UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Dipartimento di Economia Marco Biagi

DEMB Working Paper Series

N. 140

Measurement errors and tax evasion in annual incomes: evidence from survey data matched with fiscal data

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February 2019

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ISSN: 2281-440X online

Abstract

Individual records, referred to personal interviews of a survey on income carried out in Modena during 2012 and tax year 2011, had been matched with their corresponding records in the Ministry of Finance databases containing the fiscal incomes of tax year 2011. The analysis of the resulting data set suggested that the fiscal income was generally more reliable than surveyed income, but in the literature the exact opposite is often assumed. Moreover, the obtained data set enables identification of the factors determining over- and under-reporting, as well as measurement error, through a comparison of the surveyed income with the fiscal income, only for suitable categories of interviewees: the taxpayers who are obliged to respect the law (the constrained sector), and taxpayers who have many possibilities to evade (the unconstrained sector). The percentage of under-reporters (67.3%) was higher than those of over-reporters (32.7%). Level of income, age, and education were the main regressors affecting the measurement errors and the behaviours of taxpayers. Estimations of tax evasion and the impacts of personal factors affecting it were carried out following different approaches. The average of individual propensity to tax evasion was 25.93% of the corresponding fiscal income. The potential total tax evaders were about 10%.

Keywords

Fiscal income, surveyed income, response bias, under-reporting, over-reporting, administrative data

JEL codes

C46, D31, H26

Acknowledgements

The authors are grateful to MA Giovanni Bigi, official of statistical department of Commune of Modena, who contributed to build up the final data set using administrative archives.

1. Introduction

Measurement errors concern the difference between the measured value of a variable on a statistical unit (often an individual), here the Surveyed Income (SI), and its corresponding true value, which is generally taken from a reliable administrative source. In fact, the investigation of inaccuracies in income surveys on employees are obtained as differences between the data declared by individuals in the interviews and the corresponding data contained in the archives of employers, considered as reliable and true values, from the early inquiries of this type (Bancroft 1940) to more recent ones (Bingley and Martinello 2017; Hariri and Lassen 2017). This approach has often limited the investigation over space and time, depending on the administrative organization, the data accessibility, and the financial resources.

Tax evasion concerns the difference between the true income of a statistical unit (a taxpayer) and its corresponding value declared to tax authorities, here termed Fiscal Income (FI). In other words, it refers to individual behaviour carried out in different ways to infringe the current tax rules in order to obtain an illegal profit or only formally legal revenue as in elusion and erosion. Hereafter, the term evasion comprehends elusion and erosion too. The consequences of non-compliance with legal requirements are numerous: an alteration of the tax distribution burden among the taxpayers, the disequilibrium among employers on the labour market when it involves undeclared work, a distortion in the allocation of economic resources among individuals, a reduction of funds available for education or welfare or health services, an increase in the cost of ascertaining taxable income. The latter suggests that tax evasion may be reduced, but not eliminated because its ascertainment is limited by financial resources and it is almost impossible to suppress elusion and/or erosion. Hyperbolically, it has been stated that it is economically unprofitable too (Paulus 2015; Shaw et al. 2010). For example, in some cases fiscal evasion becomes a subjective softening of redistributive impact in terms of vertical equity, the shadow economic activities may offer opportunities of employment for persons in the most vulnerable conditions. However, these arguments are questionable and morally not admissible.

The evaluation of measurement error of an individual income may be obtained through the difference between the SI and the corresponding FI recorded in the database of the Ministry of Finance. While generally the administrative data are assumed to be reliable and error-free, it is likely that no database is error-free for many reasons, such as careless slips, omissions, redundancies, and other imprecisions. Moreover, the amount of FI may be affected by some voluntary or involuntary mistakes and imprecisions. Therefore, some authors assume SI as true income in order to obtain a measure of fiscal under-reporting or evasion (Fiorio and D'Amuri 2005; Matsaganis and Flevotomou 2010). Other authors uphold that FI data are obtained through an accurate examination of documents involving a precise amount for each individual (Baldini et al. 2009; Jäntti 2004; Paulus 2015), while SI may contain many sources of biases and imprecisions (Lalla et al. 2012; Moore et al. 2000). Therefore, there are two unreliable manifest variables and the true income variable turns out to be a latent variable. In the following FI was assumed as income reference term.

The evaluation of tax evasion of an individual income may be obtained through the difference between SI and FI again. Therefore, the same expression measures both error and evasion, so the two measurements are indistinguishable. In fact, there are various methods to evaluate tax evasion, depending on the available information: the tax audit data, income surveys, consumption data, and discrepancies in economic statistics (Leventi et al. 2013). The first three methods involve surveyed data reporting the amount of income, which is not easy to obtain without sampling and measuring errors (Lalla et al. 2012). The method applied in the following is a peculiar case of income surveys because the data used in the analyses are obtained through the matching of individual surveyed information with the corresponding tax record in the fiscal database of the Ministry of Finance, which constitutes a rare occasion in the literature.

To pursue the estimation of the income measurement error and tax evasion, a sample of individuals was interviewed and, using individual fiscal codes, the surveyed data were matched with the records in the City Council of Modena's fiscal database of 2012 for reference to income year 2011 (containing gender, age, various types of income, and so on). The use of the fiscal code reduced mismatches to zero because it was an accurate and checked datum. To carry out the estimates some assumptions were made: (1) the income components considered in the analysis were salaries and pensions, because their ascertainment without errors was relatively easier than other income components, (2) the measurement errors in employment income and pensions did not depend on the economic sectors, while tax compliance may depend on the economic sectors, (3) tax evasion cannot be carried out in the public (*constrained*) sector or else it happens through negligible forms and amounts. In fact, pensioners or employees cannot evade the income obtained from pensions or labour carried out within the constrained sector, involving the equality between the FI and the true income. The latter does not hold in the private (*unconstrained*) sector. In abstract terms, the true income cannot present differences between public and private sector, but the determination of the true income pertaining to the private sector may be more complicated than that pertaining to the public sector (Hurst et al. 2014; Messacar 2017). Moreover, the data analysis may be carried out through the differences' values, but the percentage changes between SI and FI was used because they introduce a vertical equality among measurement errors and specifically among individual tax evasion estimates, discarding or weakening the dependence from the sociodemographic variables.

The first aim of the present paper concerns the analysis of income measurement errors, determined by the individual differences between the SI and FI, analysed with respect to the personal characteristics affecting both SI and FI to understand the structure and estimate the impact of determinants of error reporting. The results cannot be extended to Italy, but they confirm many empirical evidences reported in the literature and constitute a rare output coming from the comparison of two measures of income obtained through fiscal and survey procedures, and tracing a possible approach to these issues.

The second aim deals with tax evasion involving estimates of its pattern and determinants, the extent and the distribution of undeclared income.

The rest of the paper is organised as follows. Section 2 discusses some problems related to item measurement errors in survey data and tax evasion briefly reviewing the main empirical findings. Section 3 defines the symbolization of the quantities. Section 4 describes the key characteristics of the survey and the fiscal data, as well as the basic features of the total sample and the two subsamples: constrained and unconstrained sectors. Section 5 illustrates the analysis of over- and under-reporting and tax evasion, distinguishing between the constrained and the unconstrained sector and identifying the determinants affecting them. Finally, Section 6 concludes with some comments.

2. Background

Income survey data are affected by many factors generating errors. Unit nonresponse and item nonresponse are distortion causes (Lalla et al. 2012), but their effects depend on the type of surveyed target variable and often on individual characteristics, such as age, education level, and social status. The explanations of survey participation are framed on sociological and/or psychological theories (Tourangeau et al. 2000) and aimed at increasing the respondents number, considering the tools (survey materials, techniques for interviewing, and characteristics of the sampling unit) and the dynamics of interviewing (the errors of the players). The interviewers training is an important step, but surveys are limited by time and logistics, as well as human and financial resources, which determine the sampling design and the strategies for data collection. Furthermore, surveys on income, private property, and savings are burdensome to interviewees and sources of specific errors (Curtin et al. 1989; Hurd et al. 2003).

Measurement errors are generally caused by an inadequate tool, which is often an ambiguous or a poorly formulated sentence in social and economic inquiries. The causes of measurement errors lead to their classification: (1) instrument errors involving the tool or the procedure or the questionnaire, (2) technique errors deriving from the methodology and strategies used for data collection, (3) interviewer errors concerning an erroneous conduct of the interview, and (4) interviewee errors arising from his/her intention to answer with lying statements. In the last two cases, the errors depend on the personal characteristics of both figures (gender, age, education level, personality), their comprehension or recollection of past events, whether they are qualified to answer and willing to be truthful, as well as the conditions created during the interview (among others, Tourangeau et al. 2000; Moore et al. 2000; Biancotti et al. 2004).

The analysis of measurement errors data presents high difficulties when they have an unknown pattern, requiring assumptions for the latter which are often not supported by empirical knowledge. The validation of data affected by errors requires finding a corresponding data source without errors. Then, the differences between the equivalent variables of the two sources measure the error size. From the early validation study (Bancroft 1940) to the first statistical models (Mellow and Sider 1983; Bound and Krueger 1991; Bollinger 1998), the evaluation of the accuracy of SI has often been carried out through this procedure: the sampling records of employees are linked to the analogous records in the administrative archives of employers and the individual SI are compared with the income recorded by employers. The early studies, as well those which followed them (Kapteyn and Ypma 2007; Bricker and Engelhardt 2008; Meijer et al. 2012; Abowd and Stinson 2013), even if these were handling different aspects, basically found that measurement errors are non-classical and negatively correlated with the true values: mean-reverting. The review of Bound et al. (2001) is exhaustive, but also Bollinger and Hirsch (2013), and Pickhardt and Prinz (2014) deal with interesting characteristics of the subjects.

