the achievement of its actual redistributive effect. All the following figures were obtained taking the taxpayer as the unit of analysis.

Table 1 – Redistributive indices and total sample amounts (in million euros) for each scenario

INDEX	**EX**	**CIT**	**FLAT**	**NFLAT**
G_Y: pre-tax Gini index	0.4432	0.4431	0.4432	0.4432
G_{Y-T}: post-tax Gini index	0.3914	0.3871	0.4332	0.4263
RE: redistributive effect	0.0517	0.0560	0.0100	0.0168
RS: Reynolds-Smolensky index	0.0525	0.0567	0.0103	0.0179
R: reranking	0.0008	0.0007	0.0003	0.0011
K: Kakwani index (progressivity effect)	0.1988	0.2048	0.0695	0.0678
t: average tax rate	0.2089	0.2168	0.1291	0.2091
$t/(1-t)$: average tax rate effect	0.2641	0.2768	0.1482	0.2644
C_T: concentration index of taxes	0.6420	0.6480	0.5126	0.5110
C_{Y-T}: concentration index of disposable income	0.3907	0.3864	0.4329	0.4252
PIT gross income	844,590	889,265	844,590	844,590
PIT exemptions	44,675	-	44,675	44,675
'80 euro' bonus*	11,073	10,984	11,073	11,073
TOTAL GROSS INCOME	**900,338**	**900,249**	**900,338**	**900,338**
Progressive taxation (PIT + surtaxes)	182,048	195,158	110,197	182,191
Proportional taxation	6,059	-	6,059	6,059
TOTAL REVENUE	**188,107**	**195,158**	**116,256**	**188,250**
Observations	11,734	11,734	11,734	11,734
Taxpayers	**40,714,464**	**40,714,464**	**40,714,464**	**40,714,464**

* The bonus is kept constant in all scenarios except for CIT since gross income subject to PIT determines whether individuals receive the bonus and to what extent. This also explains why the pre-tax Gini index in CIT differs slightly from the others.

Considering first EX in Table 1, the redistributive effect of the tax system is equal to 0.0517, a result that is in line with studies making use of tax returns as the base data set (Di Nicola et al., 2015; Di Caro, 2020). Reincluding income components that are currently exempt from progressive taxation in the PIT base would lead to an increase in the redistributive effect to 0.0560 (8.3%). The progressivity effect as measured by the Kakwani index and the average tax rate effect would increase by 3.0% and 4.8% respectively. In contrast, the introduction of a flat-rate tax scheme with a marked reduction in revenue would drastically decrease the redistribution achieved to a value of RE equal to 0.0100 (-80.7%). As a result, the progressivity and average tax rate effects would show sharp decreases of -65.0% and -43.9% respectively. These results do not vary significantly when revenue neutrality is imposed. Such a flat-rate tax scheme would reduce RE to 0.0168 (-67.5%). The greater redistributive capacity in NFLAT when compared with FLAT is mainly driven by an increase in the average tax rate effect (t: 12.91% → t: 20.91%) and only partially determined by a reduction in the progressivity effect of the tax system (K: 0.0695 → K: 0.0678).

The total value of exemptions from progressive taxation is close to 45 billion euros (5.0% of total gross income), that was earlier defined as the effective erosion of the PIT base. Table 2 in Appendix B provides detailed information on these income components and their distribution among income groups. On the revenue side, CIT would be expected to increase revenue by an amount of 7 billion without taking into account behavioural responses that might be induced by the new tax system. The loss in revenue that would occur if FLAT were applied is equal to almost 72 billion, a significant amount that underlines the lack of sustainability of such a reform in the Italian context (unless the role of the existing welfare state is questioned and severe cuts in public spending are proposed).

Table 3 – RE decomposition using O14 for different degrees of extension of EX

VARIABLE	**EX (S1) %RE**	**EX (S2) %RE**	**EX (S3) %RE**	**Value in billions**
Tax schedules (S)	**48.1**	**46.9**	**45.5**	**244.6**
Gross PIT (S_1)	43.4	42.3	38.5	221.4
Regional surtax (S_2)	3.5	3.4	3.2	12.5
Municipal surtax (S_3)	1.3	1.3	1.2	4.6
Proportional tax on rental income from residential property (S_4)	-	-	1.8	1.8
Proportional tax on shops (S_5)	-	-	0.0	0.1
Proportional tax on productivity bonuses (S_6)	-	-	0.1	0.2
Proportional tax on income from self-employment (S_7)	-	-	0.6	4.0
Tax credits (C)	**54.7**	**52.4**	**54.7**	**56.4**
Dependent family members (C_1)	5.4	5.2	5.7	11.1
Income source (C_2)	46.3	44.3	46.0	39.9
Expenses for refurbishment of historic buildings (C_3)	0.0	0.0	0.0	0.2
Energy conservation projects (C_4)	-0.1	-0.1	-0.1	0.1
Rents (C_5)	0.3	0.3	0.3	0.3
Health-related expenses (C_6)	2.2	2.2	2.3	2.7
Mortgage interest payments (C_7)	0.2	0.2	0.2	0.8
Insurance premiums (C_8)	0.1	0.1	0.1	0.1
Non-tertiary education expenses (C_9)	0.0	0.0	0.0	0.1
Tertiary education expenses (C_{10})	0.0	0.0	0.0	0.3
Other tax credits (C_{11})	0.2	0.2	0.2	0.8
Deductions and exemptions (D)	**-1.6**	**2.0**	**1.3**	**49.8**
PIT: self-employed social insurance contributions (D_1)	-2.2	-2.2	-2.2	19.6
PIT: other deductions (D_2)	-0.5	-0.5	-0.5	1.8
PIT: maintenance payments (D_3)	0.0	0.0	0.0	0.5
PIT: private pension contributions (D_4)	-0.1	-0.1	-0.1	2.6
PIT: cadastral income from main residence (D_5)	1.2	1.2	1.2	8.9
80 euro bonus (D_6)	-	3.6	3.7	11.1
Cadastral income from properties left available (D_7)	-	-	0.0	2.1
Company welfare provisions (D_8)	-	-	-0.7	3.2
Reranking (R)	**1.2**	**1.3**	**1.5**	**-**

In Table 3, the contributions of tax schedules, tax credits, deductions and income components exempt from progressivity to income redistribution are computed using the method in Onrubia et al. (2014) for different degrees of extension of EX. Scenario 1 (S1) focuses merely on PIT components; Scenario 2 (S2) adds the ‘80 euro’ bonus; finally, Scenario 3 (S3) brings together the PIT components and all the sources of income that are excluded from progressive taxation and taxed at a proportional tax rate or are entirely tax-free. S1 and S2 are particularly useful for validating our results. Despite the differences in the tax year simulated and the base data set employed, the distribution of contributions found in S1 is consistent with previous findings obtained using the same decomposition approach (Barbetta et al., 2018; Boscolo, 2019a; Boscolo, 2019b; Di Caro, 2020). Tax credits are the instrument that most determines PIT redistribution (C: 54.7%) followed by tax schedules (S: 48.1%), while deductions have a small regressive effect (D: -1.6%). Focusing on the various contributions, tax credits granted on the basis of an income from work typology determine almost half of the redistributive effect in S1 (C_3: 46.3%). The second highest contribution is given by the PIT tax schedule (S_1: 43.4%). Then come all the remaining tax instruments such as tax credits for dependent family members (C_1: 5.4%), the regional surtax (S_2: 3.5%), tax credits for health-related expenses (C_6: 2.2%) and so on. Self-employed social insurance contributions (D_1: -2.2%), private pension contributions (D_4: -0.1%) and a range of deductions such as social insurance contributions for domestic help, personal care services and support for people with disabilities, donations to religious institutions and other deductions (D_2: -0.5%) are the measures that contribute regressively in determining income redistribution by means of deductions, together with tax credits for energy conservation projects (C_4: -0.1%).

As for S2, the contribution to income redistribution of the ‘80 euro’ bonus was found to be positive (D_6: 3.6%), with a sign and magnitude in line with previous evidence (Baldini et al., 2015; Boscolo, 2019a; Boscolo, 2019b; Di Caro, 2020).

The income components excluded from progressive taxation in S3 all have non-regressive effects, except for company welfare provisions (D_8: -0.7%). The proportional tax on rental income from residential properties contributes positively (S_4: 1.8%) as highlighted in Boscolo (2019a; 2019b), where different static models and base data sets were employed, but it diverges from the negative effect found by Di Caro (2020) on a sample of tax returns. The positive effect found here can be better understood by looking at the distribution of income sources by non-decreasing income groups. Rental income is highly concentrated in the wealthiest groups: the richest fifth of taxpayers account for 84.7% of its aggregate value (see Appendix B, row ‘I_1’ and columns ‘*9th*’ and ‘*10th*’). If the number of taxpayers paying proportional taxes rises with increasing income values, proportional taxes tend to have progressive effects on income inequality when employing O14.

