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Abstract
It is sometimes argued that a flat-rate tax reform can reduce tax noncompliance. The argument is, however, inconsistent with the so-called Yitzhaki's puzzle of the classical expected utility (EU) model. The latter predicts an increase, rather than a reduction, in tax evasion following a cut in the tax rates resulting from a flat-rate reform. We study the impact of a flat-rate tax in a microsimulation tax-benefit model of Italy which allows us to analyse various hypotheses of tax evasion behavior. In addition to the EU model, we analyse expected utility with rank dependent probabilities (EURDP) and the model of reference dependent (RD) preference, the most favourable to overturn Yitzhaki's puzzle. Our simulations show that a flat-rate tax would barely reduce overall evasion in Italy in all models considered. Redistributive effects are in all cases large.

Keywords
Fiscal reforms, tax evasion, reference dependent preferences

JEL Codes
H20, H26, H30

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1 Introduction

Disputes around flat-rate income tax reforms are ever lively. Following the experience of several Central and Eastern European countries (Keen et al., 2008), some commentators and political parties propose that flat-rate tax reforms, by eliminating the distortionary effect of high marginal tax rates in traditional progressive systems, can also be adopted in Western economies. Critics of a flat-rate tax argue that its most likely consequences would be reduced tax revenues and increased post-tax income inequality.

To address the question, studies have estimated the potential effects of flat-rate tax reforms in some Western economies, either in econometric analyses looking at individual countries (e.g. Caminada and Goudswaard 2001; Fuest et al. 2008; Labeaga et al. 2008; Colombino and Islam 2018; Magnani and Piccoli 2020) or in a comparative approach (as in Aaberge et al. 2000; Paulus and Peichl 2009). While sensitive to the specific flat-rate tax and countries considered, findings have documented that flat-rate tax reforms bring about efficiency-equity trade-offs, with large supply-side effects which typically require low flat-rates and impose redistributions that advantage high income households.

A further argument in the debate, somewhat cursorily considered in the econometric studies above, focuses on the positive expectations of supporters of flat-rate tax of reduced tax evasion. Though not a major point in the original flat-rate tax model (Hall and Rabushka 1983; 1985), the idea that eliminating progressive marginal tax rates can improve tax compliance has attracted attention, especially since Russia's flat-rate tax reform in 2001 (Ivanova et al., 2005; Gorodnichenko et al., 2009; Duncan, 2014). There, tax revenues grew by 25% in real terms, notwithstanding that flattering the progressive system was fully achieved through a substantial cut to the top marginal rates (by 17% and 7% points, respectively, in the top two income brackets). The actual reasons for increased tax compliance in the Russia case are still debated.[1] Nevertheless, flat-rate tax proponents contend that the benefits for compliance can extend to improving inequality. This is because if the rich evade a relatively larger share of their incomes than do the poor, a flat-rate tax regime by increasing compliance would be less harmful to inequality than the effect computed considering the reduced statutory progressivity only.

Reducing tax evasion and increasing tax compliance is also a major rationale behind flat-rate tax proposals in Italy (for a general discussion, see Baldini and Rizzo, 2019).

Simulating the likely impact on tax evasion of flat-rate tax reform is problematic, however. This is because in the traditional portfolio model of tax evasion based on expected utility theory, lowering the average tax rate reduces, rather than improves, tax compliance (Allingham and Sandmo, 1972; Yitzhaki, 1974). Indeed, in the classical model, a lowering tax rate makes a taxpayer accept the increased risk associated with greater evasion (given the standard assumption of decreasing absolute risk aversion). Therefore, simulation exercises based on traditional portfolio models of tax evasion cannot, by definition, generate an increase in tax compliance following a flat-rate tax reform. Moreover, the expected utility model is known to entail other drawbacks in describing people's actual behavior in risky decisions, especially at low probabilities as typically occur in tax evasion decisions.[2]

[1] A particular issue in the debate is whether the increased compliance can be attributed to a behavioral response to the tax cut (as, for example, argued by Gorodnichenko et al. 2009; Duncan 2014; Duncan and Peter 2016), or was more a result of increased law enforcement and more efficient administration (Ivanova et al., 2005; Keen et al., 2008; Filer et al., 2019).

[2] The literature on the portfolio model of tax evasion is reviewed in Section 3 and more extensively in

In this paper, we take a novel approach to analysing the impact on tax evasion in a tax system. We simulate taxpayers' behaviors under different preference theories using a microsimulation tax-benefit model. In addition to expected utility (EU), we analyse expected utility with rank dependent probabilities, which includes the overweigthing of small probabilities; and a model of reference dependent preference in the manner of Tversky and Kahneman (1992), which is the most favourable to overturn the Yitzhaki's puzzle.

The preference models belong to the field of behavioral economics, which is changing our understanding of how economic policy operates, including tax policy (Congdon et al., 2009). Applications of reference dependent preference to tax evasion have been studied by various authors (Schepanski and Shearer, 1995; Bernasconi and Zanardi, 2004; Bernasconi et al., 2014; Dhami and Al-Nowaihi, 2007; Rablen, 2010; Hashimzade et al., 2013; Piolatto and Rablen, 2017; Rees-Jones, 2018; Engström et al., 2015). Under reference dependence, a reduction in the tax rate increases or decreases taxpayer compliance depending on whether a taxpayer's income is below or above a reference point. The asymmetric behavior arises because when a taxpayer's income is lower than the reference point, a tax reduction mitigates the psychological 'loss' the taxpayer experiences with the tax payment. When, instead, income is higher than the reference point, the consumer is in the 'gain' domain of the psychological function and the traditional portfolio effect of a tax cut prevails.

We conduct several simulations to study the possible impact of a flat-rate tax reform using the microsimulation model BETAMOD (Albarea et al., 2015, 2020). BETAMOD is tax-benefit microsimulation model for personal income tax (PIT) in Italy which works through an iterated process delivering several individual and fiscal variables of the simulated tax systems. In the process, the model also estimates individual taxpayers' evasion rates. These are estimated using a technique based on the discrepancy method of comparing the distribution of simulated data with administrative tax registered data, which is integrated with the consumption-based approach of Pissarides and Weber (1989) to adjust for underreporting in the survey data used as an input in the simulations. The simulations also account for the different opportunities for taxpayers to evade. This is important since a large proportion of incomes is subject to third-party reporting (e.g. regular employment incomes and pensions), which makes underreporting difficult or impossible. Ignoring the impossibility of cheating on some types of incomes may also distort the predictions of theoretical models of tax evasion, including of the tendency of expected utility to overpredict tax evasion (Kleven et al., 2011).

Our analysis produces several results. First of all, it confirms the difficulty of the traditional portfolio model to account for the tax evasion rates estimated in Italy. We find that reference dependent preference can instead more closely fit the estimated tax evasion rates. Nonetheless, even with reference dependent preference, the simulations show it is hardly likely that a flat-rate tax reform could reduce the overall evasion rates. In a benchmark simulation of the flat-rate tax at budget balanced (flat rate 27.35%), we find no significant differences between the average evasion rate under the current progressive tax system and the flat-rate tax (estimated close to 10% with and without the flat-rate tax). Likewise, there are no noteworthy effects on the tax gap (measured as total taxes lost due to tax evasion). We do find, however, different reactions among taxpayers. Taxpayers with gross incomes lower than about 45,000 euros increase evasion, whereas taxpayers with gross incomes greater than 45,000 tend to reduce evasion. The findings are consistent with the intuition of reference dependent preference which predicts that rich taxpayers who experience a smaller 'loss' associated with tax legally

Andreoni et al. (1998); Slemrod and Weber (2012); Alm (2012, 2019).

due evade less; whereas poor taxpayers who suffer a ‘loss’, since the flat-rate increases slightly the taxes legally due evade more. Nevertheless, the simulation confirms that the flat-rate tax substantially diminishes the redistributive impact of the tax system, particularly with the effective average tax rates which increase for taxpayers with incomes lower than 35,000 euros and reduces for those with incomes greater than 35,000.

Simulations with flat-rates lower than 27% (e.g. at 20% and 15%) also show that flat-rate tax reforms are unlikely to generate substantial reductions in overall evasion. Of course, the tax gaps may reduce, but only when the flat-rate becomes so low that tax revenues shrink and the impact of evasion on total tax revenues becomes in any event small. Redistributive effects may, on the other hand, become large. The problem in such a case is with the return at high income levels of the Allingham-Sandmo-Yitzhaki effect, which increases the difference between evasion rates at high and low income levels. For the same reason, we find that a potential increase of the tax base arising from possible supply-side effects generated by a flat-rate tax may have little impact on evasion.

Tax-benefit microsimulation models now constitute a fundamental tool for evaluating the effects of public policies (Bourguignon and Spadaro, 2006; Immervoll et al., 2007; Figari et al., 2015). Most tax-benefit microsimulation models adopt an *arithmetical* approach that ignores taxpayers’ behavioral responses to the reform. Our approach, by contrast, resembles what Bourguignon and Spadaro (2006) call *behavioral* microsimulation modelling which includes a representation of the behavioral responses of taxpayers to policy changes. Most often the types of behaviors considered relate to consumption or labor supply decisions. Overall, a major contribution of this paper is to clarify the need to also consider a channel to analyse the effect of tax evasion.

The paper proceeds as follows. In Section 2, we present the tax evasion estimates for personal income tax in Italy obtained by BETAMOD. In Section 3, we review the theoretical models of tax evasion behavior, which are then used in Section 4 to integrate the microsimulation analysis with the behavioral models. First, we determine the models’ abilities to explain tax evasion in the current progressive system; and we then simulate the models for flat-rate tax reforms. Section 5 summarises and concludes.

2 Tax evasion in Italy

Various methods are used to estimate tax evasion (Alm, 2012; Slemrod and Weber, 2012). Here, we present estimates of the evasion rates of the personal income tax (PIT) in Italy based on an approach developed by Albarea et al. (2015; 2020). Albarea et al. (2015) utilises the so-called discrepancy method to estimate the distributions of taxpayers’ evasion rates by comparing the income distribution from registered tax data with the distribution obtained from the Italian part of the household survey European Union Statistics on Income and Living Conditions (IT-SILC).[3]

Since the former distribution refers to gross reported incomes and the latter to disposable incomes, the net-to-gross income conversion is performed using BETAMOD. A problem of

[3] The discrepancy method is a general approach applicable to various ways of measuring the underground economy. According to Feige (1990, p. 995), “the discrepancy approach is feasible whenever independent means exist to estimate the same conceptual entity. If one procedure for measuring a particular form of underground activity is believed to be relatively free of biases induced by the activity, while another is known to be affected by the activity, the discrepancy between the two can be used to measure the net effect of the underground activity”.