Tax evasion has been always analysed over time, involving three central questions: (1) the measurement of its extent, (2) the explanation of taxpayers behavioural patterns, (3) the application of achieved insights to control it (Alm 2012). There are many and not equivalent methods to measure evasion for the lack of reliable data on taxpayer compliance, given that the phenomenon is illegal and the individuals involved in cheating on their taxes are subject to financial and other penalties. Only three methods, which are similar to that one used in the following, are cited here. For a review see Alm (2012). The audit of individual returns is a direct method, generally based on a stratified random sampling. For example, the USA Internal Revenue Service (IRS) has planned the National Research Program, which examines a random sample of about 46,000 taxpayers per year. Another direct method uses tax amnesty data considering the income declared in that procedure as an exact measure of tax evasion. The other direct method, similar to the that presented here, is based on the answers of individuals interviewed about their evasion behaviour.

The explanation of tax evasion is framed in (a) the current theoretical, (b) empirical, and (c) experimental knowledge. In the theoretical perspective (a), the risk to be detected is modelled in the context of tax evasion (among others, Allingham and Sandmo 1972; Slemrod 2007). In the empirical context (b), there are many analyses of tax evasion attempting to estimate its determinants and to illustrate the behaviour of taxpayers, notwithstanding the difficulties of having a measure of non-compliance. Some emerging results are that high tax rates tend to generate less compliance, the increase in compliance seems non-linear involving a kind of upper threshold to compliance, audit rates are endogenous and influence some taxpayers' decisions (D'Agosto et al. 2018), the decrease of the auditing probability increases the non-compliance (Santoro and Fiorio 2011), the spatiality may develop differences and persistence (Brosio et al. 2002), the cooperation among governments could increase compliance (Alm 2012). There are several empirical evidences that individuals under-report incomes to tax authorities and this attitude is influenced by sociodemographic characteristics: gender, age, education level, income, region, economic sectors, and so on (Phillips 2014; Hofmann et al. 2017; Messacar 2017). In the experimental framework (c), the compliance behaviour of individuals has been extensively investigated in laboratory exposing them to many different circumstances, in spite of some limitations from the theoretical and empirical point of views. Starting from Friedland et al. (1978), these types of investigation have considered the psychological attitudes of taxpayers and achieved relevant findings (Webley et al. 1991; Alm et al. 2017).

Both the empirical and experimental methods present some critical aspects. In fact, the empirical findings should be considered with caution for the lack of reliable knowledge on the individual conduct in reporting income, but the experimental outcomes also require attention because individual behaviour is generally affected by the reaction to observation (Hawthorn effect) when involved in experiments on income survey, distorting his/her answers data.

The application of achieved understanding to control evasion may take place at various levels of the process, as the studies have shed light on many facts. First, some outcomes emphasize an approach based on a friendly relationship between citizens and tax agencies. For example, individuals respond with a predictable behaviour to the fiscal policies, taxpayers are basically under-reporters and sensitive to services directed to assist them in every step of their filing tax forms, the improvements of government services are useful to create a confident relationship between taxpayers and State, simplification of tax forms is highly agreed. However, the latter is an ambiguous desire because simplicity contrasts or does not easily accomplish equity, which is always invoked for his/her own specific situation. Second, the traditional administrative policies are aimed at deterring from cheating, repressing illegal behaviour through audits and penalties, but this attitude should be mitigated by providing services for taxpayers and changing the perspectives of the administration as helper and not only as controller/ punisher. Third, the morality and social norms should be stressed in a concerted move through media and associations, schools and acknowledgements to a different attitude towards the institutions and the important role of a correct citizen. It is suitable to stimulate various organisations to promote a culture of tax compliance and/or tax morale (Torgler 2003; Alm 2012).

The amount of the phenomenon varies across countries, regions, and time, as well as with gender, age, education level, activity status and occupation, sector of activity, and so on. For example, the percentage of personal income tax compliance is about 66% for four European countries (Benedek and Lelkes 2011): 75% for Germany and Austria, 62% for Italy, and 60% for France. The percentage of evaded taxes is estimated through several methods obtaining different estimates. In the USA in tax year 2006 the percentage of tax evasion was 14.5% (Bloomquist 2014). In Europe there are countries with high rates: 25.4% for Belgium, 22.7% for Italy, 17.7% for Germany, and 16.5% for France in tax year 2002 (Benedek and Lelkes 2011). In the last years (2012–2016), the tax gap propensity resulted over 64% for firms and self-employed in Italy, while the total gap propensity was about 33% (MEF 2018). The taxation rates in Italy are high, but a large part of taxpayers do not pay the due amount entirely. In fact, tax compliance in Italy is considered generally low for many reasons: a historically low level of trust in the political system, a widespread attitude of citizens considering the public services to be due without the duty to pay taxes on which they are based, the perceived low quality of public services and the fact that sometimes they are effectively inefficient, the large extent of a shadow economy, the pervasive corruption in public activities, the diffusion of organised crime, the repeated use of tax amnesties (Bordignon and Zanardi 1997; Brosio et al. 2002).

3. Formalization

The measurement of the income is a difficult process and the value of the true income is almost impossible to achieve. The true income may be considered a latent variable, not modelled here, represented by two manifest variables: one comes from the survey (s), $\mathrm{SI}_i = y_i^s$, and another comes from the record (r) of taxpayers database, $\mathrm{FI}_i = y_i^r$ for the same individual i.

Only two components of the total income were considered in the analysis. The first component referred to wages and salaries (w) or income merely deriving from work in the survey and in the record of taxpayers database, respectively denoted by the couple of variables $\left({}_w y_i^s, {}_w y_i^r\right)$. The second one referred to pensions (p) in the survey, as well as in the record of taxpayers database, respectively denoted by the couple of variables $\left({}_p y_i^s, {}_p y_i^r\right)$ again. Consequently, the SI of each individual i was given by $y_i^s = {}_w y_i^s + {}_p y_i^s$ and, similarly, the FI of the same individual i was given by $y_i^r = {}_w y_i^r + {}_p y_i^r$. The individuals included in the operating sample had to have at least one of y_i^s and y_i^r greater than zero, involving the selection condition: $(y_i^s + y_i^r) > 0$.

The other components of revenue, such as rental income from buildings and land or capital gains, can be easily evaded or eluded and require a dedicated survey, while the choice of salaries and pensions is suitable to separate measurement error and individual tax evasion. For this end the sampled individuals were subdivided in two groups through a dichotomous variable, hereafter referred to as “type of fiscal sector”. One group, the constrained sector (*c*), contained pensioners and individuals working in the sectors of public administration, education, health and social services because they cannot easily evade tax or conceal his/her own income. The other group, the unconstrained sector (*u*), contained the individuals working in the other sectors and not perceiving pensions exclusively. The constrained sector is adequate to investigate the measurement errors and to represent a reference base in the analysis of tax evasion. In fact, individuals in the unconstrained sector, such as self-employed, have many possibilities and strategies to establish their tax compliance, which may be emphasized also by social interactions, as the behaviours of their peers (Benedek and Lelkes 2011). Generally, their condition affects the participation rate and the cooperation in a survey (D’Alessio and Faiella 2002; Moore et al. 2000), but in some situations SI and FI may be surprisingly similar or FI may appear more precise and higher than SI (Jäntti 2004; Lalla et al. 2012).

The difference between the SI and FI, $d_i = y_i^s - y_i^r$, denotes a discrepancy between the two measurements. It represents an over-reporting in the interview when it is positive $(d_i > 0)$ and an under-reporting when it is negative $(d_i < 0)$. It is possible to assume that SI is true income, arguing that tax evaders have no interest to conceal their true income in a private and anonymous interview (Fiorio and D’Amuri 2005; Matsaganis and Flevotomou 2010), and to consider the positive values as the amount of tax evasion. However, in this approach the justification of the negative values becomes difficult. Moreover, this amount of evasion is affected by errors because there are many problems in the measurement of income, among others: high self-selection rates in respondents, a widespread prevalence of item non-response to earning and wealth questions, frequent irregularities over time of receiving revenue receipts, differences between the asked time span and the remembered dates of arrived sums (D’Alessio and Faiella 2002; Hurd et al. 2003; Schräpler 2006). Then, over-reporting and under-reporting observations may be analysed through an ordinary multiple regression model to ascertain the determinants of these two different behaviours. The use of the logarithm of the dependent variable (regredend) is usual in income data analysis because each estimated coefficient expresses the percentage change of the regredend generated by the increase of a unit in the corresponding independent variable, keeping the other independent variables constant. Therefore, the regredend might be the natural logarithm (ln) of d_i, denoted by $\ln(\pm d_i)$ where the sign + indicates over-reporters and the sign – indicates under-reporters to obtain a positive argument. The cases d_i=0 were excluded by construction in the target samples. The regredend might be the differences $[\ln(y_i^s) - \ln(y_i^r)]$, involving the possibility to model over- and under-reporters simultaneously (Hariri and Lassen 2017), but it confounds easily the effects of measurement error and tax evasion.

To evaluate the importance of the observed differences, d_i, the percentage changes of SI and FI were considered: $\%\,\mathrm{C}_i = 100 \cdot (y_i^s - y_i^r) / y_i^r$. Thus, an individual over-reporting a 10% percent value may have declared whatever value of FI. However, the calculation of $\%\,\mathrm{C}_i$ presented some problems. If y_i^r=0, then $\%\,\mathrm{C}_i$ would be infinite or unmeasurable, denoting individuals who should not file the tax form or who were total tax evaders. Therefore, $\%\,\mathrm{C}_i$ was fixed equal to +100% for y_i^r=0. There were cases with y_i^s much greater than y_i^r implying values of $\%\,\mathrm{C}_i$ much greater than +100% and involving both low and high values of y_i^s. On the contrary, it was not possible to have values of $\%\,\mathrm{C}_i$ lower than −100% at the individual level, as y_i^s=0 implies directly $\%\,\mathrm{C}_i$ equal to −100%. Negative values of y_i^s were not admissible, although possible, because y_i^s included only wages and salaries for dependent employment, or the income deriving from job for other employment categories, and pensions. The use of $\%\,\mathrm{C}_i$ as dependent variable implied assuming a sort of vertical equity in tax evasion: rich and poor are labelled by percentages of their errors or evasion, although the poor had more occasions of evading taxes than the rich (Cowell 1985; Benedek and Lelkes 2011), but only up to a certain point may be the obvious remark. As above and for the same reasons, to ascertain the determinants of over- and under-reporting behaviour, the regredends of models were the logarithm of $\%\,\mathrm{C}_i$, denoted by $\ln(\pm\%\,\mathrm{C}_i)$ where the sign + indicates over-reporters and the sign − indicates under-reporters again to obtain positive values for the argument of logarithm.