Proportional taxes on rental income from shops and productivity bonuses present a neutral effect on overall redistribution as defined in this study (S_5: 0.0%; S_6: 0.1%), as does cadastral income from properties left available (D_7: 0.0%). Finally, substitute tax regimes on income from self-employment as in the 2019 tax year have a small progressive effect (S_7: 0.6%), with a contribution that seems to confirm the observations above for S_4. Access to these tax regimes has recently been granted to taxpayers with a maximum turnover of 65,000 euros, while the threshold was much lower under previous regimes, as it was equal to 30,000 euros up to the 2014 tax year (IRA, 2012) and ranged between 25,000 and 50,000 euros from 2015 to 2018 (IRA, 2016). In fact, their contribution in the 2014 tax year has been found to be small and negative (Boscolo, 2019a).

As often pointed out in the literature, a plethora of methods are available for the measurement of progressivity and redistribution (Urban, 2014). The choice of one method rather than another may lead to substantially different results. Among those meant for the study of specific contributions, an extensive comparison between O14 and the method put forward in Urban (2014) is described in Boscolo (2019b) dealing with the Italian tax-benefit system. The two methods were shown to provide similar results. However, the discussion can be further extended by applying K13, a method adopted for the study of dual income taxation systems (Kristjánsson, 2013). What makes the comparison between O14 and K13 particularly interesting is that the results of the latter method can be used to better interpret the positive redistributive effect found above for income components excluded from progressive taxation. The main difference in their structure is to be found in the tax base on which contributions are computed. While O14 defines taxable income as the sum of the taxable share of each income source, K13 takes the same number of tax bases as the number of income components that make up gross income as the basis for the measurement. In fact, the employment of K13 allows for a more comprehensive understanding of the average tax rate effects of income components.[10] As explained in Appendix A, RS in K13 can be divided into two components: a direct effect capturing progressivity effects; and an indirect effect measuring differences in tax levels between income subject to progressive taxation and income taxed at a proportional tax rate or tax-free income.

The results of the application of K13 are presented in Table 4. First, it is worth stressing that each of the income components exempt from progressive taxation now shows a negative effect on income redistribution (see column '%RE') except for the neutral effect of the proportional tax on rental income from shops, perhaps due to its low aggregate value. Substitute tax regimes on income from self-employment are the tax instrument with the greatest negative contribution (S_7: -2.1%), followed by company welfare provisions (D_8: -1.3%), which were also found to be regressive using O14, and the proportional tax on rental income from residential properties (S_4: -0.8%). The remaining exemptions and proportional taxes complete the picture, presenting a smaller but still negative effect. As for progressive taxation, its overall effect is the only factor responsible for the reduction in income inequality (S_1-S_3-S_3: 106.8%), a reduction that would be even higher (+6.8%) in the case of the absence of regressive effects and reranking.

Table 4 – RE decomposition using K13 for EX (S3)

VARIABLE	**Effect**			
	Direct	**Indirect**	**RE**	**%RE**
Progressive taxation (S_1-S_2-S_3)	0.05224	0.00302	0.05526	106.8
Proportional tax on rental income from residential property (S_4)	0.00001	-0.00041	-0.00040	-0.8
Proportional tax on rental income from shops (S_5)	0	0	0	0
Proportional tax on productivity bonuses (S_6)	0	-0.00019	-0.00019	-0.4
Tax regimes on income from self-employment (S_7)	0.00003	-0.00110	-0.00107	-2.1
80 euro bonus (D_6)	0	-0.00016	-0.00016	-0.3
Cadastral income from properties left available (D_7)	0	-0.00028	-0.00028	-0.5
Company welfare provisions (D_8)	0	-0.00065	-0.00065	-1.3
Reranking (R)	**-**	**-**	**0.00077**	**1.5**
Redistributive effect (RE)	**0.05228**	**-0.00023**	**0.05173**	**100.0**

Direct effects should not be negative when a proportional tax rate is applied. S_4 and S_7 both present a small positive direct effect due to their tax schedule, where two tax rates are applied instead of one (10% and 21% in S_4; 5% and 15% in S_7).

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[10] Correlating the values in billion euros presented in the last column of Table 3 with the contributions of income components exempt from progressive taxation (S_4, S_5, S_6, S_7, D_6, D_7, D_8) to the redistributive effect, O14's contributions show a high and positive correlation (0.79), contrary to what is true for K13 (-0.07).

These positive effects are then nullified by the corresponding indirect effects. Only progressive taxation has an indirect effect that contributes positively to determining redistribution (S_1-S_3-S_3: 0.00302). Therefore, the negative contributions to overall redistribution found for all the other measures must be attributed to the prevalence of negative indirect effects. These results are in line with those reported by Kristjánsson (2013) on the tax system in Iceland, but no other evidence has yet been provided for Italy.

As a result, the policy implications deriving from a comparison of the two decomposition approaches differ significantly. While the employment of K13 would suggest a reinclusion of certain income components exempt from progressive taxation in the PIT base due to their negative impact on income inequality reduction, which is true above all for income from self-employment subject to substitute tax regimes and rental income from residential properties, taking O14 for the study of specific tax-benefit contributions would perhaps imply simply reconsidering the role of these components. In this case, despite the consensus that redistribution would be better achieved by resubjecting all income components to progressive marginal tax rates, the different tax treatment might be justified more easily by the need to boost labour supply efforts or tax compliance, since their effect on redistribution is small but still positive.

5. Horizontal inequity analysis

In this section, the results of the unequal tax treatment of close equals are presented and discussed. For each simulated scenario, the decomposition approaches in [3], [4] and [5] were applied on simulations with bandwidth varying by one income unit within the range 1-3,000 euros (extremes included). Along with this, two criteria were employed for the choice of the optimal bandwidth. First, we defined the optimal bandwidth as the one with the highest contribution of the vertical effect on the redistributive effect following van de Ven et al. (2001):

$$[15] \quad OB^{VCL} = max\left\{\frac{VE_i}{RE}\right\}$$

This was implemented for each of the decomposition approaches mentioned above on the *i-th* bandwidth. Then, following Mazurek et al. (2013), the potential vertical effect in [5] can be written as follows:

$$\begin{aligned}[16] \quad V^{UL} &= V^{VCL} + R_{EG} - P_{VW} \\ &= \left(G_{Y_e} - G_{Y-T_e}\right) + \left(C_{Y,Y^1 \to Y-T^2} - C_{Y-T,Y_e^1 \to Y-T^2}\right) \\ &\quad - \left[\sum_{i=1}^{k} \left(\alpha_{i,Y-T} - \alpha_{i,Y}\right) G_{Y_i}\right]\end{aligned}$$

$$[17] \quad OB^{MPV} = \left\{P_{VW_i} = R_{EG_i}\right\}$$

where P_{VW} is defined as the *vertical within group progressivity effect*.[11] Mazurek et al. suggest determining the most convenient bandwidth by minimising the greater ratio between P_{VW_i}/V^{UL} and R_{EG}/V^{UL} or, equivalently, by choosing the narrowest bandwidth such that $P_{VW_i} = R_{EG_i}$ as in [17], since $P_{VW_i}(R_{EG_i})$ generally increases (decreases) with increasing values of the bandwidth. If taxation policy is implemented such that net income, $Y - T_j$, is the result of the application of the effective tax schedule, $v(Y)$, together with a random term (u_j) capturing the deviation from the actual tax schedule and the effective one for the *j-th* taxpayer as in Aronson et al. (1994) and van de Ven (2001), the optimal bandwidth is identified when within group deviation averages converge to zero, meaning that the rank of $\left[(1/N_k)\sum_{j\in k} Y - T_j\right]$ converges to that of $\left[(1/N_k)\sum_{j\in k} Y_j\right]$ for the *k-th* group of close equals, and so R_{EG} must tend to zero. It should be noted that this criterion can be applied solely when using [5]. In cases in which multiple optimal bandwidths exist for a specific scenario, the minimum one was selected in line with the interpretation that a low bandwidth value better approximates the implications stemming from the horizontal equity principle.

As for the decomposition approach in [8], we pointed out that the determination of close equal groups is statistically driven. However, this does not imply that the analyst has no control over the selection procedure. Urban (2013) puts forward some suggestions regarding the appropriate estimate of expected post-tax income levels. The optimal half-bandwidth of the kernel was determined in a manner consistent with Urban's application:

$$[18] \quad OB^U = \sum_{v=1}^{k} min\left|I^{p}_{Y-T,v,\varepsilon=0} - I^{e}_{Y-T,v,\varepsilon=0}\right|$$

where v, the parameter of aversion to rank inequality, ranges in the interval [1.0; 4.0] and increases by 0.1 units. Expected post-tax income levels were computed using the third-degree local polynomials and the Epanechnikov kernel function. Individuals falling in the extremes (the 1st and the 100th quantile) of the non-weighted reference distribution under EX were excluded from the analysis regardless of the scenario analysed, so as to preserve optimality in the computation.