Table 1 – Main aggregates of PIT in 2014

	Number of taxpayers (Thousands people)		Values (Billions euro)	
	Official tax returns	BETAMOD Simulation	Official tax returns	BETAMOD Simulation
Gross income	-	40,184	-	897.045
Evaded income	-	12,266	-	87.692
Reported income	40,183	40,184 (0.0)	807.994	809.353 (0.2)
Deductions	7,390	7,592 (2.74)	24.796	24.593 (-0.8)
Taxable income after deductions	39,430	38,712 (1.7)	777.512	776.131 (-0.2)
Net tax liabilities	30,729	30,584 (-0,5)	151.185	150.885 (-0.2)
Net tax liabilities without evasion	-	32,877	-	174.913
Tax gap	-	-	-	24.028

Percentage-differences from official tax returns in brackets.

the discrepancy method, however, is that survey respondents can misreport their incomes too. In Albarea et al. (2020), income data from IT-SILC are therefore corrected for possible survey misreporting using the consumption-based method developed by Pissarides and Weber (1989). Mainly, the latter authors proposed that differences in consumption propensities estimated from survey data for alternative categories of income earners are due to varying tendencies to misreport incomes by category. Specifically, the method assumes that all categories report consumption expenditures accurately, while incomes are reported correctly only by some categories (reference categories) of income earners. Pissarides and Weber (1989) used employees as the reference category, while the self-employed were reckoned to substantially underreport. BETAMOD adopts a specification owed to Feldman and Slemrod (2007) which estimates different rates of income misreporting for different income sources. BETAMOD uses pensions as the reference income category and estimates potential misreporting for two main income categories: income from self-employment and rental income from immovable properties, partnerships, and other capital incomes, henceforth referred to as “rents”. This enables estimating that employees may themselves misreport income from secondary or irregular work, while employment income from regular jobs cannot be misreported given that is subject to employer source-withholding.[4] The misreporting estimates are then used to correct the incomes compared with the official data from tax registers.

An advantage of the integrated approach is to bring the estimates of the tax evasion rates based on micro methods to be closer to estimates obtained by macro studies.[5] At the

[4]Indeed, the IT-SILC survey asks respondents to report employment income data directly from administrative records.

[5]It is particularly well-known that studies based on micro methods — or, as they are sometimes called, bottom-up methods — tend to obtain lower estimates of tax evasion rates than do studies based on macroeconomic aggregates — referred to as top-down methods and often considered more accurate (Giovannini,

same time, it remains possible to conduct microsimulation analyses to estimate, e.g., the distributional impact of tax evasion and/or the effect of tax reforms. In Albarea et al. (2015; 2020), we present the method in detail and conduct comprehensive analyses of the 2010 PIT. Here we present the estimates updated to the 2014 PIT (using IT-SILC release 2015), which we use in the subsequent analyses to look at the predictions of the theoretical models of tax evasion and at the possible effects of a flat-rate tax reform in Italy.

Table 1 compares the main aggregates from the simulations with official data. The results provide evidence of the consistency of both the numbers of taxpayers and the values of the aggregates between simulated data and official tax returns. The figures show that BETAMOD simulates reported incomes, taxable income after deductions and net tax liabilites with minor differences (between 0.2% to 2%) in relation to official tax returns. The simulations also report the aggregate estimates of tax evasion. Total evaded income is estimated at about € 87.7 billion, corresponding to an overall evasion rate of 9.8%. In consequence, actual net tax liabilities are lower than potential tax liabilities by € 24 billion (PIT tax gap). Just slightly lower than estimates obtained by other studies (Ministry of Economy and Finance, 2016), the figures affirm the relevance of the problem of tax evasion in Italy.

Our approach permits studying the distributive effects of tax evasion. Figure 1 reports the income distributions resulting as outputs from the simulations. Panel a) and panel b) shows the distributions of true gross incomes and reported incomes estimated by BETAMOD, distinguishing for income source. The difference between the two distributions corresponds to the distribution of evaded incomes, as shown in panel c). The distributions indicate, as expected, that tax evasion is concentrated between self-employed incomes and rents, which represent the smallest shares of the income distribution, even if they are more frequent in the upper part of the income distribution.[6] The highest amounts of evaded incomes are in the central income classes (between € 15,000 and € 26,000) and in the highest official class (incomes greater than € 75,000).[7]

Figure 2 shows the histograms of tax evasion rates across income sources. The panel for employment income shows that the majority of employed workers (almost 86%) report their gross income fully and that very few (about 3%) evade more than 30% of employment income. Tax evasion rates are much higher among the self-employed, with only 11.5% full complying, about 35% with evasion rates lower than 50%, and 38% with evasion rates higher than 50%. The distribution of evasion rates is even more right-skewed in the case of rents, with almost 62% of rental-income earners evading more than 60% of rents. Composing these results for total income produces a distribution with 68.5 % of fully compliant taxpayers, about 17% of amateur tax evaders with evasion rates lower than 30% of their incomes, and about 15% of major tax evaders with evasion rates greater than 50%.

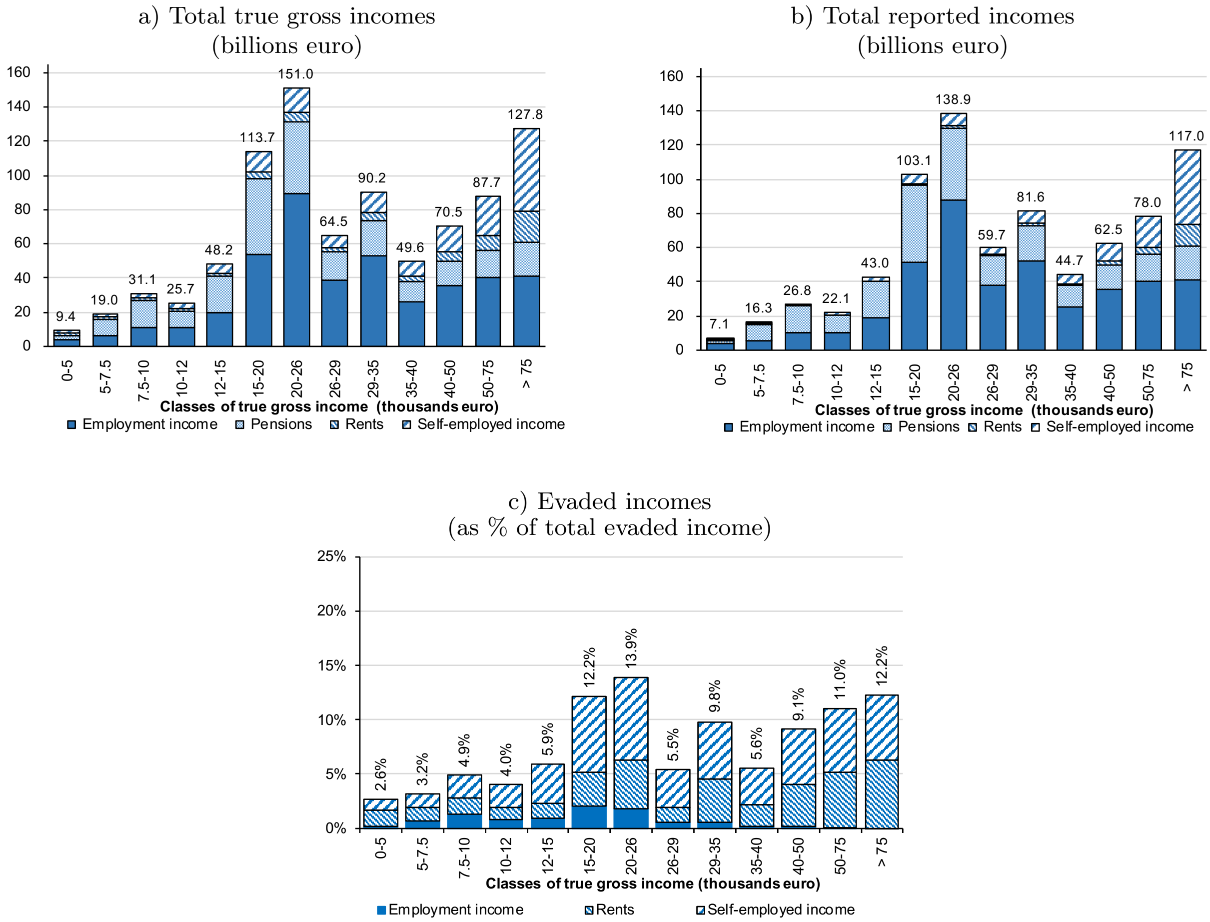
Tax evasion causes redistributive effects. Figure 3 reports the average tax evasion rates (TEVs) by true gross income class and income source. It shows evasion rates on employment incomes, self-employment incomes and rental incomes, all decreasing in the three components. This is consistent with previous studies (Fiorio and D'Amuri, 2006; Giovannini, 2011). The composition effect on total income implies that the overall evasion rate decreases until a total gross income of about € 30,000 and then fluctuates between 8% and 11%. The high tax evasion rates in the classes at the bottom of the distribution — 25% on total income in the

2011; Slemrod and Weber, 2012; Alm and Embaye, 2013; Schneider and Enste, 2013).

[6]In BETAMOD simulations, self-employed incomes and rents correspond to 17.4% and 6.6%, respectively, of total gross incomes, versus 48.4% and 27.6% corresponding respectively to employment incomes and pensions.

[7]Income classes in Figure 1 are based on class coding from official data.

Figure 1 – Distributions of true gross incomes, reported incomes, evaded incomes in BETAMOD



lowest class between € 0-5,000 and at about 15% in the classes between € 5-10,000 — may be somewhat unexpected. This because the actual tax due at such low income levels is indeed very low also due to various forms of tax credits and tax expenditures which tend to bring net tax liabilities for most low-income taxpayers to zero, or very close to it.[8] Thus, the finding indicates that many taxpayers at low income levels prefer to underreport their incomes rather than report their full incomes and claim the tax benefits they are eligible for.[9] This also implies that the high tax evasion rates at these low income levels do not represent a large tax gap.[10]

[8] Italian PIT has five income tax brackets with the following corresponding marginal tax rates: (I) 23% for incomes between 0-15,000 euros, (II) 27% between 15,000-28,000, (III) 38% between 28,000-55,000, (IV) 41% between 55,000-75,000, (V) 43% >75,000. There is no formal no-tax area, even if a system of income tax deductions and tax expenditures brings the net liabilities in low income classes actually to zero for most taxpayers.

[9] From a different perspective, the preference for underreporting at low income levels can be seen as the other side of the coin of low take-up benefits rates, typically well below 100%, which is indeed a recognised feature of several tax benefit programs including, e.g., earned income tax credits (Bhargava and Manoli, 2015).

[10] For example, we estimate that although the unreported income of the classes between € 0-10,000 totals about € 9.5 billion (almost 10.7% of total evaded income), the corresponding tax gap is around € 680 million (less than 3% of the total gap).