Given that individual Measurement Error (ME) and Tax Evasion (TE) are given by the same expression, d_i=ME=TE, then a raw evaluation of the average Tax Evasion ($\overline{\mathrm{TE}}$) in percentage may be obtained by the difference of the means of percentage changes in the unconstrained ($\overline{\%\,\mathrm{C}_u}$) and constrained ($\overline{\%\,\mathrm{C}_c}$) sector, considering over-reporters only:

$$\overline{\mathrm{TE}}_{\text{u-c}}=\overline{\%\,\mathrm{C}_u}-\left|\overline{\%\,\mathrm{C}_c}\right|. \tag{1}$$

The equation (1) involves the implicit assumptions that: (a) the measurement error is distribution free, and (b) the constrained sector provides the average size of measurement error. However, it is easier to restrict equation (1) to over-reporters only, even if the under-reporters may be tax evaders. $\overline{\mathrm{TE}}_{\text{u-c}}$ represents the average of the individual propensity to evade.

If a single sector is available or the total target sample is under analysis, then the difference might be carried out considering the difference of the percentage changes between over-reporters (o-r) and under-reporters (u-r):

$$\overline{\mathrm{TE}}_{\text{o-u}}=\overline{\%\,\mathrm{C}}_{\text{o-r}}-\left|\overline{\%\,\mathrm{C}}_{\text{u-r}}\right|. \tag{2}$$

The equation (2) implies the assumptions that: (a) the measurement errors of income are symmetrical with respect to zero and, therefore, (b) the under-reporters provide the average size of measurement error. Therefore, the construction of the constrained- and unconstrained-sector becomes unnecessary and over-reporters only provided data for tax evasion, even if the under-reporters may be tax evaders.

The tax evasion may depend on the explanatory variables (regressors), especially on age and SI or FI. Therefore, considering the regredend as function of a vector of regressors, $\mathbf{x\beta}$, another simple and crude estimation of tax evasion may be obtained by a difference analogous to the equation (1):

$$\widehat{\text{TE}}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{u-c}} = \bar{f}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{u}} - \left| \bar{f}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{c}} \right|. \tag{3}$$

For the total target sample, as in the equation (2), individual tax evasion may be estimated by the difference of the percentage changes between over-reporters (o-r) and under-reporters (u-r):

$$\widehat{\text{TE}}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{o-u}} = \bar{f}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{o-r}} - \left| \bar{f}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{u-r}} \right|. \tag{4}$$

The modelling approach squashes in some way the outlying values, reducing their effects, and spreads the differences among regressors tending to concentrate the estimates of the individual tax evasion about low levels. Moreover, the results refer to all individuals being in the unconstrained sector or over-reporters. In fact, these indices denote the expected propensity tax gap for the *i*-th individual, given that both his/her SI and $\%\,\text{C}_i$ are greater than his/her FI and the threshold of $\%\,\text{C}_i$ indicating the evasion, respectively. Therefore, these four indices are measures of tax evasion too, but they do not coincide with the ordinary measure, given by the percentage ratio between the amounts of evaded income and the total imposable income.

Using equation (1) or equation (2), the ordinary measure is obtained through a peculiar weighted mean, rather tedious to define. Let $\%\,\text{C}_{(i)}$ be the positive ordered values of $\%\,\text{C}_i$. Let $y_{(i)}^s$ and $y_{(i)}^r$ be the corresponding values of $\%\,\text{C}_{(i)}$. Let $\%\,\text{C}_{(i=T)}$ be the threshold, for which the $\%\,\text{C}_{(i>T)}$ involves tax evasion. Let $\text{TSI}_\text{e} = \sum_{i=T+1}^{n} y_{(i)}^s$ be the total SI subjected to evasion and let $\text{TFI}_\text{e} = \sum_{i=T+1}^{n} y_{(i)}^s$ be the total FI, which corresponds to the SI subjected to evasion. Let $\text{w}_{(i)} = y_{(i)}^r \big/ \text{TFI}_\text{e}$ be the weight for $\%\,\text{C}_{(i)}$. Then, the ordinary tax evasion ($\widehat{\text{TE}}_\text{O}$) is given by

$$\widehat{\text{TE}}_\text{O} = \frac{\text{TFI}_\text{e}}{\text{TSI}_\text{e}} \left(\sum_{i=T+1}^{n} w_{(i)}\ \%C_{(i)} \right). \tag{5}$$

The cases $\%\,\text{C}_{(i)} = +100$ should be handled adequately, but measurement errors and tax evasion are not disentangled. In addition, equation (5) implies the determination of the threshold, $\%\,\text{C}_{(i=T)}$, which is a typical empirical issue involving many different acceptable solutions. Known the threshold, it is possible to improve the propensity tax gap for the *i*-th individual, given that he/she is evader, expressed by the equations (1) – (4), dividing their outcomes by the proportion of evaders, but, for the sake of brevity, all these possibilities will not be discussed in the following.

4. Data Sources

The third wave of the survey on economic and social conditions of households in the province of Modena (SESC-MO3) was carried out in 2012 by the CAPP (Centre for Analyses of Public Policies) of the University of Modena's Department of Economics "Marco Biagi" and it was based on two-stage cluster sampling, stratified in accordance with the socio-healthcare districts, in which the municipalities were the primary sampling units and the households were the secondary sampling units (Lalla et al. 2012). At the end of the survey, there were 835 households, whose members (1960 individuals) were interviewed in Modena. The adopted sampling design was similar to that of the analogous surveys (Banca d'Italia 2014; Istat 2006), as well as the participation rates (Hüfken 2010; Peracchi 2002). Other details may be found in Appendix A1.

The fiscal database of the Ministry of Finance is strictly protected by privacy policies that make it unusable either for selecting a good sample or for matching their records with the corresponding surveyed records. However, the fiscal database of taxpayers residing in Modena became available three years after the survey was conducted in 2012, allowing for exact matching of the sample unit records, using their fiscal identification numbers, with the corresponding records in the fiscal database of 2012 containing data for 2011, respecting anonymity. The FI became available for 1810 matched units only, while the others (150 individuals) were generally minors not obliged to file tax form. Moreover, the eligible individuals for the objectives of the analysis were obtained selecting only wages and salaries and pensions, with the conditions $(y_i^s + y_i^r)$>0 and (age≥18), where the latter stated that the individual should be adult, leading to a sample of n=1210 units.

Table 1 provides descriptive statistics of SI by gender and by age classes. The youth (age-class 18-29 years) showed an annual income almost equal with respect to gender: the mean of men was 5.0% greater than that of women, but in the subsequent class the percentage change was already 39.2% and continued to increase up to 64.3% in the age-class 60-69 years. The differences in the income between men and women are widespread in the world (among others, Goodwin-White 2014; Bradley et al. 2015).

The constrained sector was built up selecting individual classified into the three sections of NACE Rev. 2 (2008): Section O "Public administration and defence, compulsory social security", Section P "Education", and Section Q "Human health and social work activities". The pensioners receiving pension income only were included in the constrained sector: they were made up by retirees and individuals receiving social pensions without having worked or life annuities or survivor's pensions or other periodical benefits. The unconstrained sector included the remaining Sections of NACE Rev. 2 (2008), not included in the constrained sector. The differences between the constrained and unconstrained sectors may be observed in Table 2.

For the subsample A_{sr} of individuals having both SI and FI greater than zero, the means of SI and FI in the constrained sector were significantly lower than those in the unconstrained sector (−8.4% and −10.3%, respectively), as expected. The distributions in the two fiscal sectors tended to a lognormal shape (Figure 1). The means of FI were statistically greater than those of SI implying that individuals tended to be reticent answering to the questions concerning the income and involving a weakness of the assumption that tax evaders had no interest in concealing their true income when responding to an income survey, as assumed by Fiorio and D'Amuri (2005) and by Matsaganis and Flevotomou (2010). The distribution of FI (Figure 2) was similar to that of SI, except for a spike in the first class (€ 0−1000).

Table 1. Surveyed income by gender and by age-classes in the target sample

Age-class	18-29 yrs.	30-39 yrs.	40-49 yrs.	50-59 yrs.	60-69 yrs.	70-99 yrs.	Total
Women	45	82	129	105	103	136	600
(1) Mean	12067.81	13178.76	15993.95	17786.97	14718.72	13636.21	14875.19
SD [a]	5500.56	6367.35	6817.15	7709.71	8059.69	7988.90	7516.38
SI=0	11	7	7	6	3	5	39
Men	42	81	114	89	87	118	535
(2) Mean	12672.83	18347.19	24566.91	27417.64	24182.17	18243.72	21686.98
SD [a]	5557.25	7153.67	10636.55	14263.82	14506.32	14018.24	12831.49
SI=0	13	5	10	7	5		40
(2)/(1) [b]	1.050	1.392	1.536	1.541	1.643	1.338	1.458
Total	87	163	243	194	190	254	1131
Mean	12359.89	15747.12	20015.83	22205.16	19051.98	15776.71	18073.30
SD	5504.15	7229.27	9787.17	12163.33	12375.70	11412.00	10896.74
SI=0	24	12	17	13	8	5	79

Note: [a] SD= Standard Deviation, SI= Surveyed Income.

[b] (2)/(1)= (mean of men)/(mean of women). Note that the ratio {[(2)/(1)] − 1}= {[(mean of men)/(mean of women)] minus one} is equal to the proportion change of means between men and women: [(mean of men) − (mean of women)]/ (mean of women). If the latter is multiplied by 100, then it becomes percentage change of means.