The comparison between scenarios was conducted by adopting the optimal bandwidth (or half-bandwidth) as in [15], [16] and [18] found for EX according to the decomposition approach applied. Since alternative specifications of the tax system can lead to different optimal bandwidths (or half-bandwidths), an assessment is provided of the criterion that minimises the difference between the 'true' value indices – those obtained by the application of each scenario-specific optimal bandwidth – and the 'approximate' ones – those resulting from the use of the optimal bandwidth for EX.

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[11] According to Pellegrino and Vernizzi (2011)'s notation: $R_{EG} = G_{Y-T_e} - C_{Y-T_e,Y}$.

5.1. Results

First, it needs to be stressed out that classical horizontal effects play a minor role regardless of the decomposition approach employed. As shown in Figures 4 and 5, the sign and magnitude of the effect found for the present tax system is in line with previous evidence for the Italian context (Pellegrino and Vernizzi, 2011).

Figure 4 – Horizontal effects (HE^{VCL}, HE^{AJL-UL}, HE^{UL} and HE^{UL-T}) for EX

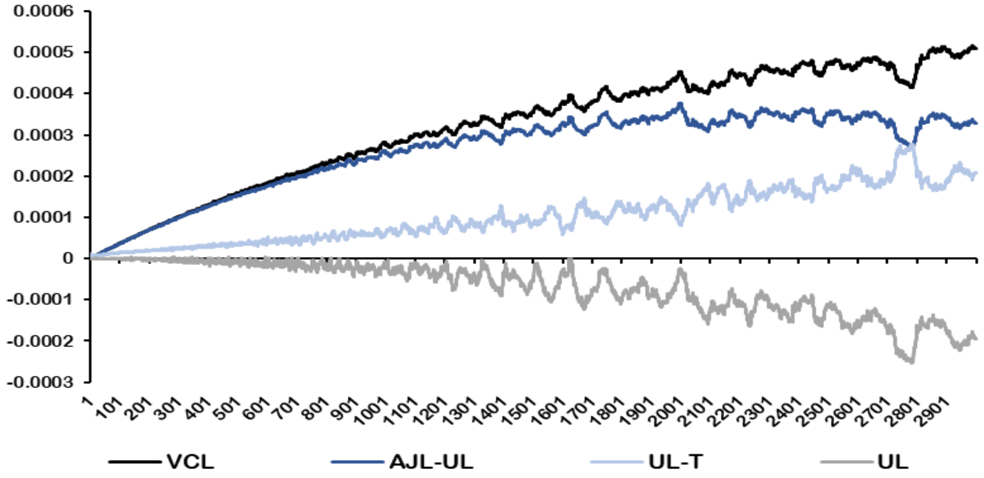
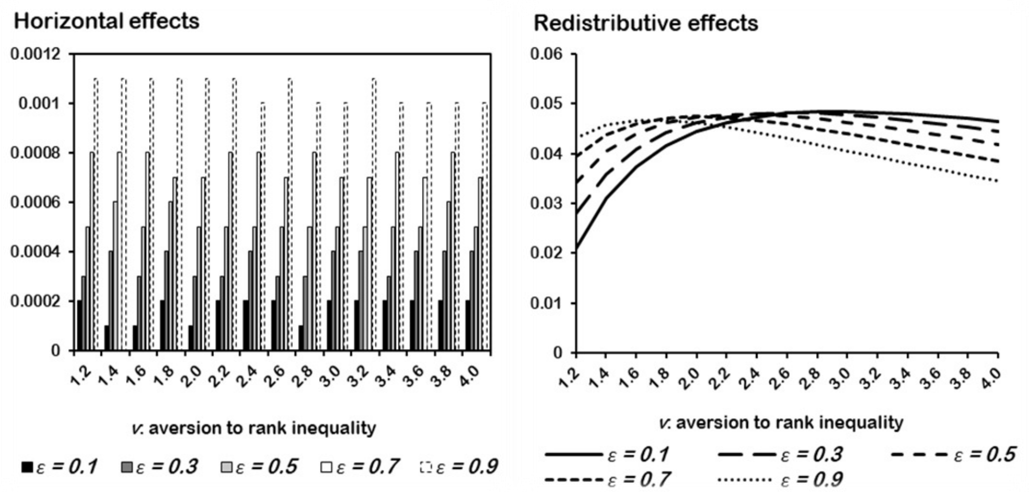


Figure 5 – Horizontal effects (HE^{DJA}) and redistributive effects (RE^{DJA}) for EX



Horizontal effects grow with increasing values of the bandwidth regardless of the decomposition approach adopted except for HE^{UL}, which shows a negative decreasing trend over the bandwidth adopted confirming what Urban and Lambert (2008) pointed out.

As for HE^{DJA}, the magnitude of the effect in absolute terms remains essentially unchanged over different values of v. On the other hand, when relating horizontal effects to overall redistributive effects of the current tax system depicted in Figure 5 (right-hand side), a direct relationship emerges between relative risk aversion attitudes (ε) and classical horizontal inequality (HE^{DJA}) regardless of v, the parameter of aversion to rank inequality.

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As for HE^{DJA}, the magnitude of the effect in absolute terms remains essentially unchanged over different values of v. On the other hand, when relating horizontal effects to overall redistributive effects of the current tax system depicted in Figure 5 (left-hand side), a direct relationship emerges between relative risk aversion attitudes (ε) and classical horizontal inequality (HE^{DJA}) regardless of v, the parameter of aversion to rank inequality.

Table 5 shows the optimal bandwidth (or half-bandwidth of kernel) found for each of the simulated scenario according to the three criteria employed. The practice of imposing the bandwidth value that optimises the formation of close equal groups for a specific scenario – in our case the baseline scenario – to other simulated (counterfactual) scenarios was previously applied by Mazurek et al. (2013). But what seems relevant here is the application of this empirical strategy to half-bandwidths of kernel, in other words to the decomposition approach of Duclos et al. (2003). Despite the specificities of the criteria used in the assessment of the most suitable close equal groups, the concept of half-bandwidth of kernel does not differ significantly from that of bandwidth. The column headed 'Max/Min' presents the ratio between the maximum and the minimum bandwidth and serves as a proxy for the bias introduced in the calculation of 'approximate' horizontal effects. Out of all criteria, OB^{VCL} is found to be the most accurate only when applied to the decomposition approach in [3]. The capability of the criterion to minimise the dispersion among optimal bandwidths of dissimilar scenarios is strictly related to the framework into which the criterion was first conceived. In fact, OB^{VCL} is rather inaccurate when applied to the specifications in [4] and [5]. As for OB^{MPV}, which can be applied solely to the decomposition approach in [5], it provides a greater level of accuracy (almost three times greater) than that achievable with OB^{VCL}. Finally, OB^{U}, which is specific to the decomposition approach in [8], performs poorly when compared to the previous application with OB^{MPV}. However, it is necessary to bear in mind that the specification in [7] leads to an absolute measure of horizontal inequity that does not verify equation [5], and that the decomposition approach in [3] comes with a number of methodological limitations that have been addressed by subsequent methods in the literature – the remaining decompositions employed in this study. On the other hand, in the opinion of the author, the specification in [8] is the most theory-grounded method for the study of classical horizontal inequity out of those considered.

Table 5 – The optimal bandwidth (half-bandwidth of kernel)

CRITERION	**EX**	**CIT**	**FLAT**	**NFLAT**	**Max/Min**
OB^{MPV}: UL	750	600	336	664	2.23
OB^{VCL}: VCL	1,997	2,013	2,012	2,013	1.01
OB^{VCL}: AJL-UL	280	704	1,347	1,623	5.80
OB^{VCL}: UL	280	336	1,347	1,623	5.80
OB^{U}: DJA	1,156	1,302	4,597	4,670	4.04

Tables 6 and 7 show the results of the decomposition methods. Several considerations follow from comparing simulated scenarios.

i) *The erosion of the PIT base* – the gradual exclusion from progressive taxation of income components previously included in the PIT base, for a value of roughly 45 billion euros in 2019 – *shows practically no effect on the horizontal inequity features of the tax system.* The difference in the level of horizontal inequity between EX and CIT – the latter being a counterfactual scenario that subjects to progressive taxation those income components currently excluded – is negligible regardless of the decomposition approach.[12]

ii) On the other hand, *the erosion of the PIT base has a substantial effect on the vertical redistributive features of the tax system*. As far as the decompositions in [3], [4] and [5] are concerned, the loss of vertical equity attributable to current exemptions from progressivity ranges in the interval [-0.004212; -0.004187], roughly 8.1% of RE in EX (see approximate value indices in Table 6). This is true also when employing the specification in [8], for a loss that ranges in the interval [-9.1%; -6.1%] depending on the specific combination of v and ε (see approximate value indices in Table 7).

iii) Peculiar to the loss of vertical equity, *the erosion of the PIT base has led to a rather modest increase in the reranking of unequals*. The increase ranges in the interval [0.10%-0.11%] of RE in EX according to decompositions in [3], [4] and [5], while it is negligible and often nil for the selected combinations of v and ε in [8].

iv) In contrast with the previous comparisons, *the introduction of a flat-rate personal income tax scheme with a drastic reduction in revenue would lead to a minimal gain in terms of horizontal inequity*. Its absolute level would be half that of the present tax system[13] but at the cost of a remarkable increase in income inequality by means of a four-fifth reduction in vertical equity. These findings are confirmed regardless of the decomposition approach.

v) Finally, *the introduction of a flat-rate personal income tax scheme with a neutral effect on revenue would not just substantially increase income inequality, but would also lead to no gain in terms of horizontal inequity*. In fact, the absolute level of horizontal inequity would be equal to or greater than the present one regardless of the decomposition approach. Unlike the previous case, such a flat tax reform would come with greater reranking of unequals than the present level and a three-fifth loss in vertical equity.