Figure 2 – Histograms of tax evasion rates across income sources

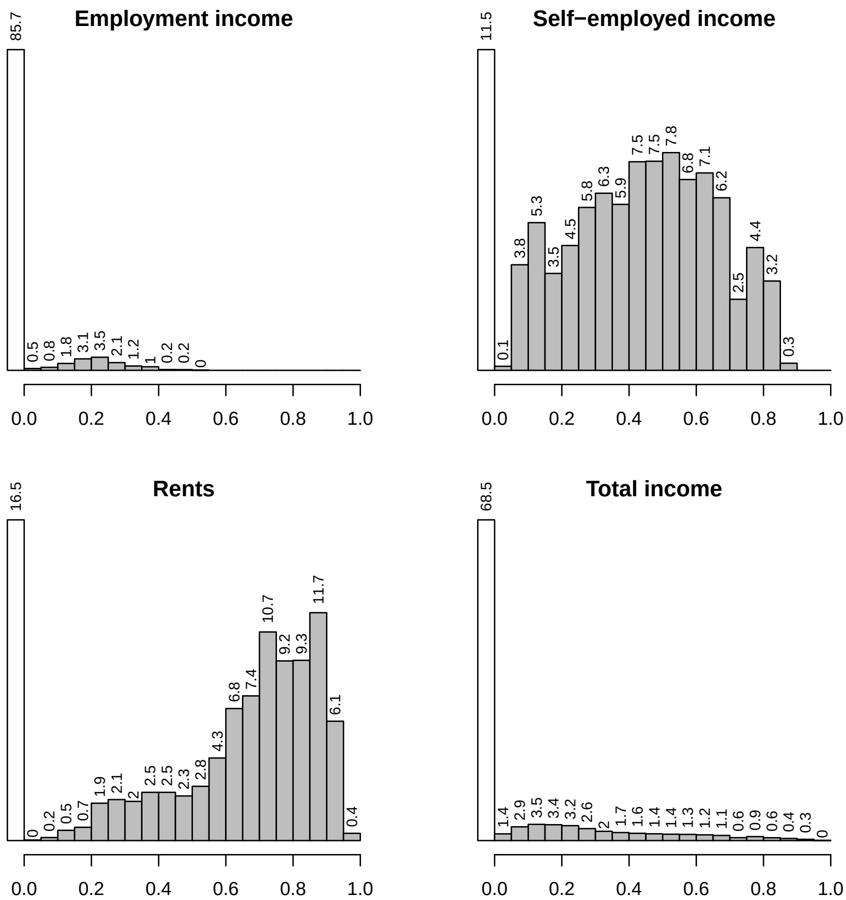


Table 2 reports a set of inequality indices. Tax evasion makes the distribution of reported incomes appear more unequal than it is (Gini index for reported incomes with evasion at 0.4310 is higher than without evasion, at 0.4165). However, evasion increases inequality in the distribution of after-tax incomes: the concentration index for the distribution of net incomes with evasion (0.3702) is higher than the index for the theoretical distribution without evasion (0.3625); the Reynolds-Smolensky index is lower in the simulation with evasion, mainly because of a reduction in the effective average tax rate of 3.5 percentage points. Evasion also causes positive reranking effects.

The distributions of gross and reported incomes estimated by BETAMOD represent the starting points in the paper's successive analyses. Our aim is to add models of tax evasion behavior in the microsimulation analyses to determine which model best explains behaviors and to then use the models to simulate the effects of flat-rate tax reforms in Italy.

3 Modelling compliance decisions

The cornerstone of any theoretical approach in the analyses of tax evasion decisions is the classical expected utility (EU) portfolio approach modeled by Allingham and Sandmo (1972).

Figure 3 – Tax evasion rates (TEV) for income sources by gross income classes (%)

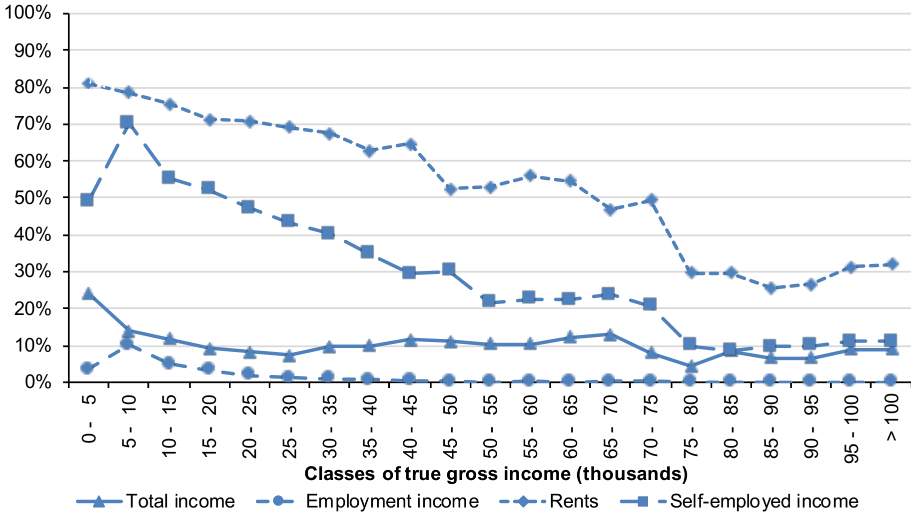


Table 2 – Inequality index

	Actual (with evasion)		Theoretical (without evasion)	
	Gini	Concentration	Gini	Concentration
True gross income	0.4173	0.4174	0.4165	0.4165
Reported income	0.4310	0.4174	0.4165	0.4165
Taxable income	0.4349	0.4152	0.4180	0.4159
Post-tax income	0.3718	0.3702	0.3633	0.3625
Reynolds-Smolensky index	0.0472		0.0540	
Kakwani index	0.2291		0.2218	
Average tax rate	0.1682		0.1957	
Reranking effect	0.0016		0.0008	

Below, we review the EU model and two of its extensions developed in the behavioral economic literature to explain some shortcomings of the classical model: one is expected utility with rank dependent probability (EURDP) and the other is the reference dependent (RD) preference approach.

All the three methods represent simplifications of the real world. Among other aspects, they are based on individual decision making and do not consider the possible effects of various forms of social interactions on tax evasion.[11] Nevertheless, the models capture essential features of people's decisions to pay or not to pay taxes legally due, representing natural departure points for inclusion in behavioral microsimulation analysis.

[11]There is an extensive literature on models of tax evasion decisions, including approaches with considerably rich social settings. We refer below to some of the developments. In general, while approaches with complex settings add to reality, they do not solve some of the classical model's ambiguities (comprehensive surveys in Andreoni et al., 1998; Kirchler, 2007; Sandmo, 2012; Hashimzade et al., 2013; Alm, 2019).

3.1 The EU model of tax evasion

In the classical EU model of tax evasion, a taxpayer with gross income $Y > 0$ is required pay taxes on the amount $D \in [0, Y]$ that she reports to the tax authority. The tax authority does not observe Y directly, but with probability $p > 0$ conducts an audit that detects any concealment of income with certainty. If audited and found to have concealed part of her income the taxpayer must pay the evaded taxes plus a sanction. In the original Allingham and Sandmo's (1972) model, sanctions were computed on evaded income, whereas Yitzhaki (1974) noted that sanctions are calculated in most countries, including in Italy, as a percentage of the evaded taxes. Moreover, while both Allingham and Sandmo (1972) and Yitzhaki (1974) considered a linear tax schedule, the approach easily extends to a general progressive tax framework (Pencavel, 1979).

To formally outlay the approach, we specify the taxpayer's income if not caught as Y_{NC}:

$$Y_{NC} = Y - T(D)$$

where $T(\cdot)$ represents the tax schedule; and the taxpayer's income if caught as Y_C:

$$Y_C = Y - T(D) - (1+s)T(E)$$

where $s > 0$ is the penalty rate and $E = Y - D$ is evaded income.

The taxpayer is assumed to choose D to maximize the following expected utility function:

$$EU = (1-p)U(Y_{NC}) + pU(Y_c) \tag{1}$$

Although it simplifies the real world, the model summarises the critical aspects of the economic calculus applied to compliance decisions.[12] Primarily, the model delivers the intuitive predictions that compliance responds positively to tax enforcement parameters, in the sense that both the penalty rate s and the audit rate p act positively on compliance.

Two other implications of the model are, however, less convincing and have caught scholarly attention. The first prediction concerns the low level of tax compliance predicted by the EU model. Mainly, for the degrees of risk aversion normally associated with EU and the values of enforcement parameters typical of many countries, the model predicts very high levels of tax evasion which, in some limiting cases, seem to defy common sense.[13]

The second prediction is the so-called 'Yitzhaki's puzzle'. This predicts that an increase (decrease) in the fiscal pressure reduces (increases) tax evasion whenever a taxpayer has decreasing absolute risk aversion, which is the standard DARA hypothesis in the risk literature. As noted, Yitzhaki (1974) obtained the prediction for the linear tax schedule, namely when $T(D) = \tau D$ and $\tau \in (0, 1)$. The prediction was also confirmed with respect to various other parameters of a progressive tax schedule, including with respect to both the marginal and the average tax rates (e.g., Srinivasan, 1973; Pencavel, 1979).

A sizeable literature has also enquired into the generality of the predictions (surveys in Hashimzade et al., 2013; Alm, 2019). One early development has, for example, analysed

[12] In fact, Allingham and Sandmo (1972) presents their model of tax evasion as a natural application of the economics-of-crime approach of Becker (1968).

[13] A well-known limiting case follows from the conditions of internal solutions. In EU, they imply that *all* taxpayers should underreport at least a fraction of their incomes as long as the expected return to one euro of evaded taxes is positive, namely $E(r) = 1 - p - ps > 0$ (Allingham and Sandmo, 1972; Bernasconi, 1998). The case $E(r) > 0$ is precisely what holds in many countries where p is hardly greater than 3%, even for categories of taxpayers with ample opportunities to evade, and s is often lower than 2.

whether Yitzhaki's puzzle is confirmed or not when taxpayer's gross income is endogenous because it depends on labor supply decisions. Other analyses have investigated the relation between compliance and other aspects of supply-side choices (such as the choice to be self-employed or an employee, or work in the regular or irregular sector; Cowell, 1981, 1985; Pestieau and Possen, 1991). The theoretical approaches with endogenous incomes have made the analysis more complete, but at best they have made the predictions of the EU model ambiguous, without invalidating Yitzhaki's puzzle. Furthermore, the empirical evidence has shown that there is generally little interaction in people's actual behavior between their occupational and/or labor supply choices and their tax evasion decisions (Parker, 2003). For this reason too, most analyses consider, as we do here, tax evasion in isolation from labor supply (Slemrod and Yitzhaki, 2002).

Similarly inconclusive results for Yitzhaki's puzzle have been obtained from theoretical approaches which consider richer institutional set-ups than the basic framework of equation (1), such as looking at the effects of the uncertainty about the relevant fiscal parameters. The same is true for extensions that add social or ethical motivations in the compliance decision (such as stigma, social norms, morality, perceived fairness of the tax system), while maintaining the EU preference.

Nevertheless, given the threat-of-audit underlying the EU model is relevant for only a fraction of taxpayers, and in developed economies most taxpayers are simply unable to cheat subject to some form of third-party reporting (as, e.g. retirees and regular employees in the previous section), an important question concerns the extent to which the EU puzzles might be overemphasised as a practical matter. This is investigated by the policy simulations conducted below.[14]

3.2 Tax evasion with rank-dependent probabilities (EURDP)

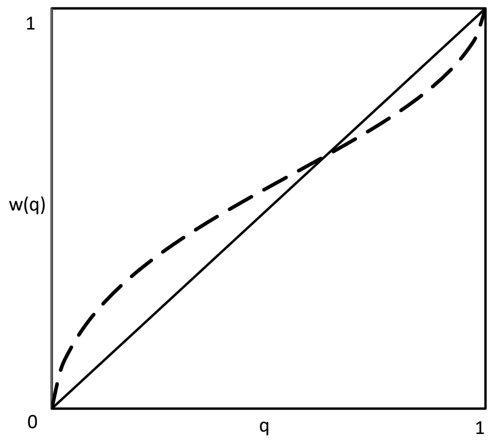
As well as simulating the EU model, we focus on some well-known features of individual behavior that the behavioral economics literature emphasises in many contexts as major drivers of divergences from the classical EU theory.