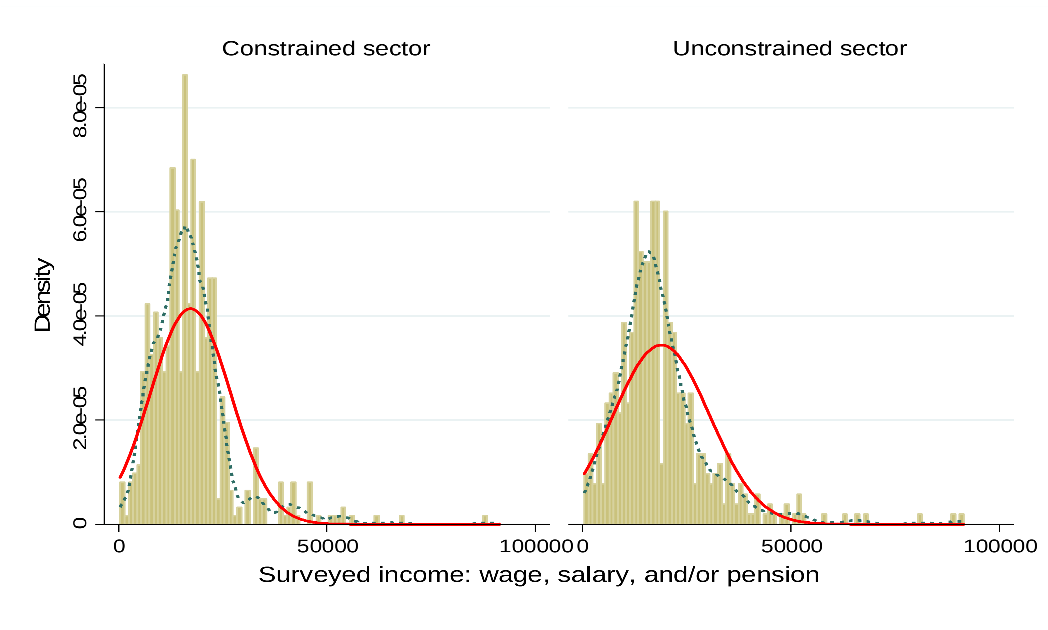

Figure 1. Epanechnikov kernel density estimates (dashed line) and corresponding normal density plot (solid line) of the ***surveyed income*** in 2011 for constrained and unconstrained sectors (0<SI<100000)

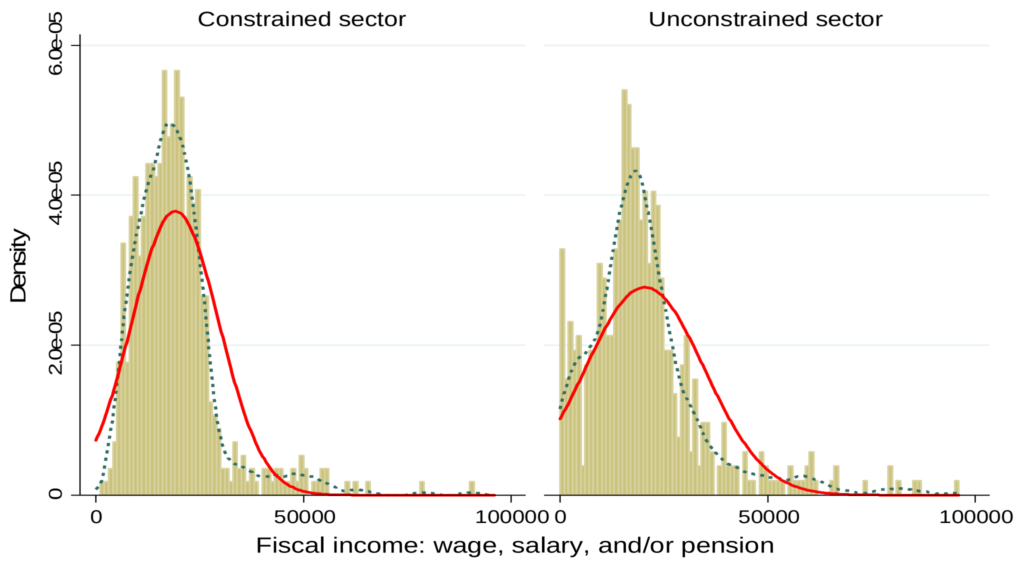

Figure 2. Epanechnikov kernel density estimates (dashed line) and corresponding normal density plot (solid line) of the ***fiscal income*** in 2011 for constrained and unconstrained sectors (0<FI<100000)

The differences, d_i, between SI and FI revealed negative means in both sectors (Table 2), but that in the constrained sector (−1595.95€) was greater (lower in the absolute values) than that of the unconstrained sector (−2199.07€), always in A_{sr}. Negative values implied that the amounts of non-cooperation in an income survey weighted more than those of cooperative individuals. The distributions in the two fiscal sectors were bell shaped (Figure 3), but that of the constrained sector was markedly leptokurtic. The percentage changes showed negative values of mean (−3.76%), but that of the constrained sector (−4.49%) was lower than that of the unconstrained sector (−2.86%), stressing anyway the reliability of FI. In fact, these values were incredibly low, notwithstanding the 24 outlying values (5/24 in the constrained sector) greater than +100%. Note that 8 of these 24 outliers (1 of these 8 in the constrained sector) were greater than 200%, but they were smoothed weighting them through SI and FI, and reallocated between +100% and +200%. As expected, the distributions of percentage changes in the two fiscal sectors revealed a great spike at ±100% (Figure 4).

The subsample A_{s0} of the individuals reporting SI greater than zero and FI equal to zero proved to be 9.4% (59 individuals out of 626) in the constrained sector and 11.1% (65 individuals out of 584) in the unconstrained sector, but they were not necessarily total tax evaders. The percentage of the non-declared income to fiscal authorities was 7.5% of the total SI. The percentage changes between SI and FI were indefinite and imposed equal to +100% by convention.

The subsample A_{0r} of the individuals reporting SI equal to zero and FI greater than zero concerned the non-cooperation in the survey interview, inducing a peculiar kind of measurement error or reticence proving to be 1.8% (11 out of 626) in the constrained sector and 11.1% (65 out of 584) in the unconstrained sector. The two percentages were statistically different, involving a significant less cooperation among the individuals of the unconstrained sector with respect to income measurement. The means of SI were statistically equal between the two fiscal sectors. The percentage changes between SI and FI resulted −100% by definition.

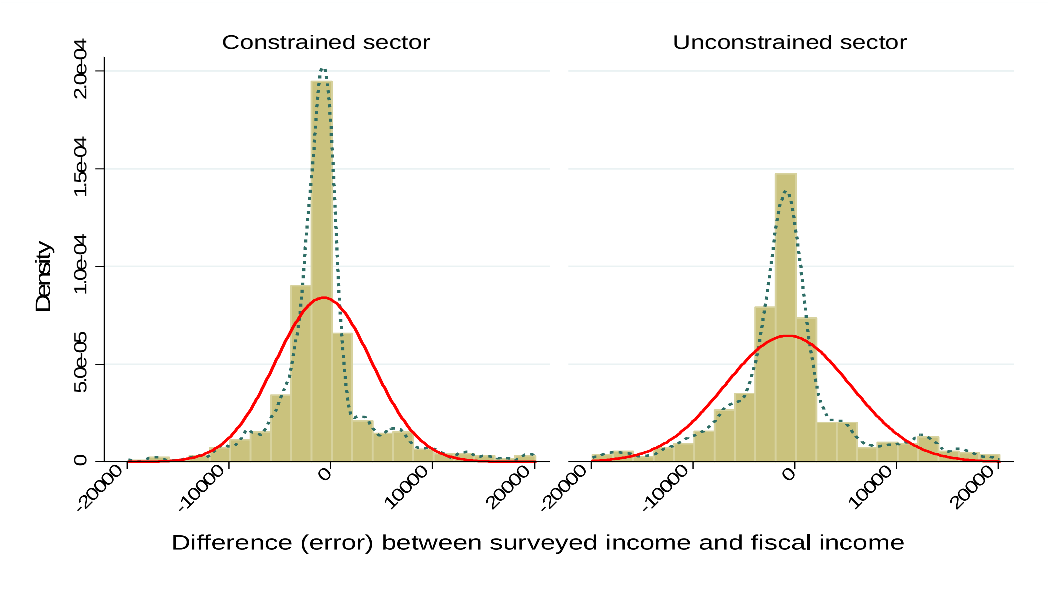

Figure 3. Epanechnikov kernel density estimates (dashed line) and corresponding normal density plot (solid line) of the ***differences*** (E) between surveyed income and fiscal income in 2011, for constrained and unconstrained sectors with truncated tails (–20,000 <E< +20,000)

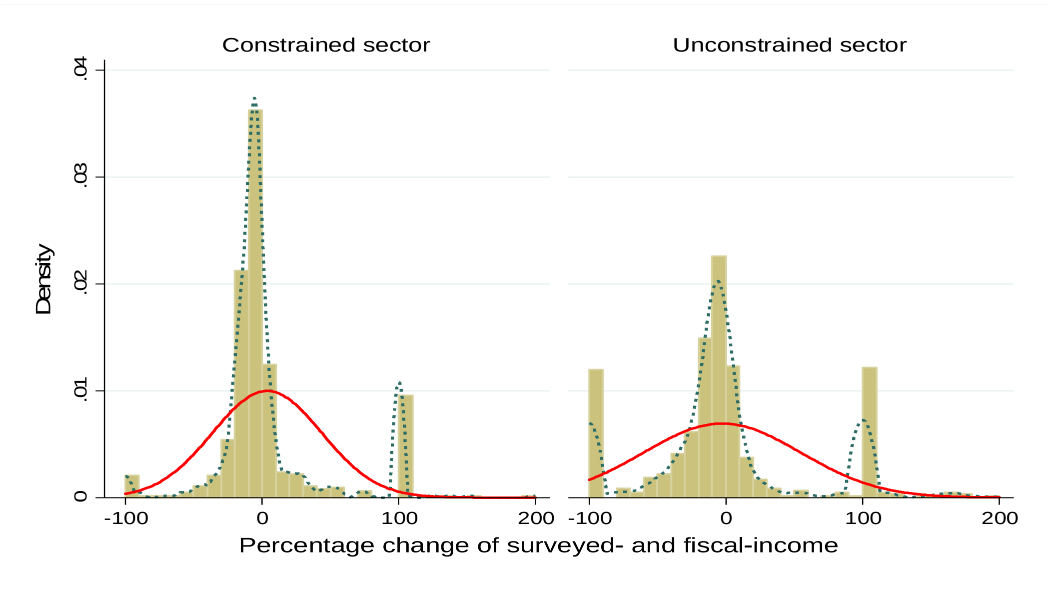

Figure 4. Epanechnikov kernel density estimates (dashed line) and corresponding normal density plot (solid line) of the ***percentage change*** (PC) of surveyed- and fiscal-income in 2011 for constrained and unconstrained sectors with truncated right tail (–100 ≤PC< 200)