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[12] The difference in percentage of RE in EX is equal to: i) 0.02% for HE^{UL-T} with OB^{MPV}; ii) 0.06% for HE^{VCL} with OB^{VCL}; iii) 0.01% for HE^{AJL-UL} with OB^{VCL}; iv) 0.004% for HE^{UL-T} with OB^{VCL}; v) zero in the case of HE^{DJA} with OB^{U} regardless of the selected combination of v and ε in Table 7.

[13] The difference in percentage of RE in EX is equal to (or ranges in the interval): i) 0.05% for HE^{UL-T} with OB^{MPV}; ii) 0.38% for HE^{VCL} with OB^{VCL}; iii) 0.04% for HE^{AJL-UL} with OB^{VCL}; iv) 0.02% for HE^{UL-T} with OB^{VCL}; v) [0%; 1.74%] for the selected combinations of v and ε in the case of HE^{DJA} with OB^{U}.

6. Discussion and policy implications

The erosion of the PIT base has increased the level of horizontal inequity of the tax system only negligibly. What seems to be controversial is that horizontal redistributive effects of this phenomenon have been taken, among other reasons, to justify the introduction of a flat-rate tax scheme in the Italian system (Stevanato, 2017).

As pointed out in the economic literature, progressivity in taxation can be achieved in different ways. The compliance of the tax system with the principle of progressive taxation could also be accomplished by introducing a flat-rate tax scheme. In fact, a proportional tax rate jointly combined with a significant *no tax area*, with further deductions where appropriate, would ensure the progressivity of the PIT and of the entire tax system in line with the principles of the Italian Constitution. Considering only the progressive nature of the PIT, even a small *no tax area* would ensure its accomplishment. Moving to a flat tax scheme with a drastic reduction in revenue would reduce horizontal inequity, while leading to a simplification of the tax system, as well as possibly having a positive impact on individual labour supply and tax compliance.

Despite the many issues that still need to be addressed in relation to the taxation of personal income (MEF, 2008), the argument that greater horizontal equity would result from such a revision of the tax system should be carefully considered in light of the marked reduction in the redistributive effect that would follow. This is not to say that the erosion of the PIT base is of negligible importance. The deviation from the theoretical framework that inspired the structure of the PIT does in fact affect the reduction of income inequality: the redistributive effect would increase by 8.3% in the case in which income components now subject to proportional taxation were reincluded in the PIT base, as this study points out. Furthermore, this increase would be 16.8% in the case in which capital income and gains were among the income components reincluded (Boscolo, 2019a). On the contrary, moving to a flat tax scheme such as those simulated here would dramatically decrease the redistributive effect in both cases. More importantly, no substantial gain would be achieved in terms of the treatment of close equals in the case in which the proportional tax rate were to be set at a low level. In the opinion of the author, this gain would not be enough to justify the disproportionate loss in vertical equity that would follow. This is partly due to the low existing level of horizontal inequity that characterises the Italian tax system. On the other hand, a reform with a neutral effect on revenue would lead to equal or greater horizontal inequity compared with the current system. However, the introduction of a flat tax that is intended to exploit all the benefits mentioned above would need to be carried out by setting the tax rate at such a level that would reduce revenue substantially and thus increase income inequality compared to the current situation. Even when designing a flat tax so as to limit as far as possible the drawbacks relating to greater income inequality, it remains to be seen whether it would be effective in terms of boosting individual labour supply, reducing tax evasion and achieving greater horizontal equity.

7. Concluding remarks

This paper used static microsimulation techniques and decomposition approaches for the study of classical horizontal inequity to clarify three points: i) the erosion of the PIT base – the gradual exclusion from progressive taxation of income components previously included in the PIT base – has a negligible impact on the level of horizontal inequity of the tax system; ii) the introduction of a flat-rate personal income tax scheme with a drastic reduction in revenue would halve the existing level of horizontal inequity at the cost of a four-fifth reduction in vertical equity; iii) the introduction of a flat-rate personal income tax scheme with a neutral impact on revenue would not reduce the existing level of horizontal inequity, despite leading to a three-fifth reduction in vertical equity.

Table 6 – RE decomposition using [3], [4] and [5]: indices multiplied by 100

INDEX	*OB^{MPV} for EX (approximate value indices except for EX)*								*OB^{MPV} for each scenario (true value indices)*							
	EX		**CIT**		**FLAT**		**NFLAT**		**EX**		**CIT**		**FLAT**		**NFLAT**	
	Effect	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**
VE^{UL}	5.2478	**101.44**	5.6681	**101.20**	1.0302	**103.24**	1.7925	**106.53**	5.2478	**101.44**	5.6675	**101.19**	1.0299	**103.21**	1.7928	**106.54**
HE^{UL}	-0.0023	**-0.04**	-0.0015	**-0.03**	0.0006	**0.06**	-0.0004	**-0.02**	-0.0023	**-0.04**	-0.0021	**-0.04**	0.0003	**0.03**	0.0000	**0.00**
HE^{UL-T}	0.0049	**0.09**	0.0039	**0.07**	0.0021	**0.21**	0.0047	**0.28**	0.0049	**0.09**	0.0039	**0.07**	0.0017	**0.17**	0.0052	**0.31**
R^{AJL}	0.0528	**1.02**	0.0474	**0.85**	0.0178	**1.78**	0.0783	**4.65**	0.0528	**1.02**	0.0494	**0.88**	0.0236	**2.36**	0.0805	**4.78**
R_{WG}	0.0228	**0.44**	0.0208	**0.37**	0.0139	**1.39**	0.0317	**1.88**	0.0228	**0.44**	0.0185	**0.33**	0.0080	**0.80**	0.0292	**1.74**
R_{EG}	0.0012	**0.02**	0.0005	**0.01**	0	**0.00**	0.0002	**0.01**	0.0012	**0.02**	0.0008	**0.01**	0.0001	**0.01**	0.0004	**0.02**
RE	**5.1733**	**100.00**	**5.6009**	**100.00**	**0.9979**	**100.00**	**1.6827**	**100.00**	**5.1733**	**100.00**	**5.6009**	**100.00**	**0.9979**	**100.00**	**1.6827**	**100.00**