A first source relates to people's tendency to weight in risky decisions the outcome probabilities and to transform them nonlinearly. A popular model representing this tendency is expected utility with rank-dependent probability (EURDP). This class of models was introduced into the literature by Quiggin (1982) and developed further by several authors (see Diecidue and Wakker, 2001, for an intuitive derivation of the theory). The salient characteristic of EURDP is that the weight attached to each outcome depends solely on the probability of the outcome and its ranking position.

A typical weighting function in EURDP is denoted as w. It is increasing, onto, with

[14]Indeed, while there are many empirical studies from both the field and experiments, indicating that the EU model does not capture all taxpayers' motivations to comply in situations of pure self-reporting, there is surprisingly limited evidence on the ability of the EU model to predict evasion and compliance at an aggregate level. Mainly, to what extent is the model able to accurately forecast tax revenues and overall tax evasion in a country when third-party reporting is taken fully into account? For example, based on the evidence collected from a stratified random sample of people participating in a tax evasion field experiment in Denmark, Kleven et al. (2011) confirm a substantial level of tax evasion for self-reported income, but also that the overall evasion rate was modest because most income is subject to third-party reporting, for which the experiment recorded a tax evasion rate close to zero. In consequence, the authors concluded that the aggregate results could be explained by extending the standard model of tax evasion to include the key distinction between self-reported and third-party reported income.

Figure 4 – A probability weighting function



$w(0) = 0$ and $w(1) = 1$. Moreover, a vast literature has focussed on the form of w finding large support for an inverse S-shape: namely, concave for small probabilities, convex for high probabilities, and relatively insensitive toward changes in intermediate probabilities. An inverse S-shaped weighting function indicates that, at low probabilities, people are optimistic about high outcomes and pessimistic about low outcomes. Figure 4 shows an example of a probability weighting function based on the (decumulative) parametric form:

$$w(q) = 1 - \frac{(1-q)^{\gamma}}{[q^{\gamma} + (1-q)^{\gamma}]^{(1/\gamma)}} \tag{2}$$

for probability $q \in [0, 1]$. Estimates of equation (2) by various authors suggest an average value of $\gamma = 0.64$.[15]

By applying the weighting function w to the tax evasion gamble, it turns the taxpayer's decision to report income D as:

$$EURDP = (1 - w(p))U(Y_{NC}) + w(p)U(Y_c) \tag{3}$$

The model implies that taxpayers overweight the small audit probabilities and, as a consequence, comply more than predicted by EU. Various empirical and experimental studies have found support for this prediction (references in e.g. Hashimzade et al., 2013). Indeed, Sandmo (2012) himself remarked that "what matters for the taxpayer's decision is not the objective frequency of audit, but his subjective perception" (p. 10).

It is, however, important to note that the EURDP model does not modify the EU prediction with respect to the impact of a change in the tax rate which, at least in the specification of equation (3), does not affect the weight placed on the audit probability. It will therefore be more interesting to compare simulations of EURDP with EU for the level of predicted compliance than for the impact of the change in the tax rates.

[15] A large literature has discussed various alternative parametrisations for the weighting function. Equation (2) is a one-parameter form of a slightly more general model sometimes called linear-in-log-odds (Gonzalez and Wu, 1999). The value of $\gamma = 0.64$ is an average estimate resulting from various studies reviewed by Booij et al. (2010).

3.3 Tax evasion under reference dependent (RD) preference

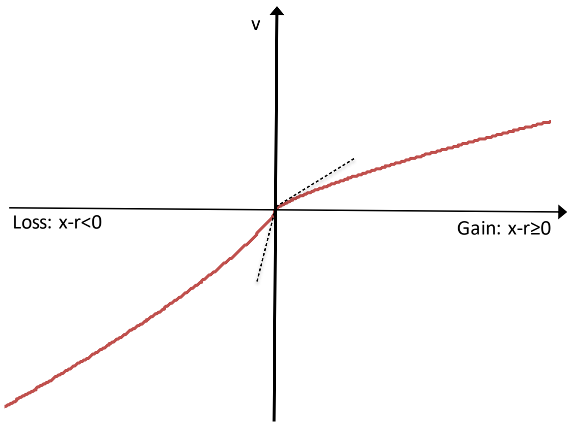
A more radical departure from EU is taken in models of so-called reference dependent preference (RD), where individual behaviors diverge from neoclassical predictions based on how the outcomes of decisions are framed and perceived.congdon2009behavioral.

The idea of reference dependent preference was introduced by Kahneman and Tversky (1979) in prospect theory and further developed in cumulative prospect theory (Tversky and Kahneman, 1992). A key feature of the theory is that people perceive outcomes as gains and losses compared to some reference point. They are risk-averse in the domain of gains and risk-loving in the domain of losses and take that losses loom larger than symmetric gains. This latter feature of the model, called loss aversion, implies that the utility function of a reference dependent model is kinked at the reference point. Figure 5 shows a typical reference dependent value function v with a reference point r:

$$v(x|r) = \begin{cases} (x-r)^{\alpha} & \text{for } x \geq r \\ -\lambda(r-x)^{\beta} & \text{for } x < r \end{cases} \tag{4}$$

where α and $\beta \in (0,1]$ and λ is the parameter capturing loss aversion greater than 1. Tversky and Kahneman (1992) estimated a value of $\lambda = 2.25$ under the restriction $\alpha = \beta$. A large subsequent literature finds values of similar magnitude with the qualification that most studies estimating the utility curvature for gains and losses separately also found that losses are evaluated more linearly than gains (e.g. Booij et al., 2010).

Figure 5 – A reference dependent value function



A further characteristic of RD applied to risky decisions as in cumulative prospect theory is that people use a weighting function w very similar to the one shown in Figure 4 above to transform the outcome probabilities of a lottery.[16]

Experiments and empirical investigations have confirmed choices consistent with reference dependent preference in several domains of economic and non economic decisions (DellaVigna, 2009; Barberis, 2013; O'Donoghue and Sprenger, 2018).

Recent contributions have also considered the theory of reference dependence in the analysis of tax evasion (Hashimzade et al., 2013). A model of RD preference applied to tax evasion

[16]For cumulative prospect theory, some authors argue for treating the weighting function in the domains of gains and of losses separately (Wakker, 2010). Separate estimates do not modify substantially the implications of the theory applied to specific contexts.

can be written as follows:

$$RD = (1 - w(p))v(Y_{NC} - r) + w(p)v(Y_c - r) \tag{5}$$

where both income Y_{NC} if not caught and income Y_C if caught enter the value function v as differences from a reference income r.

The approach requires specifying the reference income r relevant in the evasion/compliance decision. Authors have proposed various candidates as possible reference point. Yaniv (1999) yaniv1999tax, and more recently Rees-Jones (2018) and Engström et al. (2015) take the taxpayer's reference to correspond to the taxpayer's income net of any advance tax payment. They show that this can explain the so-called "withholding phenomenon" (Schepanski and Shearer, 1995), or the tendency of taxpayers who are under-withheld at filing to evade more than those who are over-withheld do. Dhami and Al-Nowaihi (2007) suggest that the reference point corresponds to the disposable income under full compliance, that is $Y - T(Y)$. This implies that the taxpayer perceives any tax due as a loss. Bernasconi et al. (2014) develop the model, showing that the actual amount of tax due perceived as a loss can also depend on a process of hedonic adaptation of the reference point. Rablen (2010) analyses the perception of the tax paid, as either gain or loss, in relation to the nature of the public expenditure financed through taxation. Alm and Torgler (2011) argue that there can be other dimensions - institutional, ethical, emotional - in addition to the status quo influencing a taxpayer's reference income. Piolatto and Rablen (2017) provide a detailed analysis of how the choice of the reference points in the alternative models bear on Yitzhaki's puzzle.

Bernasconi and Zanardi (2004) take a more agnostic position and analyse model (5) for a generic reference r showing that Yitzhaki's puzzle depends on two cases: i.) whether the taxpayer perceives the tax legally due as a loss, meaning that $Y - T(Y) < r$, in which case Yitzhaki's puzzle is overturned and the taxpayer responds to an increase (cut) in the tax due by evading more (less); ii.) or the taxpayer does not perceive the tax legally due as a loss, occurring when $Y - T(Y) \geq r$, in which case Yitzhaki's puzzle is confirmed.

In the simulations below we take a similar agnostic position about the many possible determinants of a taxpayer's reference income. Nevertheless, we have it that the reference income is discernible in their evasion decision. We assume that when a taxpayer evades because she perceives the tax due as a loss (that is, $Y - T(Y) < r$), the reference income is typically revealed by the taxpayer's disposable income before audits. We believe this has several justifications. First, it agrees with the idea that the reference point corresponds to the level of disposable income which, presumably, the taxpayer has adapted to. Second, when the taxpayer is actually a tax cheater (so that $D < Y$ and $Y - T(D) > Y - T(Y)$), the reference corresponding to disposable income means that she under-complies just enough to bring her back to the reference point.[17] Third, considering the current Italian PIT system, the disposable income reference means that a natural candidate for the taxpayer's reference point corresponds to the taxpayer's disposable income estimated by BETAMOD (by definition before audit), namely $r = Y^{BETAMOD}$. Indeed, we note that the reference at $Y^{BETAMOD}$ is also congruent with the argument used by many supporters of the flat-rate tax in Italy, i.e. that most people evade taxes not for the possible gain from the reduced tax liability if undetected; but because taxes are too high and they must evade to limit the certain loss incurred when taxes are paid in full.

[17]This is, at least, in the case 'not caught', since in the case 'caught' it is $Y - T(Y) < r$ and the taxpayer is by definition in the loss domain (that is, with $Y_C - r < 0$).

4 Microsimulations with models of tax evasion

How well do the theoretical models of tax evasion predict tax evasion rates in the current progressive PIT system in Italy? And what effects do the models predict in the case of a flat-rate tax reform? To answer these questions we undertake *behavioral* microsimulation analyses (Bourguignon and Spadaro, 2006) of different tax systems, focusing on tax evasion. The microsimulations start from the distribution of true gross incomes obtained in Section 2 and compute for each taxpayer the compliance rate which maximises the utility under the three models EU, EURDP, and RD. The approach requires adopting specific computational algorithms for the theoretical models and for the enforcement system.

4.1 The algorithms for the simulations

The EU algorithm is based on the isoelastic utility $u(x) = \frac{x^{(1-e)}}{1-e}$ with the parameter of relative risk aversion set at $e = 1.8$, consistently with estimates from classic works in the theory of risk and uncertainty (references Karni and Schmeidler, 1990; Kaplow, 2005; Chetty, 2006). The algorithm for EURDP uses the same isoelastic utility function and the weighting function reported in equation (2), with the parameter $\gamma = 0.64$ as an average value found in the literature. Reference dependent preference (RD) is simulated using the same weighting function of EURDP and the value function in equation (4) with parameters $\lambda = 2.25$, $\alpha = 0.7$ and $\beta = 0.9$. All parameter values represent average estimates reported in the literature (Booij et al., 2010). The reference point is set at $r = Y^{BETAMOD}$, as indicated above.