Table 2. Descriptive statistics of surveyed income (SI), fiscal income (FI), measurement errors, and percentage changes (PC) by type of fiscal sector

Sectors	Constrained sector			Unconstrained sector			Total		
Variable	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
(SI & FI)>0									
SI	556	18039	10051	451	19700	11580	1007	18783	10789
FI	556	19635	11779	451	21899	14548	1007	20649	13133
Errors	556	–1595.95	4093.03	451	–2199.07	7036.70	1007	–1866.07	5610.83
PC	556	–4.49	23.15	451	–2.86	36.66	1007	–3.76	29.96
Median(PC)	556	–6.12		451	–6.48		1007	–6.33	
FI=0									
SI	59	11404	10168	65	13128	9973	124	12308	10062
PC	59	100	0	65	100	0	124	100	0
SI=0									
FI	11	7868	4385	68	11823	14025	79	11272	13165
PC	11	–100	0	68	–100	0	79	–100	0
Sample size	626			584			1210		
(SI – FI)>0									
SI	193	14256	8666	203	17722	11075	396	16033	10111
FI	134	13343	6868	138	16584	10997	272	14987	9323
PC > 0	193	44.53	44.92	203	52.85	50.01	396	48.79	47.72
Median(PC)	193	23.82		203	28.00		396	24.28	
(SI – FI)<0									
SI	422	18842	10589	313	19619	11867	735	19173	11150
FI	433	21284	12357	381	22026	15799	814	21631	14069
PC < 0	433	–14.52	18.46	381	–32.33	35.10	814	–22.86	28.91
Median(PC)	433	–8.92		381	–15.58		814	–11.58	

Over-reporters (d_i>0) emerged from data with means of SI greater than the corresponding means of FI, but not significantly (Table 2). As expected, the means of SI and FI in the constrained sector were significantly lower than their corresponding mean in the unconstrained sector with p<0.001 and p<0.004, respectively. The means of the percentage changes were 44.53% in the constrained sector and 52.85% in the unconstrained sector, but perhaps the former was too high. The distribution of the logarithm of percentage change, $\ln\left[\text{abs}(\%C_i)\right]$, looked like a mixture of a bell-shaped curve and a Dirac or point mass distribution, appearing to be slightly negatively skewed (–0.75) and mildly mesokurtic (2.85) in the constrained sector (Figure 5). The point mass distribution corresponded to a remarkable right spike indicating individuals with FI equal to zero (30.6% of 193), but 50.8% (of these latter individuals) had SI less than €8,000 and presumably they were not obliged to file tax forms. The same profile showed in the unconstrained sector (Figure 6) with skewness= –0.82 and kurtosis= 3.02.

Under-reporters (d_i<0) showed means of SI not significantly lower than the corresponding means of FI (Table 2). The under-reporters resulted more numerous than over-reporters (69.2% versus 30.8% in the constrained sector, 65.2% versus 34.8% in the unconstrained sector, 67.3% versus 32.7% in the total sample) and the interviewees of the unconstrained sector tended to conceal percentages of income higher than those of the constrained sector. The means of the percentage changes in the constrained sector (–14.52%) was less than one half of that in the unconstrained sector (–32.33%) and significantly different (p<0.001). For under-reporters in the constrained sector, the density of the logarithm of percentage change (Figure 5) seemed a bell-shaped curve, negatively skewed (−0.66) and mildly leptokurtic (5.11). In the unconstrained sector, the logarithm of percentage change of under-reporters (Figure 6) presented a slight negative skewed (−0.29) distribution, mildly mesokurtic (2.98), with a notable right spike at the abscissa equal to 4.6, like to that of over-reporters, corresponding to non-cooperative individuals with $\%\,C_i = -100\%$, who were the 17.8% of 381 under-reporters.

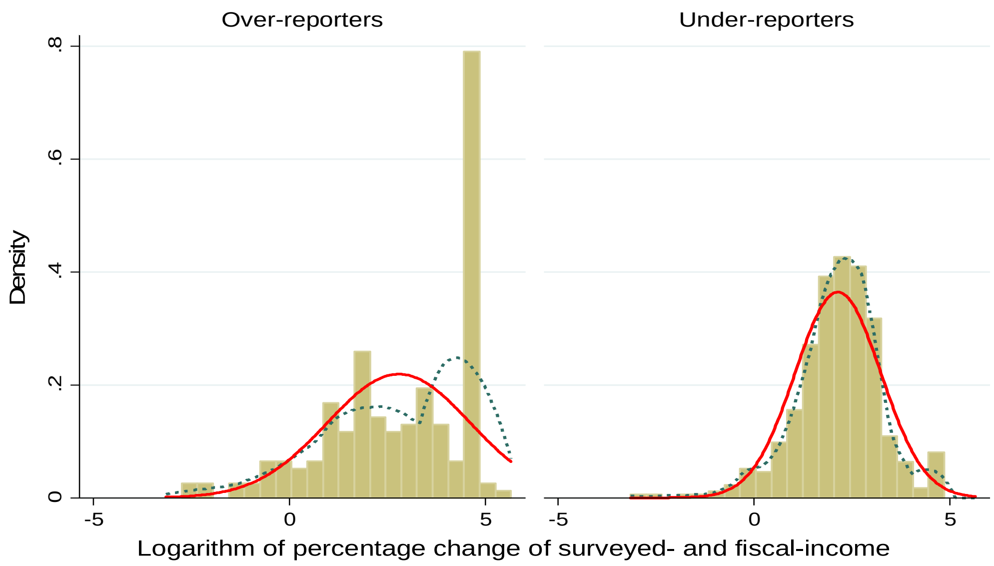

Figure 5. Epanechnikov kernel density estimates (dashed line) and corresponding normal density plot (solid line) of the ***logarithm of the absolute percentage changes*** of surveyed income and fiscal income for over- and under-reporters ***in the constraint sector*** (year 2011)

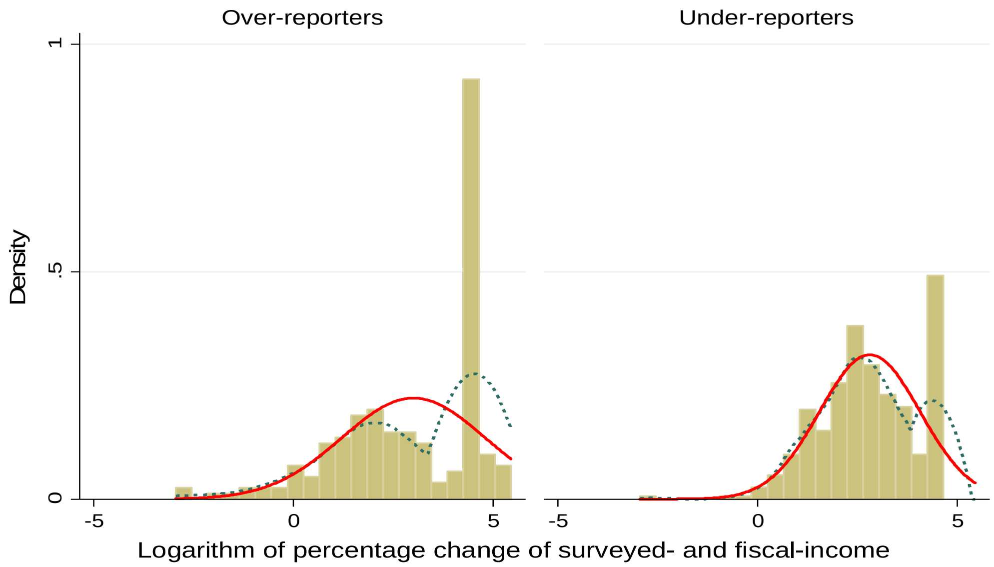

Figure 6. Epanechnikov kernel density estimates (dashed line) and corresponding normal density plot (solid line) of the ***logarithm of the absolute percentage changes*** of surveyed income and fiscal income for over- and under-reporters ***in the unconstraint sector*** (year 2011)

The first raw estimates of tax evasion may be made from the data of Table 2. Applying equation (1), $\overline{\text{TE}}_{\text{u-c}}$ = [−2.86−(−4.49)]= 1.63%. However, as suggested above, it is better to restrict the calculus to over-reporters: $\overline{\text{TE}}_{\text{u-c}}$ = (52.85−44.53)= 8.32%. Almost certainly, the percentage of tax evasion appeared underestimated, but it is an individual propensity to tax evasion referred to all people belonging to the unconstrained sector, even if they were extremely reticent in the interview and presumably they had the ability and the inclination to evade tax and answers to questionnaires. The last crude estimation was not coherent with other estimates at national level: 22.7% in tax year 2002 (Benedek and Lelkes 2011) and over 33% from 2011 (MEF 2018). The discrepancy may depend on the difficulty to characterize both the constrained- and unconstrained-sector. For example, people working in the economic sector health tend to evade more than other public sectors, presenting many propitious situations. The use of equation (2), $\overline{\text{TE}}_{\text{o-u}}$ = (48.79−22.86) = 25.93%, yielded a result comparable with other findings, cited above. The various obtained raw estimations are a natural consequence of the complexity of the tax evasion, which generates apparently strange values and several procedures to measure it. The emerging questions concern at least three aspects: (a) the high positive error in the constrained sector implying the presence of tax evasion and/or an its imperfect definition, (b) the low tax evasion in the unconstrained sector with respect to outer or expected estimations, (c) the usefulness of the individual propensity to tax evasion.