INDEX	*OB^{VCL} for EX (approximate value indices except for EX)*								*OB^{VCL} for each scenario (true value indices)*							
	EX		**CIT**		**FLAT**		**NFLAT**		**EX**		**CIT**		**FLAT**		**NFLAT**	
	Effect	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**
VE^{VCL}	5.2554	**101.59**	5.6741	**101.31**	1.0320	**103.42**	1.7959	**106.73**	5.2554	**101.59**	5.6743	**101.31**	1.0327	**103.49**	1.8000	**106.97**
HE^{VCL}	0.0454	**0.88**	0.0423	**0.76**	0.0255	**2.56**	0.0518	**3.08**	0.0454	**0.88**	0.0411	**0.73**	0.0259	**2.60**	0.0532	**3.16**
R^{VCL}	0.0367	**0.71**	0.0309	**0.55**	0.0086	**0.86**	0.0614	**3.65**	0.0367	**0.71**	0.0323	**0.58**	0.0089	**0.89**	0.0641	**3.81**
VE^{AJL-UL}	5.2455	**101.40**	5.6667	**101.17**	1.0296	**103.18**	1.7901	**106.38**	5.2455	**101.40**	5.6693	**101.22**	1.0316	**103.38**	1.7969	**106.79**
HE^{AJL-UL}	0.0094	**0.18**	0.0089	**0.16**	0.0071	**0.71**	0.0140	**0.83**	0.0094	**0.18**	0.0189	**0.34**	0.0211	**2.11**	0.0548	**3.26**
R^{AJL-UL}	0.0628	**1.21**	0.0569	**1.02**	0.0246	**2.47**	0.0934	**5.55**	0.0628	**1.21**	0.0495	**0.88**	0.0126	**1.26**	0.0594	**3.53**
VE^{UL}	5.2506	**101.49**	5.6698	**101.23**	1.0300	**103.22**	1.7939	**106.61**	5.2506	**101.49**	5.6700	**101.23**	1.0316	**103.38**	1.7966	**106.77**
HE^{UL}	0.0004	**0.01**	0.0002	**0.00**	0.0003	**0.03**	0.0010	**0.06**	0.0004	**0.01**	0.0004	**0.01**	0.0020	**0.20**	0.0038	**0.23**
HE^{UL-T}	0.0025	**0.05**	0.0023	**0.04**	0.0015	**0.15**	0.0029	**0.17**	0.0025	**0.05**	0.0023	**0.04**	0.0037	**0.37**	0.0062	**0.37**
R^{AJL}	0.0628	**1.21**	0.0569	**1.02**	0.0247	**2.48**	0.0935	**5.56**	0.0628	**1.21**	0.0560	**1.00**	0.0126	**1.26**	0.0642	**3.82**
R_{WG}	0.0090	**0.17**	0.0087	**0.16**	0.0067	**0.67**	0.0129	**0.77**	0.0090	**0.17**	0.0101	**0.18**	0.0191	**1.91**	0.0458	**2.72**
R_{EG}	0.0051	**0.10**	0.0031	**0.06**	0.0004	**0.04**	0.0038	**0.23**	0.0051	**0.10**	0.0026	**0.05**	0	**0.00**	0.0001	**0.01**
RE	**5.1733**	**100.00**	**5.6009**	**100.00**	**0.9979**	**100.00**	**1.6827**	**100.00**	**5.1733**	**100.00**	**5.6009**	**100.00**	**0.9979**	**100.00**	**1.6827**	**100.00**

Table 7 – RE decomposition using [8] with different combinations of v and ε

INDEX	OB^U *for EX (approximate value indices except for EX)*								OB^U *for each scenario (true value indices)*							
	EX		**CIT**		**FLAT**		**NFLAT**		**EX**		**CIT**		**FLAT**		**NFLAT**	
	Effect	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**	**Effect**	**%RE**
	v=1.1 and ε=0.1								***v=1.1 and ε=0.1***							
VE^{DJA}	0.0142	**102.16**	0.0152	**102.01**	0.0032	**103.23**	0.0055	**105.77**	0.0142	**102.16**	0.0152	**102.0**	0.0032	**103.2**	0.0055	**105.8**
HE^{DJA}	0.0001	**0.72**	0.0001	**0.67**	0.0001	**3.23**	0.0001	**1.92**	0.0001	**0.72**	0.0001	**0.7**	0.0001	**3.2**	0.0001	**1.9**
R^{DJA}	0.0002	**1.44**	0.0002	**1.34**	0	**0**	0.0002	**3.85**	0.0002	**1.44**	0.0002	**1.3**	0	**0.0**	0.0002	**3.8**
$\boldsymbol{RE^{DJA}}$	**0.0139**	**100.00**	**0.0149**	**100.00**	**0.0031**	**100.00**	**0.0052**	**100.00**	**0.0139**	**100.00**	**0.0149**	**100.0**	**0.0031**	**100.0**	**0.0052**	**100.0**
	v=4.0 and ε=0.1								***v=4.0 and ε=0.1***							
VE^{DJA}	0.0474	**101.94**	0.0505	**101.61**	0.0116	**104.50**	0.0202	**108.60**	0.0474	**101.94**	0.0505	**101.6**	0.0116	**104.5**	0.0202	**108.6**
HE^{DJA}	0.0002	**0.43**	0.0002	**0.40**	0	**0**	0.0001	**0.54**	0.0002	**0.43**	0.0002	**0.4**	0	**0.0**	0.0001	**0.5**
R^{DJA}	0.0007	**1.51**	0.0006	**1.21**	0.0005	**4.50**	0.0015	**8.06**	0.0007	**1.51**	0.0006	**1.2**	0.0005	**4.5**	0.0015	**8.1**
$\boldsymbol{RE^{DJA}}$	**0.0465**	**100.00**	**0.0497**	**100**	**0.0111**	**100.00**	**0.0186**	**100.00**	**0.0465**	**100.00**	**0.0497**	**100.0**	**0.0111**	**100.0**	**0.0186**	**100.0**
	v=2.0 and ε=0.5								***v=2.0 and ε=0.5***							
VE^{DJA}	0.0485	**102.54**	0.0518	**101.97**	0.0121	**104.31**	0.0210	**108.81**	0.0485	**102.54**	0.0517	**101.8**	0.012	**103.4**	0.0209	**108.3**
HE^{DJA}	0.0005	**1.06**	0.0005	**0.98**	0.0002	**1.72**	0.0008	**4.15**	0.0005	**1.06**	0.0004	**0.8**	0.0001	**0.9**	0.0007	**3.6**
R^{DJA}	0.0007	**1.48**	0.0005	**0.98**	0.0003	**2.59**	0.0009	**4.66**	0.0007	**1.48**	0.0005	**1.0**	0.0003	**2.6**	0.0009	**4.7**
$\boldsymbol{RE^{DJA}}$	**0.0473**	**100.00**	**0.0508**	**100.00**	**0.0116**	**100.00**	**0.0193**	**100.00**	**0.0473**	**100.00**	**0.0508**	**100.0**	**0.0116**	**100.0**	**0.0193**	**100.0**
	v=3.0 and ε=0.5								***v=3.0 and ε=0.5***							
VE^{DJA}	0.0474	**102.38**	0.0506	**102.22**	0.0122	**105.17**	0.0212	**109.28**	0.0474	**102.38**	0.0505	**102.0**	0.0121	**104.3**	0.0211	**108.8**
HE^{DJA}	0.0005	**1.08**	0.0005	**1.01**	0.0002	**1.72**	0.0006	**3.09**	0.0005	**1.08**	0.0004	**0.8**	0.0001	**0.9**	0.0005	**2.6**
R^{DJA}	0.0006	**1.30**	0.0006	**1.21**	0.0004	**3.45**	0.0012	**6.19**	0.0006	**1.30**	0.0006	**1.2**	0.0004	**3.4**	0.0012	**6.2**
$\boldsymbol{RE^{DJA}}$	**0.0463**	**100.00**	**0.0495**	**100.00**	**0.0116**	**100.00**	**0.0194**	**100.00**	**0.0463**	**100.00**	**0.0495**	**100.0**	**0.0116**	**100.0**	**0.0194**	**100.0**
	v=1.1 and ε=0.9								***v=1.1 and ε=0.9***							
VE^{DJA}	0.0423	**102.92**	0.0450	**102.74**	0.0117	**105.40**	0.0202	**108.6**	0.0423	**102.92**	0.0448	**102.3**	0.0115	**103.6**	0.0199	**107.0**
HE^{DJA}	0.0011	**2.68**	0.0011	**2.51**	0.0005	**4.50**	0.0015	**8.06**	0.0011	**2.68**	0.0009	**2.1**	0.0003	**2.7**	0.0012	**6.5**
R^{DJA}	0.0001	**0.24**	0.0001	**0.23**	0.0001	**0.90**	0.0001	**0.54**	0.0001	**0.24**	0.0001	**0.2**	0.0001	**0.9**	0.0001	**0.5**
$\boldsymbol{RE^{DJA}}$	**0.0411**	**100.00**	**0.0438**	**100.00**	**0.0111**	**100.00**	**0.0186**	**100.00**	**0.0411**	**100.00**	**0.0438**	**100.0**	**0.0111**	**100.0**	**0.0186**	**100.0**
	v=4.0 and ε=0.9								***v=4.0 and ε=0.9***							
VE^{DJA}	0.0358	**103.77**	0.0379	**103.55**	0.0108	**106.93**	0.0188	**110.59**	0.0358	**103.77**	0.0377	**103.0**	0.0105	**104.0**	0.0184	**108.2**
HE^{DJA}	0.0010	**2.90**	0.0010	**2.73**	0.0004	**3.96**	0.0011	**6.47**	0.0010	**2.90**	0.0008	**2.2**	0.0001	**1.0**	0.0007	**4.1**
R^{DJA}	0.0003	**0.87**	0.0003	**0.82**	0.0003	**2.97**	0.0007	**4.12**	0.0003	**0.87**	0.0003	**0.8**	0.0003	**3.0**	0.0007	**4.1**
$\boldsymbol{RE^{DJA}}$	**0.0345**	**100.00**	**0.0366**	**100.00**	**0.0101**	**100.00**	**0.017**	**100.00**	**0.0345**	**100.00**	**0.0366**	**100.0**	**0.0101**	**100.0**	**0.017**	**100.0**

Appendix A

The decomposition formulas for the Reynolds-Smolensky index applied in Section 4 are discussed here. It is worth specifying that VE in [1] can be thought of as the sum of the vertical effect and the classical horizontal effect, as expressed in [5].