To simulate the enforcement system, we follow a simple procedure. First, applying the same approach used to estimate the evasion rates in BETAMOD, we assume that pensions and employment income from regular jobs cannot be concealed and are therefore fully reported, whatever evasion rate maximizes the corresponding utility model. Second, since employment income from irregular work is hard to detect, we assume this to be the first income source that taxpayers underreport. As a measure of irregular employment income, we use the tax evasion rate on employment income estimated for each taxpayer in Section 2, which thus becomes the maximum evasion rate on employment income also permitted by the maximization algorithms. Last, we distribute any amount of tax evasion resulting from the maximization algorithms and surplus to the amount already assigned to employment income from irregular jobs to self-employment incomes and rents by reason of the ratio of the evasion rates estimated in Section 2 for the two income sources.

The values of the enforcement parameters adhere on the one side to the Italian system and on the other side account for the psychological arguments considered above. The penalty rate s in all simulations is equal to 2, which well represents the upper range of the level of sanctions in Italy.[18] For the audit probability (on incomes different from pensions and regular employment), we begin in the EU simulation with a value of $p = 3.5\%$, which corresponds to an upper-bound assessment from official audit data.[19] Since, however, "what matters for

[18] In Italy, where tax penalties are generally higher than in several other countries, statutory sanctions for non-fraudulent evasion range between 100% to 240% of unpaid taxes. Applied sanctions are, however, sensibly reduced, up to 1/3, for various reasons, e.g. when the taxpayer caught evading taxes pays the tax authority's notice directly (without appeal).

[19] While for obvious reasons the tax authorities do not provide precise data on the audit probabilities for the various categories of income recipients, they do release some aggregate information annually on the numbers of audits conducted (e.g. Ministry of Economy and Finance, 2016). For example, in the year of our study (2014), about 309,000 thousands ordinary tax audits from a total of 40,183,000 registered taxpayers were conducted,

the taxpayer's decision is not the objective frequency of audit, but his subjective perception" (Sandmo, 2012, p. 10), the EURDP simulation is conducted with a perceived audit rate equal to $\pi = 15\%$. This is obtained by applying the weighting function of equation (2) with the indicated parameter γ to the objective probability $p = 3.5\%$ of the basic EU model.[20] The same value of $\pi = 15\%$ is used in the simulation of the RD model, for which the overweighting of small probabilities is an inherent feature of the approach. Comparing RD and EURDP thus allows us to analyse the effects of reference dependence and the subjective weighting function separately.

4.2 Microsimulation of the progressive PIT

Here we present the results of the simulations of the current progressive system contrasting the predictions of the theoretical models with the actual estimates of tax evasion obtained by BETAMOD and discussed in Section 2. Figures 6.a and 6.b show the distributions of the tax evasion rates (TEV) and of the effective average tax rates (EATR), respectively, for the classes of true gross incomes simulated for the models; and Table 3, top section, reports various average results and synthetic indicies for the current progressive PIT.

4.2.1 Progressive PIT under EU

The EU simulations show a clear tendency of the EU model to over-predict tax evasion. The TEVs predicted by EU are higher than the BETAMOD estimates: on average, 16.8% versus 9.8% (cfr. Table 3, top section). The EU tax gap is more than twice that estimated by BETAMOD, corresponding in absolute terms to € 51.6 billion of revenue losses for evasion predicted by EU versus € 24 billion estimated by BETAMOD.

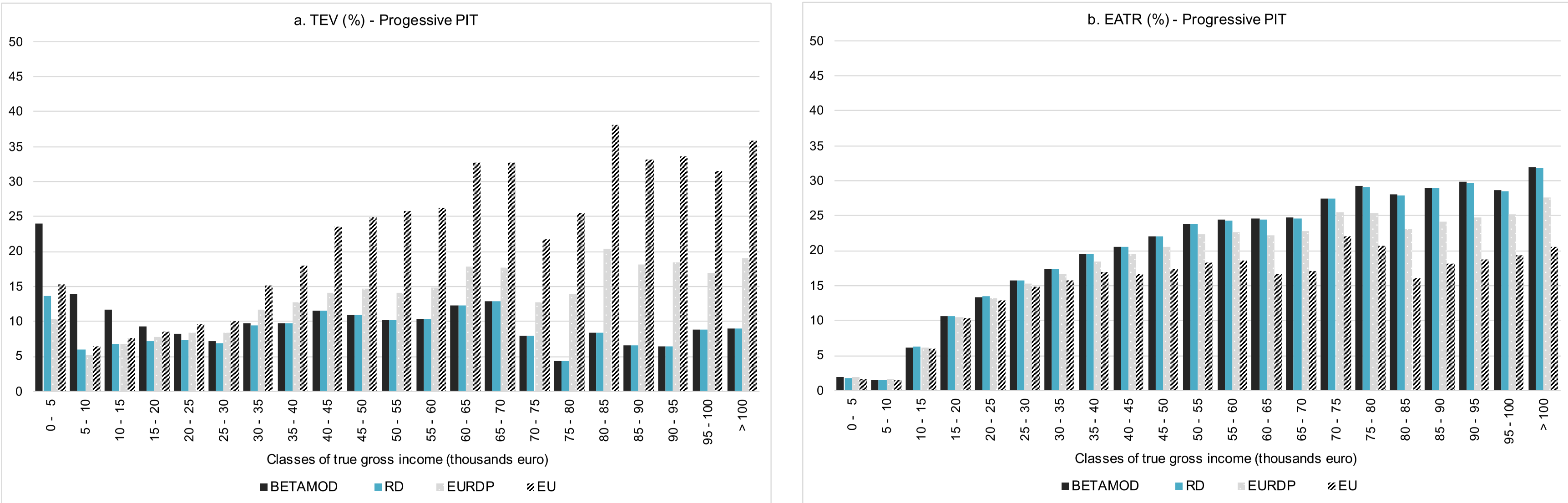
Figure 6.a also shows that the TEVs calculated by EU increase with incomes: for example, the average TEV for incomes between € 0-50,000 is 13.9%, raising to 30.6% for incomes greater than € 50,000. In consequence, the difference between the EATRs estimated by BETAMOD and predicted by EU also increases with incomes. Mainly, the difference amounts to more than 10 percentage points in the top income class (Figure 6.b). These increasing patterns are entirely due to the ampler opportunities to evade for taxpayers in higher income classes than available to those in lower and middle classes based on their different income sources (cfr. Section 2). Indeed, were equal opportunities to evade available to all taxpayers, TEVs should decrease with income according to the isoleastic EU model.[21] Nonetheless, the pattern of increasing TEVs is not supported by the comparison with the BETAMOD estimates, which, as previously indicated, fluctuate around an average value of 10%.

corresponding to an overall audit probability lower than 0.8%. Most of the controls, about 193,000, were on taxpayers reporting income from self-employment, including small and medium firms, professionals and so forth. These controls concerned not only PIT, but also VAT and other regional taxes. There were 6,050,000 taxpayers reporting income from self-employment in 2014. Thus, even considering this category and assuming all controls on PIT, the derived audit probability is equal to 3.2%, which is similar to many countries' (Alm, 2012).

[20] The resulting perceived audit rate is also consistent with, actually a bit higher than, the typical subjective assessment of the audit rate reported in taxpayer surveys, which is between 8-10% (Hashimzade et al., 2013).

[21] The prediction of decreasing tax evasion rates in particular follows from the fact that the isolelastic (or constant relative risk averse) specification implies that, at a constant tax rate, people with different levels of income invest a constant fraction of it in the risky asset; and that, at a progressive tax schedule, richer people increasingly invest a decreasing share of their income in the risky asset, attributable to Yitzhaki's puzzle.

Figure 6 – Comparisons between tax evasion rates (TEV) and effective average tax rates (EATR) estimated by BETAMOD and predicted by theoretical models



Another feature worth noting from Figure 6.a is that the TEVs predicted by EU (as well as by the other theoretical models) for the bottom income classes are lower than those estimated by BETAMOD. This is because the maximization algorithms of the theoretical models maintain that low-income taxpayers evade only when doing so generates a benefit in terms of the taxes unpaid. On the other hand, Section 2 showed that some low-income taxpayers underreport their incomes even when there is no gain to be had because they miss the opportunity to use tax expenditures which would clear their net tax liabilities with even less under-compliance. Such sub-optimal behavior also explains why, notwithstanding the comparison of TEVs, the EATRs predicted by EU are equal to or lower than those estimated by BETAMOD for *all* income classes, including the lowest (Figure 6.b).

4.2.2 Progressive PIT under EURDP

The EURDP simulation accounts for the overweighting of the audit probability in tax evasion decisions. Overall, the profile of the simulation is more like the EU model than BETAMOD, albeit the levels of evasion predicted by EURDP are lower than EU predicts.

The overall average TEV predicted by EURDP is only 1.4% higher than the BETAMOD estimate (11.2% versus 9.8%, cfr. Table 3). Yet the TEVs profiles are clearly different: similarly to EU, EURDP predicts TEVs to increase with incomes (see Figure 6.a) with the average TEV for incomes greater than 50 thousand euros, twice as much the BETAMOD average (16.7% versus 8.8%). As another consequence, the tax gap predicted by EURDP is larger than the gap estimated, 19.4% against 13.7% in relative terms. Overall, the EURDP simulations, including the EATRs in Figure 6.b, show that the model falls short of an accurate account of the tax evasion estimates obtained by BETAMOD.

4.2.3 Progressive PIT under RD

The simulations of the RD model are much closer to the BETAMOD estimates. Indeed, at the aggregate level the tax paid and the tax gap simulated by RD are almost identical to those obtained by BETAMOD: namely, taxes paid are equal to 150.9 billion euros in BETAMOD, and to 150.8 according to RD (cfr. Table 3). Total reported income is, instead, greater under RD than in BETAMOD: 821.0 billion euros according to RD versus 809.0 estimated by BETAMOD. Again, this difference is due to the 'sub-optimal' TEVs at low incomes demonstred by BETAMOD (Figure 6.a). On the other hand, starting from a gross income of about 20,000 euros, the RD predictions and the BETAMOD estimates become very close indeed.

The proximity of the RD simulation and BETAMOD also provides a test of consistency, external and internal, for the reference point at $r = Y^{BETAMOD}$. At the external level, the test trivially lies in the ability of the RD model with the reference at $r = Y^{BETAMOD}$ to fit quite well the BETAMOD estimates. In this respect, it is interesting that the model supports the intuition that many taxpayers in the current progressive system are at $Y - T(Y) < r$ and, therefore, evade just enough to obtain their reference income. At the internal level, the hypothesis that when $Y - T(Y) < r$ the taxpayers evade just enough to obtain their reference income requires that disposable income Y_{NC} resulting from the maximization of equation (5) must in fact be equal to $r = Y^{BETAMOD}$.

The good fit between RD and BETAMOD is also confirmed by the effective average tax rates (Figure 6.b) as well as by various inequality and redistributive measures reported in

Table 3. Finally, the comparison between RD and EURDP indicates that while the overweighting of small probabilities in the EURDP model is not in itself sufficient to align the theoretical predictions with observed behavior, embedding probability overweighting in a model of reference dependence seems an essential ingredient for a full account of evasion behavior.

4.3 Microsimulations of flat-rate tax reforms

We now move to an analysis of the effect of possible flat-rate tax reforms in the Italian PIT system. We conduct microsimulations of three different flat rates: a flat rate which guarantees the government budget balance of the current system; a flat rate $\tau = 20\%$; and a flat rate $\tau = 15\%$. The reform at budget balance is a natural benchmark to begin the analysis; the other two flat rates reflect figures sometimes mooted in Italian political debates in the spirit of also reducing tax evasion. To identify the impact of a flat-rate tax, the simulations maintain the current system of tax expenditures.