5. Structural analysis of measurement errors and tax evasion

To illustrate the order of magnitude of the percentage change in the sample, Table 3 reports its descriptive statistics by the constructed variable "activity status and occupation" and gender. Percentage change showed a positive mean value near zero (+0.59% in the column of total mean). The mean of percentage changes relative to women were statistically equal to those of men, but greater than those of men, involving a slight tendency of men to under-report their earnings, which was the opposite found by Bound and Krueger (1991). On the average, women showed a lower variability (heteroscedasticity) in the percentage changes than men, but their behaviour pattern differed among the various categories of the activity status and occupation. On the one hand, women who were entrepreneurs, self-employed, teachers, employees, unemployed, and inactive tended to be more under-reporters than men. On the other hand, women who were managers proved to be over-reporters (45.69%), while men were under-reporters (−13.33%) and the difference reached a statistical significance ($p<0.050$). Official and executive women tended to be under-reporters (–6.06%), but on average less than men (–7.21%). Labourers women resulted over-reporters (23.82%) more than men (9.25%). Women retirees were over-reporters (8.43%) more than men (5.96%). In conclusions, women were under-reporters in certain categories and men were over-reporters, while in others, an opposite behaviour was observed or a similar attitude with a different intensity, leading to a compensation of the under- and over-reporting.

Table 3. Descriptive statistics of percentage changes by "activity status and occupation" (ASO) and by gender

ASO\ Gender	Women			Men			Total		
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
Entrepreneur	4	–72.43	55.14	14	–52.63	80.72	18	–57.03	74.78
Manager	9	45.69	85.88	25	–13.33	19.52	34	2.29	52.57
Official | Execut.	18	–6.06	44.05	42	–7.21	23.63	60	–6.87	30.78
Self-employed	15	–63.28	63.92	32	–38.78	64.13	47	-46.60	64.40
Teacher	56	–6.42	30.10	9	9.69	53.33	65	–4.19	34.14
Employee	149	–0.63	35.66	110	2.03	37.35	259	0.50	36.34
Labourer	109	23.82	62.24	117	9.25	49.02	226	16.28	56.14
Unemployed	22	–22.00	71.71	19	–15.10	81.03	41	–18.80	75.27
Retiree	241	8.43	44.42	194	5.96	33.95	435	7.33	40.07
Inactive	16	–52.86	71.84	9	–93.35	19.94	25	–67.44	61.25
Total	639	2.98	51.70	571	–2.09	46.52	1210	0.59	49.37

The mean-reverting was observed in these data too. In the constrained sector, the correlation between SI and FI, $r(y_i^s, y_i^r)$, was equal to 0.917 for men and 0.751 for women, while the correlation between the measurement errors and the "true" values was $r(d_i, y_i^r) = -0.664$ for men and $r(d_i, y_i^r) = -0.501$ for women. The results observed for men were comparable with those reported by Bound and Krueger (1991), while the results observed for women were significantly higher than theirs. In the unconstrained sector strong differences were observed about the correlations between SI and FI for men (0.740) and for women (0.616), while the correlations between the measurement errors and the "true" values were near equal to those of the constrained sector: −0.604 for men and −0.552 for women.

The percentage changes were analysed for over- and under-reporters separately, using $\ln(+\%\,\mathrm{C}_i)$ for the former and $\ln(-\%\,\mathrm{C}_i)$ for the latter, in the constrained and unconstrained sectors. A set of regressors was singled out for an explanation of the variability of the dependent variable: type of tax form, FI, gender, age, citizenship, education, marital status, activity status and occupation, sector of activity, and tenure status of household. Their definitions were based on those used by Eurostat (2009) in the EU-SILC (European Union – Statistics on Income and Living Conditions) or ISCO-88 (ILO 1990; Istat 2001): see also Atkinson and Marlier (2010). The collected modalities of the sector of activity were based on the statistical classification of economic activities (NACE Rev. 2 2008), but they underwent a slight modification/ adaptation and were grouped according to an ordinary categorisation. Given that the percentage change equalized vertically taxpayers, the impacts of regressors were expected to be prevailingly statistically negligible.

The qualitative regressors listed above were dichotomized as usual, transforming each modality in a dichotomous (or binary) variable and expressly designing one of them as reference group (RG), which was excluded from the regressors set. FI and age were quantitative regressors, included into the model through a second-degree polynomial form to capture some nonlinearities in the behaviours of individuals of different ages and FI values. The expected impact of age on earnings might have the same form of FI, involving a high correlation between them: as young workers become older, their earnings will usually increase. A significant effect of one of the two might incorporate the effect of the other. Moreover, a binary variable indicated the non-cooperation of individuals for two different situations: in the subsample A_{0r} (SI=0 & FI>0) denoting $\%\,\mathrm{C}_i = -100\%$ and in the subsample A_{s0} (SI>0 & FI=0) denoting an assigned $\%\,\mathrm{C}_i = +100\%$ (for both see Table 2). Other details on the definition of variables may be found in Appendix A2.

The estimations of the models' coefficients should be interpreted considering that over-reporting contains measurement errors and evasion, while under-reporting would contain measurement errors only, even if the behaviour of the two groups might differ in making mistakes and tax evaders might be among under-reporters too. The log-lin functional form used to model the percentage changes, $\%\,\mathrm{C}_i$, means that the model has not a constant slope and a constant elasticity. If a given regressor, X_1, increases by one unit, then the regredend Y will change in percentage terms, *i.e.*, it will change by $\beta_1 \cdot 100$ percent, holding constant all the remaining other regressors, for every unit that X_1 increases (Studenmund 2001).

5.1. Error model analysis in the constrained sector

For over-reporters, the regredend $\ln(+\%\,\mathrm{C}_i)$ was affected by several factors positively and negatively, but few coefficients were statistically different from zero (Table 4).

Significant positive impacts were observed for free (p<0.002) and other (p<0.035) accommodations in the tenure status of households, obviously for binary variable denoting taxpayers having % C_i = +100, and for the constant of the model (p<0.040). Two coefficients were positive, but with borderline p-values: single (p<0.099) and widowed (p<0.066) of marital status. The positivity implied that persons in those categories made errors more than others. There were not significant negative coefficients, but the modality tenants or subtenants paying rent at prevailing or market rate for the tenure status of households was negative with a borderline p-value (p<0.076). FI yielded a significant coefficient for the linear term only (p<0.009), showing concave parabolic effects, with the turning point at FI equal to 41,252€ (see Appendix A2).

Table 4. Parameter estimates (β) of the multiple regression model for over-reporters and under-reporters in the constrained sector

Sample subgroups	Over-reporters: *n*= 193			Under-reporters *n*= 433		
Independent variables [a]	β	SE	p-values	β	SE	p-values
Tax Form-770	0.137	0.317	0.666	–0.236	0.165	0.154
Tax Form-Unico	0.367	0.266	0.169	0.055	0.149	0.710
FI/50000	–6.383	2.409	0.009	1.216	0.681	0.075
(FI/50000)^2	3.869	2.668	0.149	–0.234	0.338	0.489
Men	0.101	0.195	0.605	–0.079	0.118	0.503
Age/50	–2.269	2.303	0.326	–1.044	1.466	0.477
(Age/50)^2	1.270	0.874	0.148	0.355	0.583	0.543
Foreigner (RG=IT)	0.571	0.452	0.208	0.687	0.612	0.262
EL: Primary (RG)						
EL: Lower secondary	–0.165	0.265	0.534	–0.171	0.176	0.332
EL: Upper secondary	0.226	0.274	0.409	–0.267	0.169	0.115
EL: Tertiary	0.520	0.347	0.136	–0.543	0.204	0.008
MS: Married (RG)						
MS: Single	0.530	0.319	0.099	0.046	0.159	0.774
MS: Divorced	0.376	0.374	0.316	0.212	0.196	0.281
MS: Widowed	0.530	0.287	0.066	0.069	0.156	0.657
ASO: Retired and inactive (RG)						
ASO: Manager	1.111	0.804	0.169	0.434	0.386	0.262
ASO: Official or Executive	–0.086	1.170	0.941	0.707	0.347	0.042
ASO: Teacher	–0.428	0.519	0.411	0.669	0.218	0.002
ASO: Employee	–0.538	0.608	0.378	0.694	0.302	0.022
ASO: Labourer	0.547	0.791	0.490	1.128	0.365	0.002
SA: Education (RG)						
SA: Health	0.506	0.564	0.371	–0.504	0.284	0.077
SA: Public Administration	0.951	0.677	0.162	–0.189	0.288	0.512
TSH: Owners (RG)						
TSH: Tenant	–0.461	0.258	0.076	–0.098	0.160	0.539
TSH: Free	1.922	0.621	0.002	–0.012	0.262	0.964
TSH: Others	0.909	0.428	0.035	–0.471	0.297	0.113
Non-Cooperative (%C_i = ±100)	1.515	0.506	0.003	2.726	0.339	0.000
Constant	3.327	1.604	0.040	2.481	0.951	0.009
Adjusted R-squared	0.578			0.189		

Note: [a] FI= Fiscal Income. RG= Reference Group. EL=Education Level. MS= Marital Status. ASO= Activity Status and Occupation. SA=Sector of Activity. TSH= Tenure Status of Household.

For under-reporters (Table 4), the regredend $\ln\left(-\%\,C_i\right)$ was affected positively by officials or (chief) executives ($p<0.042$), teachers ($p<0.002$), employees ($p<0.022$), labourers ($p<0.002$), binary variable denoting individuals having $\%\,C_i = -100$ as expected ($p<0.000$), and the constant of the model ($p<0.009$). The positivity for under-reporters implies that the involved individuals tend to conceal or not to reveal their income more than others. Hence, for the constrained sector not only officials or (chief) executives and teachers having high education levels, but labourers and employees too do not cooperate in income surveys, tending to be concealers more than others (Cowell 1985; Benedek and Lelkes 2011). A significant negative coefficient was estimated for tertiary education level ($p<0.008$) only, while the coefficient of workers in the health sector proved to have only a borderline p-value ($p<0.077$). The linear term of FI had a positive coefficient with a borderline p-value ($p<0.075$), showing convex parabolic effects with a high turning point (130,092€). The hypothesis of no structural change between the over- and under-reporters was rejected ($p<0.000$), implying that the two models were statistically different.