The computation of the contribution made by each instrument was first carried out by applying the generalisation of the Pfähler–Lambert decomposition provided by Onrubia et al. (2014). Following the order of the terms on the right-hand side of [13], the RS index can be broken down into three main aggregates, namely: i) the sum of tax schedules; ii) the sum of tax credits; iii) the sum of exemptions, allowances and deductions. Each aggregate is given by the sum of its subcomponents, while each subcomponent is given by the product of the group weight – which is constant for all the subcomponents of a specific aggregate – the individual weight and the Kakwani index (the terms within round brackets). Y is the gross income, which is the sum of all sources of income either subject to or exempt from progressive taxation; B is the total taxable income, given by the sum of the taxable income components subject to PIT or substitute taxes; S stands for the overall gross liability; T is the total net liability; S_i indicates the *i-th* tax schedule; C_i is the *i-th* tax credit; and D_i represents the *i-th* exemption, allowance or deduction in the tax system. An upper bar means that the variable is at its average value.

$$[13] \quad RS = \frac{\bar{B}}{\bar{Y} - \bar{S}} \sum_{i=1}^{k} \frac{\bar{S}_i}{\bar{B}} \left(C_{B,Y} - C_{B-S_i,Y} \right) - \frac{\bar{Y}}{\bar{Y} - \bar{T}} \sum_{i=1}^{m} \frac{\bar{C}_i}{\bar{Y}} \left(C_{Y-S,Y} - C_{Y-S-C_i,Y} \right) - \frac{\bar{Y}\bar{S}}{\bar{B}(\bar{Y} - \bar{S})} \sum_{i=1}^{n} \frac{\bar{D}_i}{\bar{Y}} \left(G_Y - C_{Y-D_i,Y} \right)$$

What if the analysis were conducted by isolating the contribution of each instrument on the basis of its own tax base? Would these findings provide a substantially different snapshot of what determines redistribution? These questions can be addressed by applying the so-called *natural* decomposition rule as defined in Kristjánsson (2013). In contrast to the approach just discussed, the effect of each instrument is computed on its corresponding tax base. The method has been adopted as a technique for analysing the redistributive effect of a dual income tax system, where labour income is subject to progressive marginal tax rates and capital income to alternative proportional tax regimes. Since our interest is in understanding the role played also by income components exempt from taxation, company welfare provisions, cadastral income from properties left available and the '80 euro' bonus can be thought of as income sources where a zero tax rate is applied. The decomposition formula allows us to separate the RS index into direct and indirect effects. As far as direct effects are concerned, the interpretation is straightforward as they are defined as the sum of the progressivity effects of all mutually exclusive income sources making up total gross income.

Turning to the indirect effects, they can be interpreted as the result of differences in the various tax schedules applied and how income distributions fit one another. Therefore:

$$[14] \quad RS = \sum_{i=1}^{k}(RS_i^D - RS_i^I)$$

$$= \sum_{i=1}^{k}\left[\frac{\bar{Y}_{C_i}}{\bar{Y}}\frac{t_{C_i}}{1 - t_{C_i}}\left(C_{T_{C_i},Y} - C_{Y_{C_i},Y}\right) - \frac{\bar{Y}_{C_i}}{\bar{Y}}\left(\frac{t - t_{C_i}}{1 - t}\right)C_{Y_{C_i}-T_{C_i},Y}\right]$$

where Y_{C_i} is the *i-th* gross income component; *Y* is the sum of all gross income components; T_{C_i} is the amount of net tax liability due on the *i-th* gross income component; t_{C_i} stands for the average tax rate of the net tax liability due on the *i-th* gross income component; *t* is the average tax rate in the tax system as a whole; $C_{T_{C_i},Y}$ is the concentration index of the net tax liability due on the *i-th* gross income component sorted by non-decreasing values of total gross income, and so on for the remaining concentration indices.

Appendix B

Legend: I_1, rental income from residential properties subject to proportional taxation; I_2, rental income from shops subject to proportional taxation; I_3, self-employment income subject to substitute tax regimes; I_4, productivity bonuses; I_5, cadastral income from properties left available; I_6, company welfare provisions; I_7, '80 euro' bonus; I_8, income subject to progressive taxation; I_9, total gross income; T_1, gross PIT; T_2, net PIT; T_3, regional surtax; T_4, municipal surtax; T_5, proportional taxes; T_6, total taxes.

Table 2 – Statistics on income and revenue: total values and distribution among income groups

Variable	**Value**	**Taxpayers**	G_Y	$C_{X,Y}$	**Income group (%)**									
					1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**
I_1	10,585	2,038,198	0.9768	0.7824	0.1	0.2	0.8	1.0	3.2	2.0	3.4	4.5	20.5	64.2
I_2	276	481,214	0.9933	0.3951	0.7	1.3	0.9	6.3	10.7	3.8	12.2	16.8	7.1	34.0
I_3	26,609	1,198,008	0.9805	0.4932	0.1	2.4	1.8	4.4	3.1	4.5	16.1	21.6	19.3	26.6
I_4	1,983	1,858,384	0.9605	0.6421	0.1	0.0	0.2	0.5	2.5	4.6	9.8	19.5	26.2	36.6
I_5	2,064	5,641,556	0.9386	0.4629	6.1	7.4	3.1	2.6	2.8	3.1	3.6	10.8	20.5	40.1
I_6	3,158	1,802,074	0.9801	0.7027	0.0	0.2	0.1	1.2	0.6	4.5	14.5	11.9	11.4	55.7
I_7	11,073	12,758,267	0.7154	0.0505	0.8	0.6	4.3	13.3	21.3	25.2	27.0	7.5	0.0	0.0
I_8	844,590	39,637,648	0.4604	0.4410	0.6	2.5	4.1	5.8	7.6	9.3	10.3	12.3	15.4	32.0
I_9	900,338	40,714,464	0.4432	0.4432	0.6	2.5	4.0	5.8	7.5	9.2	10.6	12.4	15.4	31.9
T_1	221,363	39,093,922	0.5230	0.5041	0.4	2.1	3.5	5.0	6.6	8.3	9.4	11.2	15.0	38.5
T_2	164,948	32,077,675	0.6757	0.6553	0.3	0.1	0.4	2.2	4.4	6.6	8.5	11.5	17.0	49.1
T_3	12,477	31,458,331	0.5696	0.5311	0.3	0.2	0.2	4.9	7.2	8.9	10.5	12.5	16.3	37.2
T_4	4,623	25,838,559	0.5715	0.5334	0.0	0.0	0.0	4.3	8.4	10.6	11.7	13.9	16.9	34.3
T_5	9,196	35,355,034	0.8992	0.5341	1.4	2.7	2.6	3.6	3.9	4.6	10.0	14.6	20.0	36.6
T_6	188,107	33,253,367	0.6501	0.6420	0.3	0.2	0.6	2.4	4.6	6.8	8.9	11.7	17.0	47.6

NOTE: the values are in million euros; G_Y stands for the Gini index of the *x-th* variable; $C_{X,Y}$ is the concentration index of the *x-th* variable ranked by non-decreasing value of total gross income; the income groups are ordered by non-decreasing values of total gross income excluding individuals with zero income.

Appendix C

This appendix brings together graphical evidence on the choice of the optimal bandwidth (half-bandwidth of kernel) for each simulated scenario. With reference to the Figures from 6 to 13, the solid line stands for the optimal bandwidth found using [15] (OB^{VCL}), while dash lines refer to the multiple optimal bandwidths observed when employing [17] (OB^{MPV}). Finally, Figure 14 depicts the smoothed relationship between net income and gross income in the application of [18] (OB^{U}), that is the estimate of post-tax income levels free of horizontal inequity.