We conduct simulations of the three models of taxpayers' behavior illustrated above, namely EU, EURDP and RD.[22] We also consider some other hypotheses. In fact, the first group of simulations assume that taxpayers' evasion rates remain unchanged. This hypothesis is referred to in Table 3 as *constant TEV*.

4.3.1 Flat-rate tax with constant TEV

The hypothesis of *constant TEV* is that all taxpayers report the same fractions of gross incomes estimated by BETAMOD. It is a modelling strategy congruent with the so-called arithmetical approach to microsimulation models (Bourguignon and Spadaro, 2006). This approach applies the policy change to households' budget constraints by arithmetically deriving household disposable income given the rules for determining taxes and benefits and, in BETAMOD, the computation of the tax evasion rates; it ignores, however, any behavioral response arising from the maximiziation of an objective function. The results of the microsimulation at *constant TEV* can thus be considered first-round approximations of the winners and the losers in flat-rate reforms, against which the predictions based on the maximiziation of the objective functions of the different behavioral models can be compared.

The microsimulations at constant TEV show that the flat rate which guarantees the budget balance of the progressive PIT (indicated as 'bb flat-rate' in Table 3) is equal to 27.35%. At that rate, the overall tax due (174.1 billion) and the tax gap (23.2 billion) closely match those of the progressive system (cfr. Table 3). On the other hand, the flat-rate tax weakens substantially the impact of tax progressivity: the Kakwani index reduces from 0.229 to 0.146 and the degree of inequality, measured by the concentration index, increases from 0.370 to 0.387. The negative impact of the flat-rate tax on redistribution is also documented by the effective average tax rates (EATR) shown in Figure 7 (Fig. 7.a and 7.b). The EATRs show that the taxpayers with incomes higher than about 40 thousand euros gain from the change to the flat-rate tax, while taxpayers with incomes lower than 35 thousand euros lose. Moreover, as expected from a flat-rate tax, the benefits from the reduction of the EATRs

[22]Since the EU and the EURDP models fail short of a satisfactory account of the data in the current progressive system, it may seem pointless to simulate the effects of a flat-rate tax as predicted by the models. The simulations are nevertheless of interest to better understand some of the forces operating in the case of a flat-rate tax and for comparison with the RD model.

Table 3 – Simulations of current progressive PIT and of flat-rate tax reforms

Model	Tax system	Enforcement (p, s)	Gross income (billions)	Reported income (billions)	TEV (%)	Tax due (billions)	Tax paid (billions)	Tax gap (billions)	Tax gap as % of due	Effective average tax rate	Concent. index	Reynold Smolensky index	Kakwani index
BETAMOD	progressive		897.0	809.4	9.8%	174.9	150.9	24.0	13.7%	16.8%	0.3702	0.0472	0.2291
EU	progressive	0.035, 2	897.0	746.5	16.8%	174.9	123.3	51.6	29.5%	13.7%	0.3863	0.0297	0.1857
EURDP	progressive	0.15, 2	897.0	796.5	11.2%	174.9	141.0	35.4	19.4%	15.7%	0.3789	0.0408	0.2184
RD	progressive	0.15, 2	897.0	821.0	8.5%	174.9	150.8	24.1	13.8%	16.8%	0.3720	0.0475	0.2346
Constant TEV	flat-rate (bb): 27.35%		897.0	809.4	9.8%	174.1	150.9	23.2	13.3%	16.8%	0.3874	0.0300	0.1457
Constant TEV	flat-rate: 20%		897.0	809.4	9.8%	113.6	97.2	16.4	14.5%	11.0%	0.3931	0.0242	0.1960
Constant TEV	flat-rate: 15%		897.0	809.4	9.8%	74.4	62.6	11.8	15.8%	7.2%	0.3982	0.0191	0.2504
EU	flat-rate: 27.35%	0.035, 2	897.0	722.5	19.5%	174.1	122.9	51.2	29.4%	13.7%	0.4051	0.0143	0.0896
EU	flat-rate: 20%	0.035, 2	897.0	732.6	18.3%	113.6	77.4	36.2	31.8%	8.7%	0.4025	0.0132	0.1387
EU	flat-rate: 15%	0.035, 2	897.0	744.5	17.0%	74.4	48.6	25.8	34.7%	5.4%	0.4045	0.0112	0.1947
EURDP	flat-rate: 27.35%	0.15, 2	897.0	771.9	14.0%	174.1	137.4	36.7	21.1%	15.3%	0.3985	0.0211	0.1164
EURDP	flat-rate: 20%	0.15, 2	897.0	746.6	16.8%	113.6	80.5	33.1	29.2%	9.0%	0.4050	0.0146	0.1481
EURDP	flat-rate: 15%	0.15, 2	897.0	744.5	17.0%	74.4	48.6	25.8	34.7%	5.4%	0.4082	0.0112	0.1947
RD	flat-rate: 27.35%	0.15, 2	897.0	815.4	9.1%	174.1	149.9	24.2	13.9%	16.7%	0.3878	0.0317	0.1576
RD	flat-rate: 20%	0.15, 2	897.0	825.1	8.0%	113.6	98.1	15.5	13.7%	10.9%	0.3959	0.0235	0.1915
RD	flat-rate: 15%	0.15, 2	897.0	814.3	9.2%	74.4	60.8	13.6	18.2%	6.8%	0.4033	0.0161	0.2213
TEV constant	flat-rate: 20% (bb & ss)		897.0×(1.321)=1181.8	1066.0	9.8%	172.3	150.9	21.5	12.5%	12.8%	0.3969	0.0201	0.1358
EU	flat-rate: 20% (bb & ss)	0.035, 2	897.0×(1.495)=1336.5	1060.8	20.6%	210.3	150.9	59.4	28.3%	11.3%	0.4116	0.0072	0.0570
EURDP	flat-rate: 20% (bb & ss)	0.15, 2	897.0×(1.453)=1299.0	1062.3	18.2%	202.2	150.9	51.1	25.3%	11.6%	0.4126	0.0099	0.0751
RD	flat-rate: 20% (bb & ss)	0.15, 2	897.0×(1.321)=1182.0	1065.8	9.9%	176.1	150.9	25.3	14.3%	12.8%	0.4016	0.0205	0.1398

increase with incomes. The effect is here confirmed even considering evasion, given that the TEVs estimated by BETAMOD are relatively constant with incomes.

At the flat rates of 20% and 15%, all taxpayers gain with respect to current progressive PIT (see the EATRs in Figure 7). The benefits still increase with income, contributing to relieving the tax system of its redistributive function. This worsens a sharp fall in tax revenues (with only 97 and 63 billions of tax collected under the respective flat rates at 20% and 15%; cfr. Table 3), implying a steep reduction in government spending. The tax gaps as percentages of taxes due increase with respect to the progressive system: the gaps at the flat rates of 20% and 15% are 14.5% and 15.8%, respectively, versus 13.7% in BETAMOD; while the EATRs almost halve with respect to the statutory: the effective average tax rates are 11.0% and 7.2% versus the statutory flat rates at 20% and 15%, respectively.

Nevertheless, classical arguments in support of a flat-rate tax argue that it can generate positive supply-side effects counterbalancing the tax revenue loss due to reduction of the statutory progressive tax rates. To assess the relevance of this type of argument we conducted further microsimulations estimating the increase in taxpayers' incomes needed to guarantee the government budget balance. The simulation is with the 20% flat rate. In this exercise, we assume a uniform growth rate across all types of income, i.e. for regular employment, self-employment, rental incomes etc. Clearly, if considered literally, this is a gross oversimplification. Taken in the aggregate, it gives a first-round approximation of the GDP growth rate required for the flat-rate tax to be implemented without fiscal losses. With a flat rate of 20% and at constant TEVs, the GDP growth rate needed for budget balance is around 32%. This very large effect seems implausible even compared with the best economic performances of the transition economies which introduced flat-rate tax systems in Eastern and Central European countries.[23]

4.3.2 Flat-rate tax with EU

Taxpayers with EU preference react to the flat-rate tax reforms by evading more (cfr. Table 3 and Figures 8.a-8.c). With a flat rate of 27.35%, the average TEV under EU is 19.5% (cfr. Table 3), which is 2.5 points higher than the TEV under EU for the progressive system (16.8%). At the lower flat rates of 20% and 15%, the average TEVs reduce to 18.3% and 17.0%, respectively. It may seem surprising, and contrary to Yitzhaki's puzzle, that the TEVs reduce when the flat rate decreases. Recall, however, that Yitzhaki's puzzle applies to interior solutions. On the other hand, the effect is here due to the fact that in the EU model evasion rates were such that many taxpayers paid no tax at the flat-rate of 27.35%, so that further reducing the flat rate (to, e.g. 20% or 15%) also reduces their need to evade.

The EU simulations also showed that greater TEVs involve taxpayers with incomes greater than about 50 thousand euros (cfr. Figure 8.c); and that the changes in TEVs increase with incomes. These latter characteristics, which to different extents also apply to the other behavioral microsimulation models (see below), indicate that taxpayers with high incomes receive a double benefit from the flat-rate tax: a benefit from the reduced statutory rate and a benefit from increased tax evasion. These gains for high income-earners turn into losses for

[23] Adhikari and Alm (2016) used a "synthetic control" methods to examine the economic performance of eight Eastern and Central European countries that adopted flat-rate tax systems between 1994 and 2005 and compared their post-reform GDP per capita to a weighted average of similar but 'non-reform' countries. They find a positive impact from flat-rate taxes with an average GDP per capita of about 18% higher in the reform countries than in the 'non-reform' group.

people at low income levels, with all indices of inequality worsening significantly under the flat-rate reforms as compared to the progressive system (Table 3).

Finally, by including a supply-side effect in the EU simulations, it is observed that at a flat-rate tax of 20%, an average GDP growth rate of about 50% would be necessary to maintain the current government budget balance.

4.3.3 Flat-rate tax with EURDP

The simulations of the flat-rate tax reforms with EURDP preference have characteristics similar to those of EU. Two features are worth noting. First, under EURDP, both the average TEVs in Table 3 and those for income classes in Figure 9.a are decreasing in the flat rate: mainly, TEVs are higher at the flat rate of 15% than at 20%; and at 20% than at 27.35%. This feature is a direct implication of Yitzhaki's puzzle, which in the EURDP case thus indicates that at the 27.35% flat rate, or even 20%, fewer people than under the EU model evade sufficiently to pay zero tax. At the same time (and this is the second feature of interest), the simulations show that at the 15% flat-rate, the EURDP and the EU models are virtually identical. This interesting result shows that (owing to Yitzhaki's puzzle) the effect of overweighting of small probabilities in people's tax evasion decreases with the tax rate; such that at a low flat rate any difference between EU and EURDP tends to disappear.

4.3.4 Flat-rate tax with RD preference

The overall average TEVs in the RD simulations range from 8.0% to 9.2% in the three flat-rate reforms, but they do not change monotonically with the level of the flat rate (cfr. Table 3): the lowest TEV is at the 20% flat rate, while the highest TEV occurs when the flat rate is 15%. When the flat rate is 27.25%, the average TEV is 9.1%. The tax gap as a percentage of the tax due is equal to 13.7% when the flat rate is 20%; it is 13.9% when the flat rate is 27.25%; and it is equal to 18.2% when the flat rate is 15%.