5.2. Error model analysis in the unconstrained sector

To explain the variability of measurement errors and/or evasion, the same set of explanatory variables was used, but with some modifications for binary variables. For example, the modality teacher for the activity status and occupation was not included in the model because it had no observations, as teachers belonged to constrained sector. The modalities of sector of activity belonging to constrained sector were not included: education (containing teachers), health, and public administration.

For over-reporters, regredend $\ln\left(+\%\,C_i\right)$ was significantly affected by a few factors with positive or negative coefficients (Table 5). Significant positive impacts were observed for men ($p<0.038$), involving that they were more over-reporting than women. The constant of the model was positive ($p<0.036$). Surprisingly, there was not significant impacts for the binary variable denoting individuals having $\%C_i = +100$. Managers yielded a positive impact with a borderline p-value (0.075). There were not any significant negative impacts. The level of FI proved to have both coefficients statistically different from zero, involving negative concave parabolic effects: a negative and decreasing effect up to 59,835€. Thereafter the effect increased and became positive after about 120,000€. Age did not prove to be influent on the dependent variable, even if it exhibited a tendency to have positive convex parabolic effects.

For under-reporters, regredend $\ln\left(-\%\,C_i\right)$ was affected positively by the binary variable denoting taxpayers having $\%\,C_i = -100$ as expected ($p<0.000$). The constant of the model was positive ($p<0.000$). Only one coefficient was positive, but with a borderline p-value ($p<0.062$): the dichotomous variable denoting the activity sector of mechanical engineering industry (Table 5). No other coefficients, positive or negative, were statistically significant. FI did not prove to be statistically influent on the dependent variable, but it exhibited a tendency to have positive convex parabolic effects. Age did not prove to be statically influent too, but it exhibited a tendency to have negative concave parabolic effects. The models for over- and under-reporters proved to be structurally different ($p<0.000$).

Table 5. Parameter estimates (β) of the multiple regression model for over-reporters and under-reporters in the unconstraint sector

Sample subgroups	Over-reporters: n= 203			Under-reporters n= 381		
Independent variables [a]	β	SE	p-values	β	SE	p-values
Tax Form-770	0.059	0.275	0.831	0.124	0.139	0.374
Tax Form-Unico	0.163	0.268	0.543	0.269	0.166	0.107
FI/50000	–9.332	1.412	0.000	0.740	0.561	0.188
(FI/50000)^2	3.899	1.064	0.000	–0.025	0.315	0.936
Men	0.431	0.206	0.038	–0.120	0.110	0.275
Age/50	2.696	2.804	0.338	–1.444	1.511	0.340
(Age/50)^2	–1.302	1.617	0.422	0.547	0.856	0.523
Foreigner (RG=IT)	–0.100	0.275	0.716	–0.009	0.181	0.960
EL: Primary (RG)						
EL: Lower secondary	0.464	0.418	0.269	–0.070	0.263	0.791
EL: Upper secondary	0.339	0.409	0.409	–0.054	0.260	0.836
EL: Tertiary	0.421	0.441	0.341	0.022	0.287	0.940
MS: Married (RG)						
MS: Single	0.185	0.259	0.476	–0.190	0.135	0.161
MS: Divorced	0.080	0.312	0.797	–0.023	0.206	0.911
MS: Widowed	–0.378	0.760	0.620	0.262	0.380	0.491
ASO: Retired and inactive (RG)						
ASO: Entrepreneur	–0.306	0.998	0.759	–0.223	0.310	0.473
ASO: Manager	1.437	0.802	0.075	–0.279	0.392	0.478
ASO: Official or Executive	0.520	0.522	0.321	–0.328	0.295	0.268
ASO: Self-Employed	0.375	0.599	0.533	–0.069	0.245	0.777
ASO: Employee	–0.245	0.392	0.532	–0.428	0.228	0.062
ASO: Labourer	–0.026	0.357	0.943	–0.195	0.231	0.399
SA: Services & others (RG)						
SA: Mechanical Engineering Ind.	–0.274	0.305	0.371	0.255	0.160	0.112
SA: Other Manufacturing	0.349	0.302	0.250	0.031	0.171	0.858
SA: Trade & Transport	–0.231	0.253	0.363	–0.098	0.156	0.529
SA: Bank & Insurance	0.421	0.405	0.300	0.054	0.214	0.800
TSH: Owners (RG)						
TSH: Tenant	–0.157	0.265	0.553	0.063	0.141	0.656
TSH: Free	–0.113	0.324	0.727	–0.180	0.195	0.356
TSH: Others	0.244	0.394	0.537	–0.267	0.271	0.325
Non-Cooperative ($\%C_i = \pm 100$)	0.028	0.408	0.945	2.042	0.197	0.000
Constant	2.817	1.335	0.036	3.234	0.659	0.000
Adjusted R-squared	0.573			0.460		

Note: [a] for acronyms preceding the variable names see note of Table 4.

5.3. Error model analysis in the total target sample

The total target sample referred to the union of the constrained- (626 units) and unconstrained-sector (584 units). The estimated models for the total sample should yield similar results with respect to regressors, but it was carried out to offer both a description of the total pattern and a different way to evaluate evasion. The estimations of the models' coefficients are reported in Table 6.

For over-reporters, regredend $\ln(+\%C_i)$ was affected positively by single (0.048), widowed (p<0.030), and the dichotomous variable denoting individuals having

$\%C_i = +100$. The constant of the model was positive (p<0.000). Positive coefficient with a borderline p-value resulted for men (p<0.075), tertiary education (p<0.087), and manager (0.064). Negative impacts were observed for retired only, but with a borderline p-value (p<0.094). FI yielded significant coefficients involving negative concave parabolic effects: decreasing up to 58,644€ and thereafter the effect increased and became positive after about 120,000€. The effect of age was not significant and revealed substantially a positive parabolic effect.

Table 6. Parameter Estimates (*β*) of the multiple regression model for over-reporters and under-reporters in the total sample

Sample subgroups	Over-reporters: *n*= 396			Under-reporters *n*= 814		
Independent variables [a]	*β*	SE	p-values	*β*	SE	p-values
Tax Form-770	0.279	0.202	0.167	–0.056	0.104	0.591
Tax Form-Unico	0.213	0.181	0.240	0.123	0.111	0.266
FI/50000	–6.966	1.109	0.000	0.726	0.427	0.090
(FI/50000)^2	2.970	0.911	0.001	–0.012	0.223	0.957
Men	0.251	0.141	0.075	–0.083	0.079	0.298
Age/50	–0.441	1.194	0.712	–0.891	0.761	0.242
(Age/50)^2	0.500	0.528	0.343	0.257	0.358	0.472
Foreigner (RG=IT)	–0.039	0.227	0.865	0.085	0.165	0.607
EL: Primary (RG)						
EL: Lower secondary	0.127	0.215	0.556	–0.166	0.138	0.229
EL: Upper secondary	0.243	0.212	0.252	–0.206	0.132	0.121
EL: Tertiary	0.419	0.244	0.087	–0.304	0.150	0.043
MS: Married (RG)						
MS: Single	0.386	0.195	0.048	–0.077	0.102	0.450
MS: Divorced	0.068	0.238	0.774	0.136	0.140	0.331
MS: Widowed	0.568	0.261	0.030	0.101	0.136	0.459
ASO: Inactive (RG)						
ASO: Entrepreneur	0.101	1.001	0.919	–0.284	0.308	0.356
ASO: Manager	1.164	0.627	0.064	–0.364	0.311	0.242
ASO: Official or Executive	0.281	0.513	0.583	–0.295	0.262	0.260
ASO: Self-Employed	0.077	0.558	0.890	–0.279	0.232	0.230
ASO: Teacher	–0.509	0.766	0.507	–0.283	0.349	0.417
ASO: Employee	–0.377	0.399	0.345	–0.358	0.222	0.107
ASO: Labourer	0.066	0.368	0.858	–0.163	0.222	0.463
ASO: Retired	–0.712	0.424	0.094	–0.653	0.222	0.003
SA: Services & others (RG)						
SA: Mechanical Engineering Ind.	–0.103	0.294	0.727	0.176	0.161	0.275
SA: Other Manufacturing	0.404	0.294	0.170	–0.056	0.174	0.747
SA: Trade & Transport	–0.024	0.247	0.921	–0.172	0.159	0.281
SA: Bank & Insurance	0.476	0.397	0.231	–0.027	0.220	0.901
SA: Education	–0.257	0.586	0.661	0.192	0.266	0.469
SA: Health	0.184	0.371	0.620	–0.266	0.201	0.187
SA: Public Administration	0.248	0.480	0.605	0.137	0.179	0.446
TSH: Owners (RG)						
TSH: Tenant	–0.235	0.181	0.195	–0.025	0.106	0.809
TSH: Free	0.296	0.285	0.299	–0.104	0.156	0.506
TSH: Others	0.414	0.281	0.141	–0.364	0.200	0.068
Non-Cooper. ($\%C_i = \pm 100$)	1.006	0.293	0.001	2.222	0.172	0.000
Constant	3.325	0.744	0.000	3.185	0.418	0.000
Adjusted R-squared	0.546			0.380		

Note: [a] for acronyms preceding the variable names see note of Table 4.

For under-reporters, regredend $\ln(-\%C_i)$ was affected positively by the binary variable denoting taxpayers having $\%\,C_i = -100$, as expected (p<0.000). The constant of the model was positive (p<0.000). Negative coefficients were estimated for people having tertiary education level (p<0.043) and retirees (p<0.003), implying that highly educated people and retirees tended to be less reticent and more cooperative than others. One coefficient was negative, but with a borderline p-values: the residual modality for the tenure status of households (p<0.068). The coefficient of the squared term of FI was not significant and the coefficient of the linear term revealed a borderline p-value (p<0.090), involving essentially a linear effect in the observed range of FI. The effect of age was negative and not statistically significant. Given the previous results, the models for over- and under-reporters were structurally different (p<0.000) for the total sample too.