Figure 6 – Choosing the optimal bandwidth using [15] (OB^{VCL}) and [17] (OB^{MPV}) for EX

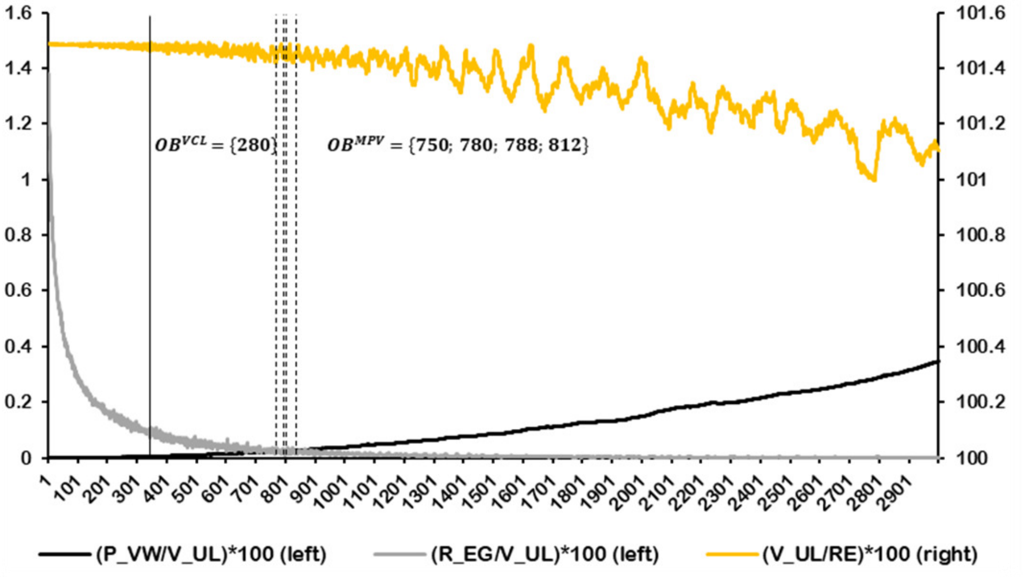


Figure 7 – Choosing the optimal bandwidth using [15] (OB^{VCL}) and [17] (OB^{MPV}) for CIT

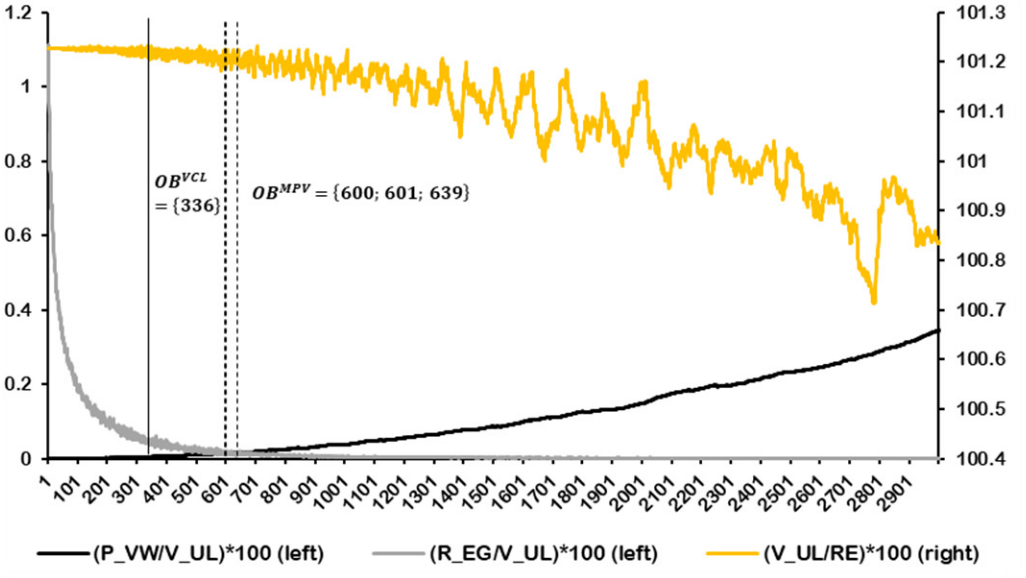


Figure 8 – Choosing the optimal bandwidth using [15] (OB^{VCL}) and [17] (OB^{MPV}) for FLAT

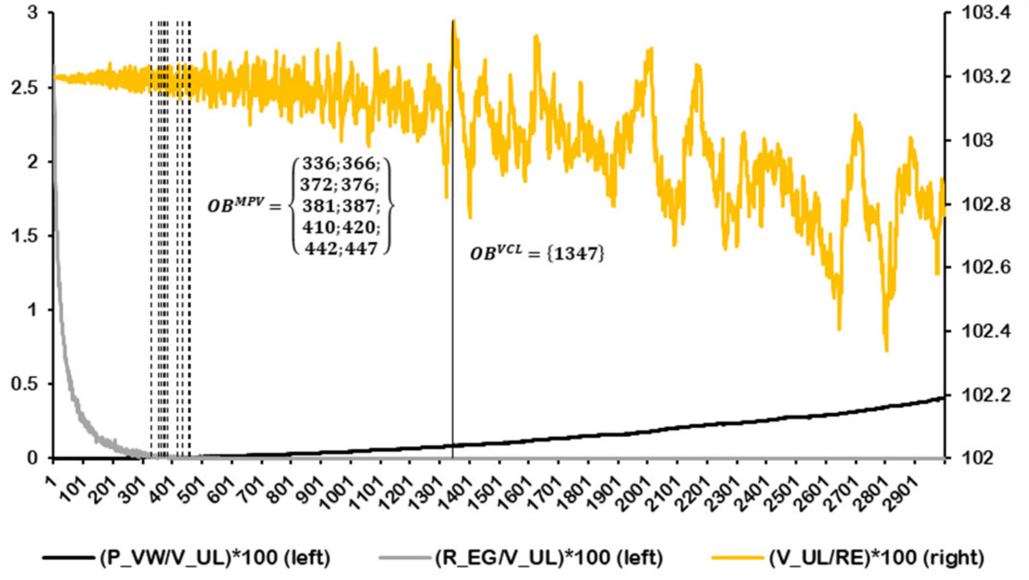


Figure 9 – Choosing the optimal bandwidth using [15] (OB^{VCL}) and [17] (OB^{MPV}) for NFLAT