The reason for the evasion rates changing non-monotonically with the flat rates depends on the characteristics of the RD preference. Indeed, recall the model implies that only taxpayers who perceive the tax due as a loss behave contrarily to Yitzhaki's puzzle; while the taxpayers who are in the gain domain behave as predicted by Yitzhaki (1974).

The TEVs in Figure 10.a and 10.b show the implications of the model at the three flat rates. When the flat rate is at 27.25%, taxpayers with incomes lower than about 45,000 euros do not benefit at all moving from the progressive to the flat-rate system. Indeed, they experience a tax increase, hence a perceived loss.[24] Accordingly, they react by evading more. On the other hand, taxpayers with incomes greater than about 50,000 euros experience a reduction in their tax burden; nevertheless, they remain in the loss domain of the value function and evade less under the flat-rate tax than under the progressive system.

When the flat rate is 20%, all taxpayers experience a reduction of taxes legally due. In fact, for some taxpayers the reduction is large enough to bring them into the gain domain of the value function, namely, with a net income under full compliance greater than their reference. From Figure 10.b, we see that these taxpayers are those with an income approximately greater than 75,000 euros, who, being in the gain domain, in fact evade even more under the flat-rate tax than under the progressive system. At the aggregate level, there is nevertheless a

[24] Recall that in the RD simulations the reference point corresponds to the net income obtained under the progressive system, namely $r = Y^{BETAMOD}$.

prevalence of taxpayers who remain in the loss domain even after the flat-rate tax reform, but closer to the reference. This therefore determines a reduction in the overall TEV with respect to the progressive system.

When the flat-rate tax reduces further from 20% to 15%, even more taxpayers move into the gain domain (those with an income greater than 60,000 euros). This effect causes Yitzhaki's puzzle to prevail at the aggregate level, which determines that both the overall average TEV and the tax gap increase following the tax-rate reduction (with respect to both the progressive system and the 20% flat rate).

Thus, the interesting implication of the RD simulations is that as the flat rate reduces from the budget balance level to the lower tax rates of 20% and 15%, an increasing number of taxpayers move from the loss to the gain domain. Taxpayers reduce tax evasion as long as they remain in the loss domain; they increase tax evasion when they start moving into the gain domain. The clear implication is that there is also a flat rate which minimizes the overall tax evasion rate. Additional simulations, not reported for brevity, show that the latter is in fact very close to 20%.[25] The flat rate minimizing the tax gap as a percentage of tax due is a bit higher (namely, 22%, with a tax gap of 13.3%). This occurs when the overall average TEV is still falling because the taxpayers who move more quickly into the gain domain as the flat-rate reduces are those of higher income classes.

Of course, the above also means that under RD preference too, tax evasion contributes to making the flat-rate tax all the more harmful to equality the lower the flat rate. The computations in Table 3 show that the concentration index of the RD simulation at the 15% flat rate (0.4033) is not very different from the concentration indexes of the EU and EURDP models (0.4045 and 0.4082, respectively), regardless that the tax gap of the RD simulation continues to be closer to the simulation at constant TEVs than to the much higher values of the EU and EURDP simulations (cfr. Table 3).

One may perhaps also wonder how the results are sensitive to the determination of the reference point and whether or not the results depend on the reference point being equal to $r = Y^{BETAMOD}$. In this respect, recall that the reference point equal to the disposable income in BETAMOD represents the most favourable case for the RD model predicting a reduction in tax evasion following a tax cut. In particular, when $r < Y^{BETAMOD}$, it means that the taxpayer under the progressive system is already in the gain domain. As discussed above, he or she will therefore respond as predicted by Yitzhaki to any reduction in the tax rate and will evade more than in the simulations reported here.[26]

A more subtle issue concerns the changing of the reference point that can be induced, directly or indirectly, by the flat-rate tax reform. Reference dependence is a multifaceted model of individual preference, particularly in determining the reference point. Supply-side effects generated by the reform can affect the reference point. In simulating the flat rate at 20% with supply-side effects required for government budget balance, we assumed that the reference incomes increase at the same rate as GDP. We found the necessary rate of growth to be 32% (cfr. Table 3). Assuming the same rate of change for both the reference point and GDP seems a cogent hypothesis in the absence of specific models of supply-side effects and for the

[25] The flat-rate which actually minimizes the TEV is at 20.5 and the corresponding TEV is equal to 7.9%.

[26] Indeed, we have conducted various other simulations of flat-rate tax reforms showing tax evasion to be higher when the reference point belongs to the interval $r \in (0, Y^{BETAMOD})$ than it is under the simulations presented here with $r = Y^{BETAMOD}$. Also recall that the case $r > Y^{BETAMOD}$ is, instead, inconsistent with the model. This is because it would imply $Y_{NC} - r < 0$ when $Y_{NC} = Y^{BETAMOD}$ and, therefore, the impossibility of the RD model predicting the observed choice of tax evasion in the current progressive system.

determination of reference points. Developing such models could represent important steps for future research on the effects of fiscal reforms in tax-benefit microsimulation analyses. Among other things, a model for the determination of the reference point could also be important to simulate the effect of a flat-rate tax reform on the level and the quality of public expenditure which, as several authors have argued, represent the other side of the coin of taxpayers' perceiving taxes paid as either losses or gains.

5 Conclusions

Tax evasion is a problem plaguing many countries. It is important to assess the implications of tax policy and fiscal reforms for tax evasion. Tax-benefit microsimulation models are important tools in qualitative and quantitative analysis of tax policies (Bourguignon and Spadaro, 2006). They can also help to address some misconceptions that affect the public on the effects of tax policy, including regressive tax policy (Slemrod, 2006).

To date, surprisingly few attempts have been made to integrate analyses of tax evasion into microsimulation models. In this paper, we integrated three theories of tax evasion behavior into a microsimulation model of personal income tax in Italy. We assessed the ability of each theory to predict tax evasion in the current tax progressive system and analysed the effect of flat-rate tax reforms on tax evasion.

Our simulations of the current tax progressive system showed that the classical expected utility theory, even when extended to include the effect of third-party income reporting, fails to provide an accurate account of the effects on tax evasion in Italy. The same applies to the expected utility model with the overweighting of small probabilities. Conversely, a model with probabilities overweighting and reference dependent preference can more effectively account for the effects of tax evasion predicting quite accurately the tax evasion rates, the tax revenue losses, the effective average tax rates, and the redistribute effects. Moreover, a model of reference dependent preference predicts that taxpayers who evade taxes because they perceive them to be too high, react by evading less when the tax rate is reduced. In this sense, the model resolves the so called Yitzhaki's puzzle of the expected utility, representing a natural behavioral theory for use in simulations of flat-rate tax reform to verify whether the policy can actually reduce tax evasion or not.

Results of the simulations give little support to the assertion that a flattened tax-rate can reduce tax evasion. The problem is that a unique tax rate, equal for all taxpayers, always leaves gainers and losers. They react very differently to the reform. Even assuming reference dependent preference and a flat-rate which maximises tax compliance, the overall effect on tax evasion is small. On the other hand, the capacity of the tax system to redistribute income reduces and the inequality gap widens.

The overall conclusion seems robust notwithstanding some simplifying assumptions which, common to any analysis, our approach adopts. Our simulations assume the revelation of the reference income in taxpayers' disposable income, congruently with the notions of adaptation and status quo. Future research may consider other factors influencing the reference point, including taxpayers' perceptions of the fairness of the fiscal exchange. Likewise, the simulations did not model for the supply-side effects of a flat-rate tax reform on the Italian economy. Empirical analyses have in general reported little interaction between labour and related supply decisions and tax evasion behavior. Nevertheless, an integrated model may be useful to gain deeper insight into the impacts of a flat-rate tax especially on expected tax

Figure 7 – Comparisons with constant TEV - Progressive PIT and flat rate reforms

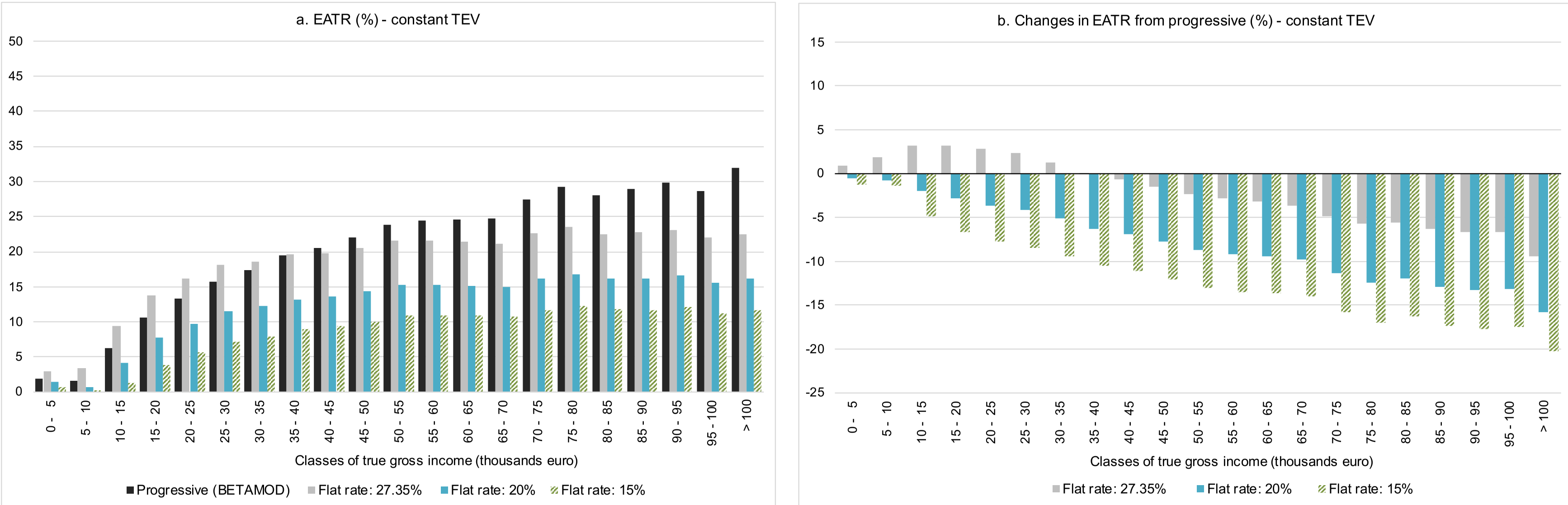


Figure 8 – Comparisons under EU - Progressive PIT and flat rate reforms

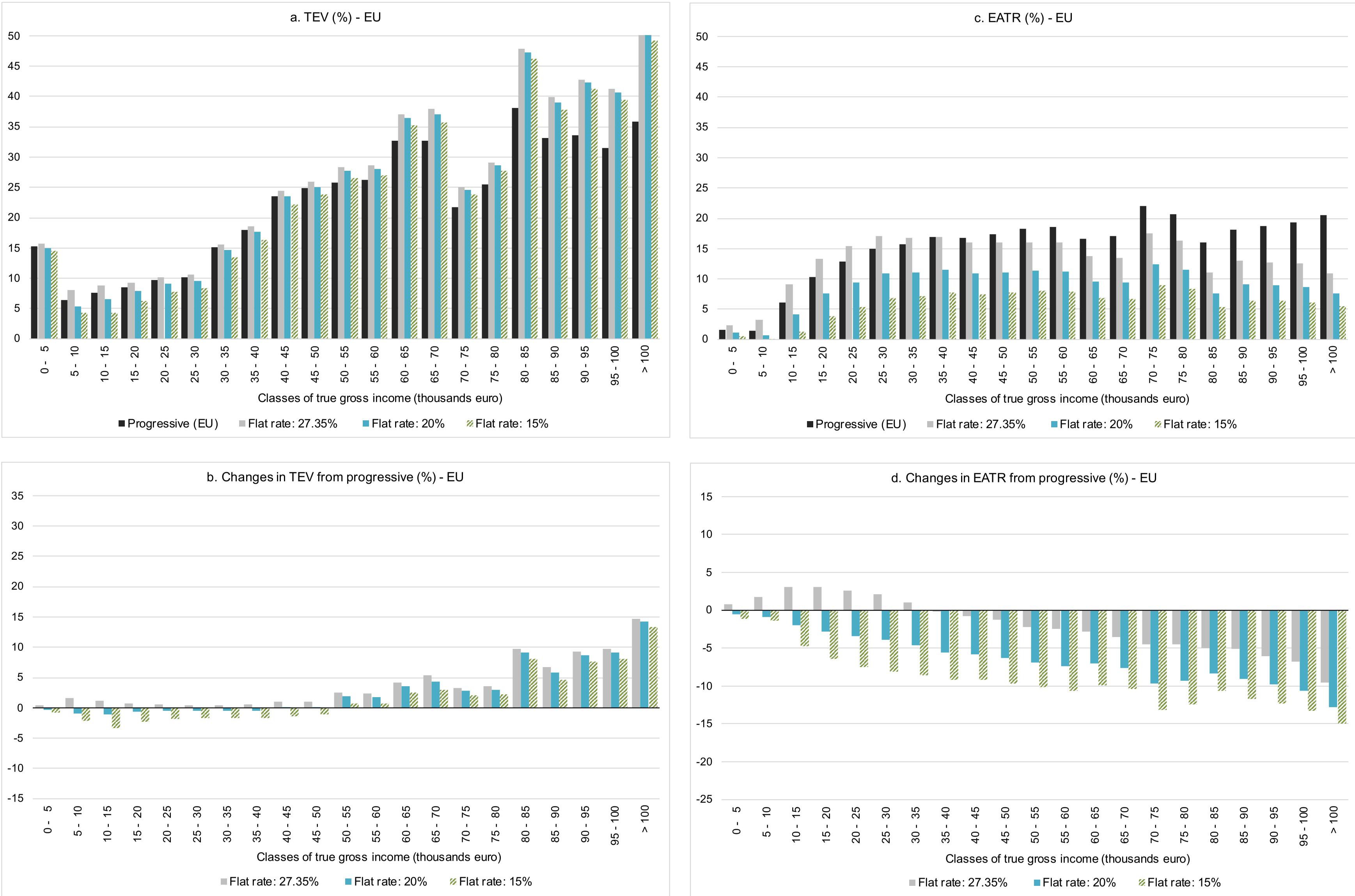


Figure 9 – Comparisons under EURDP - Progressive PIT and flat rate reforms

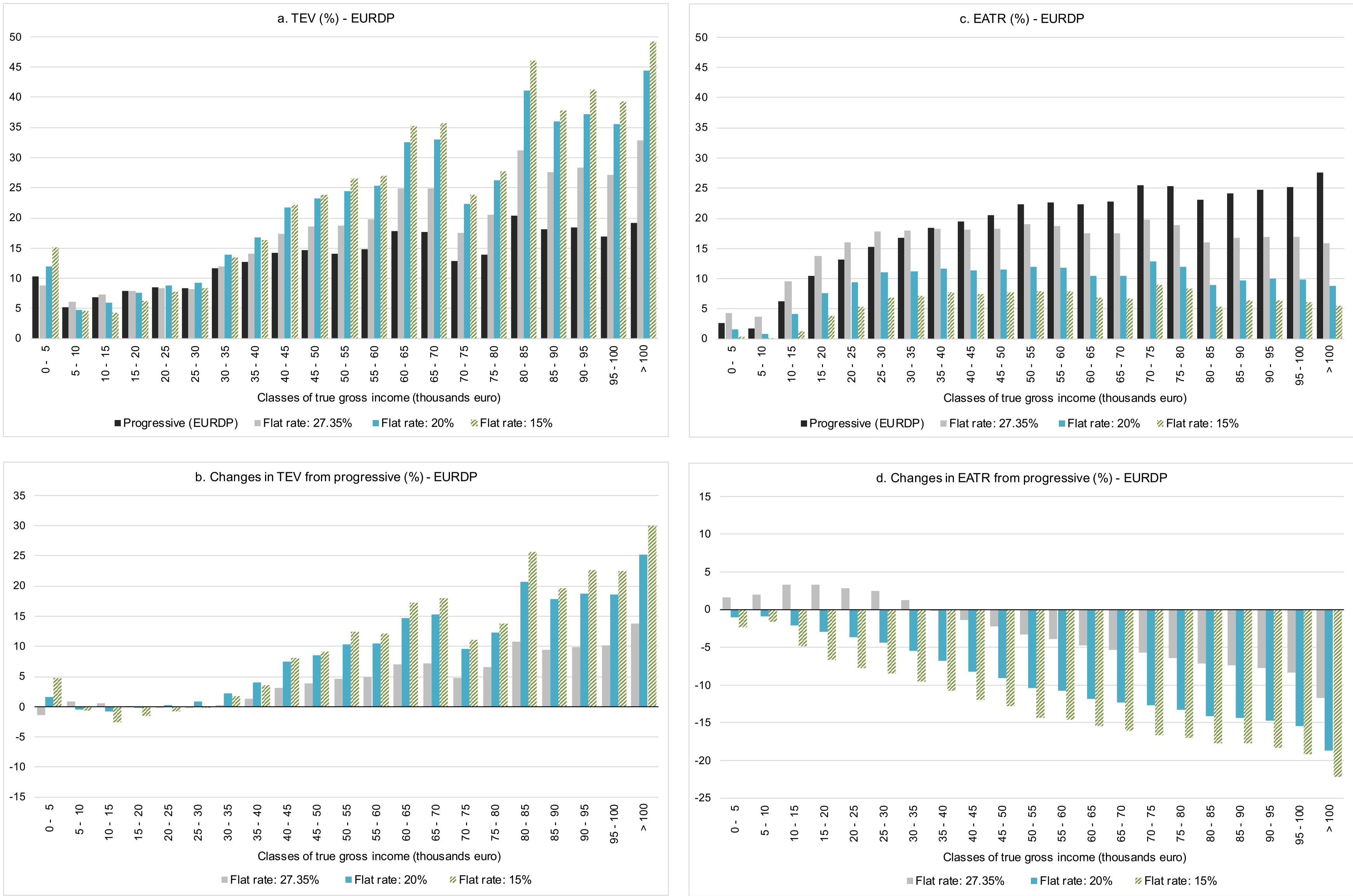
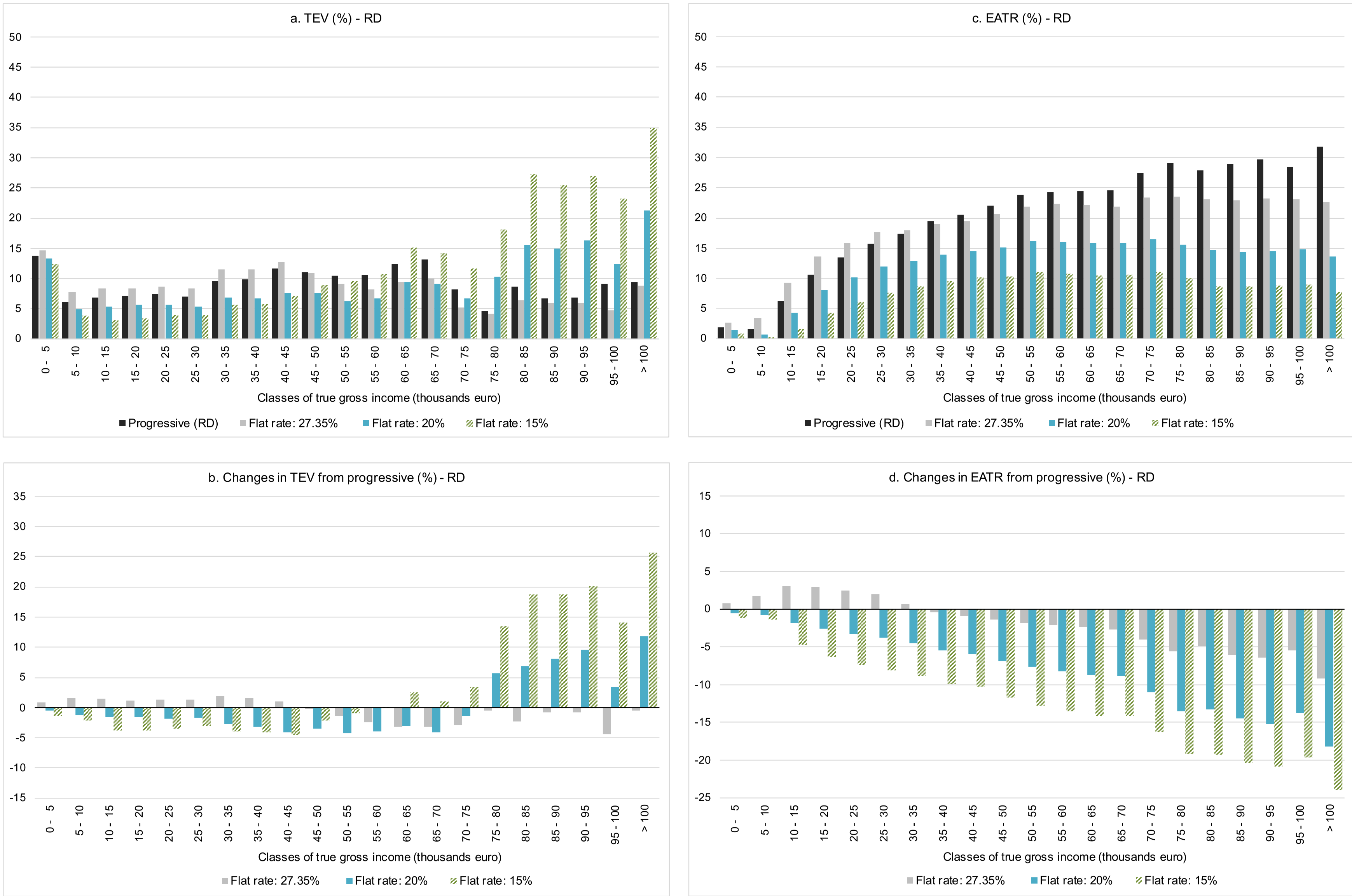


Figure 10 – Comparisons under RD preference - Progressive PIT and flat rate reforms



revenue losses and to clarify the overall economic growth rate necessary to maintain current public spending capacity. Maintaining and qualifying government capacity to provide public services can be an important strategy to revise taxpayers' perception of the tax legally due as a loss.

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