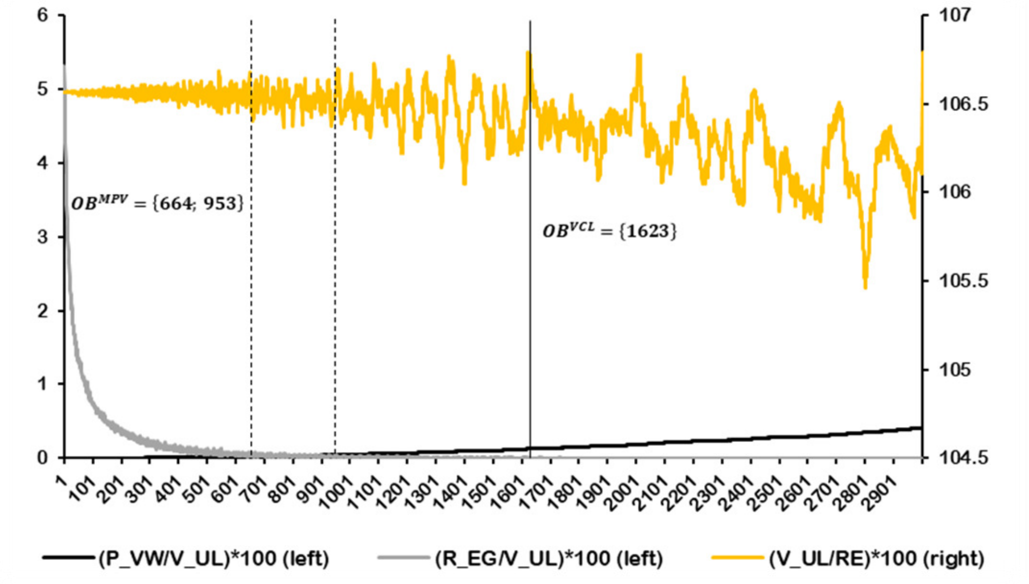


Figure 10 – Choosing the optimal bandwidth using [15] (OB^{VCL}) for EX

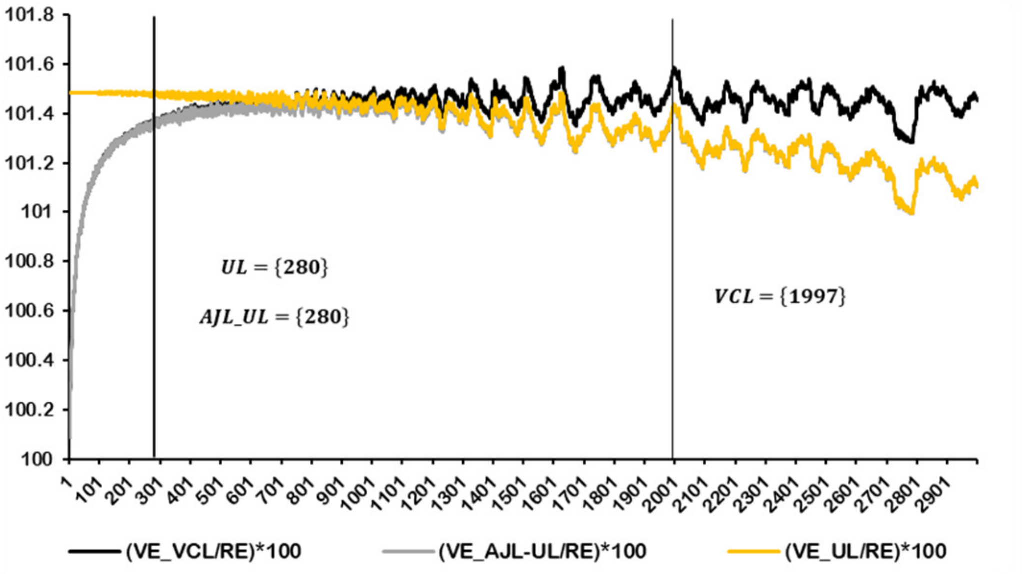


Figure 11 – Choosing the optimal bandwidth using [15] (OB^{VCL}) for CIT

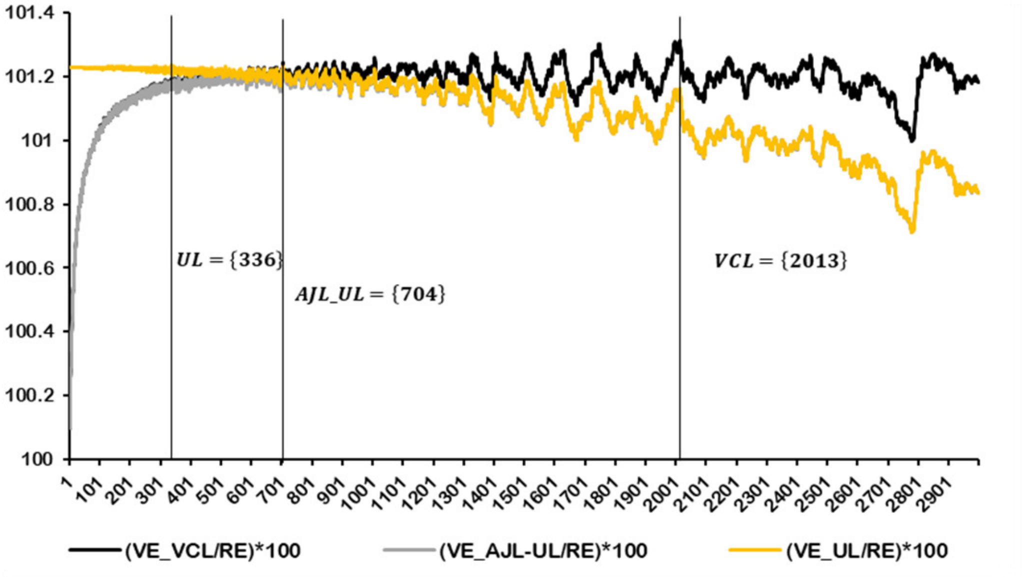


Figure 12 – Choosing the optimal bandwidth using [15] (OB^{VCL}) *for FLAT*

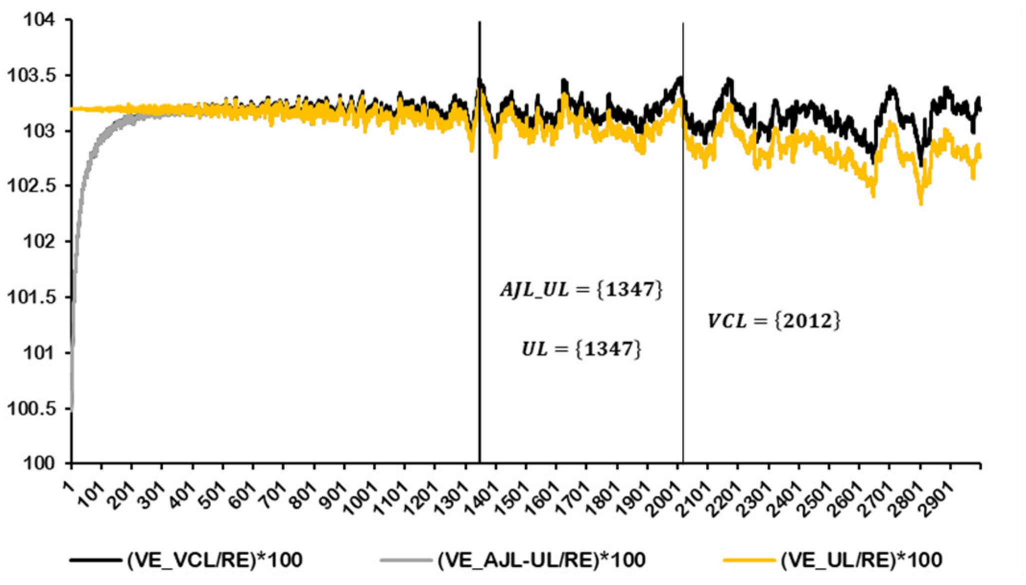


Figure 13 – Choosing the optimal bandwidth using [15] (OB^{VCL}) *for NFLAT*

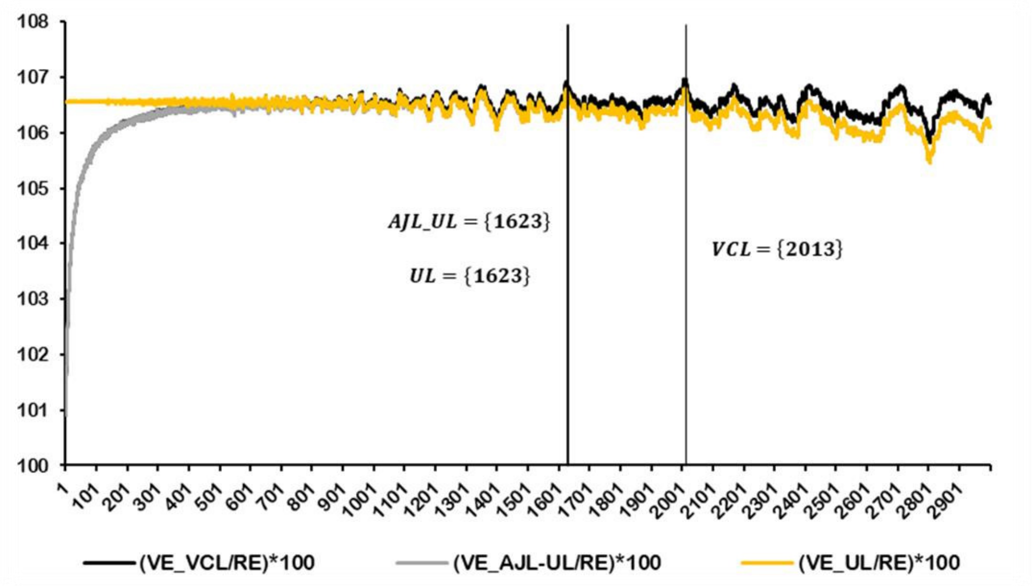
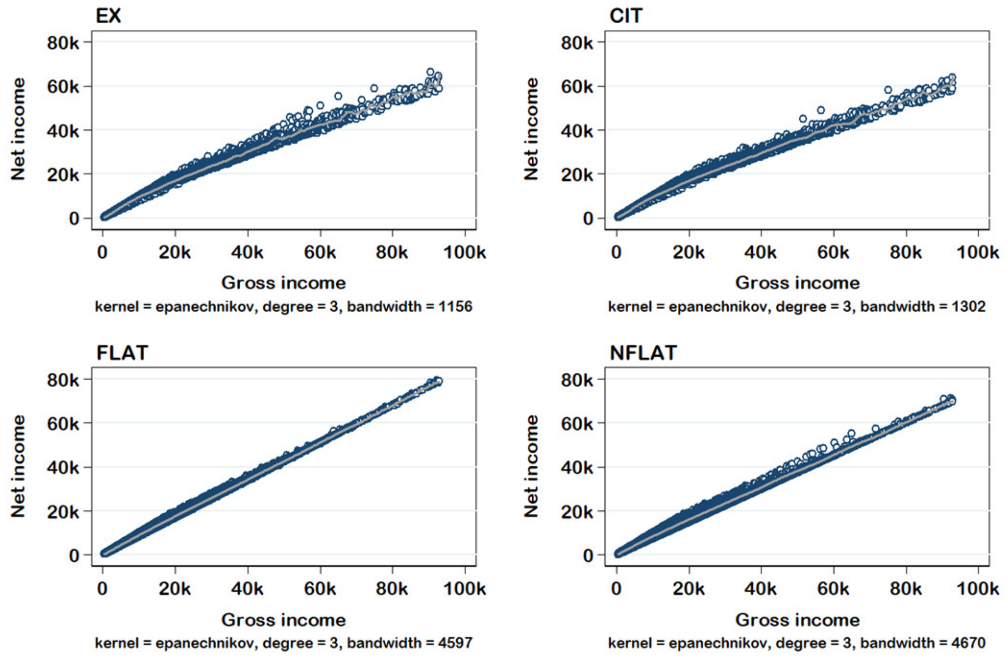


Figure 14 – Choosing the optimal half-bandwidth of kernel using [18] (OB^U)



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