5.4. Tax evasion estimations

The strategy used to obtain the raw estimates of tax evasion made from the data of Table 2, may be replicated using the estimated models. Here, the first approach was restricted to over-reporters (o-r) only and distinguished between constrained and unconstrained sectors, as indicated in equation (3), $\widehat{\mathrm{TE}}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{u-c}}$. The result was a hypersurface, which was summarised by an evaluation at the mean of regressors, but it required caution because they were dichotomous variables having unobservable means, except for FI and age. Using these means, an average of tax evasion should come out. In fact, the result obtained was $\widehat{\mathrm{TE}}\left(\bar{\mathbf{x}}\hat{\boldsymbol{\beta}}\right)_{\text{u-c}} = 3.91\%$, which was strongly lower than the crude estimation (8.32%) derived from Table 2. The evaluation of tax evasion was yielded through the average of estimated values of $\widehat{\%\,C_{\bullet}}\left(\mathbf{x}_i\hat{\boldsymbol{\beta}}\right)|_{\bullet}$, as expressly indicated by equation (3). The result obtained was $\widehat{\mathrm{TE}}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{u-c}} = 3.56\%$, which was comparable with that obtained at the mean of regressors. The high values of both subsamples had been smoothed by modelling and absorbed by the dichotomous variable denoting taxpayers obtaining $\%C_i = +100$. Sections of the hypersurfaces, at the mean of regressors, leaving FI as independent variable, are reported in Figure 7 for $\widehat{\%\,C_u}(\bullet)|_{\text{o-r}}$ and for $\widehat{\%\,C_c}(\bullet)|_{\text{o-r}}$ to illustrate the differences between the minuend and subtrahend. The resulting trends were disheartening because the expected trend in the unconstrained sector should have been greater than that of the constrained sector, while after about 33,000€ it became lower than the latter. It is possible to create an unbelievable interpretation: as FI increases, the respondents in the unconstrained sector increase the knowledge of their income and give answers more similar to FI than those in the constrained sector.

The second approach considers both over-reporters (o-r) and under-reporters (u-r), relaxing the distinction between constrained- and unconstrained-sectors and using the total sample. The estimation of tax evasion is given by the adapted symbols of equation (4): $\widehat{\mathrm{TE}}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{o-u}} = \overline{\%\,C}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)|_{\text{o-r}} - \overline{\%\,C}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)|_{\text{u-r}}$. Once more, the result is a hypersurface, which will be summarised by an evaluation at the mean of regressors. In this approach, the two types of estimation gave results strongly lower than the corresponding raw estimation (25.93%): $\widehat{\text{TE}}\left(\mathbf{x}\hat{\boldsymbol{\beta}}\right)_{\text{o-u}} = \widehat{\text{TE}}\left(\overline{\mathbf{x}}\hat{\boldsymbol{\beta}}\right)_{\text{u-c}} = 6.49\%$. Sections of the hypersurfaces, at the mean of regressors, leaving FI as independent variable, are reported in Figure 8 for $\%\,\text{C}(\bullet)|_{\text{o-r}}$ and for $\%\,\text{C}(\bullet)|_{\text{u-r}}$. The trends are more marked than those in the Figure 7: after about 28,000€ the values of the unconstrained sector become lower than those of the constrained sector, involving the same previous comment. Given that age resulted non-significant, it was not considered with respect to graphic representation.

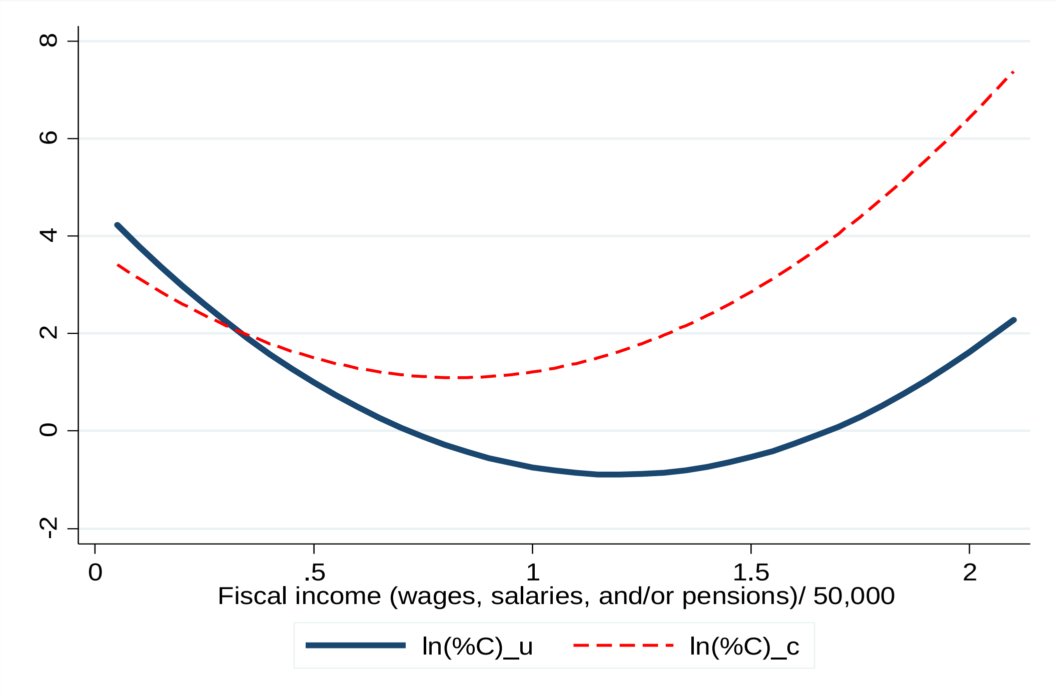

Figure 7. Estimated logarithm of the positive percentage changes of surveyed income and fiscal income for the unconstrained sector (solid line) and the constrained sector (dashed line) at the mean values of regressors in 2011

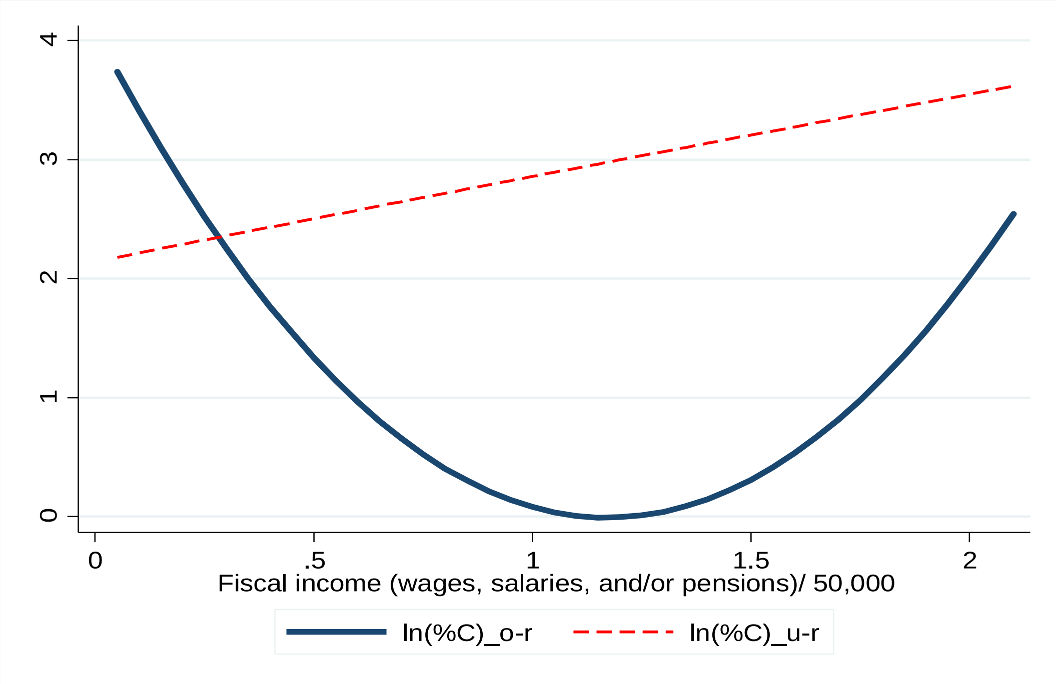

Figure 8. Estimated logarithm of the percentage changes of surveyed income and fiscal income for over-reporters (solid line) and under-reporters (dashed line) of the total sample at the mean values of regressors in 2011

6. Conclusions

The comparison between SI and FI, using their percentage change, showed some outliers, which represented an ordinary and structural condition of these types of data: refusal of providing information about income in a survey, total or partial tax non-compliance through legal avoidance and/or illegal evasion, strong differences between the amount declared in the questionnaire (SI) and the amount filed in the tax form (FI) even when the level of income was low. The two inextricable components constituting the differences between SI and FI were the measurement errors and tax evasion, here including in this term both elusion and erosion too. The analysis carried out on the available data set yielded the following main outcomes.

FI seems more reliable than SI, given that SI resulted generally lower than FI, but in the literature the exact opposite is often assumed. Therefore, the replacement of SI with the corresponding FI, when SI results lower than FI, handling the income surveyed data, is an erroneous practice because it destroys the evaluation of measurement errors, but it seems that some statistical institutes, which generate official statistics and may have access to fiscal databases, apply this procedure in carrying out surveys on income.

The measurement error, estimated through under-reporters, resulted affected by extreme values given by reticent individuals, who declared SI equal to zero, while his/her FI was different from zero. Assuming that these facts (errors and reticence) stick to realities, the measurement errors, in terms of percentage change of SI and FI, evaluated from under-reporters, showed an average amount of 14.52% in the constrained sector and 32.33% (about the double) in the unconstrained sector, which confirmed that the latter (sector) was affected by a more complex non-compliant and non-cooperative behaviour than the former. Moreover, the number of non-cooperative individuals in the sample (67.3%) was strongly higher than that of cooperative individuals (32.7%). Notwithstanding data are referred to a micro-area, the latter are comparable to the corresponding national values. Therefore, it should be stressed that the surveyed data on income are strongly biased by a frequent and noteworthy concealment of its amount.

Tax evasion is pervasive and persistent in many countries and in Italy is particularly widespread and relevant. The phenomenon is rather self-sustaining because if taxpayers think or recognise that tax evasion is common, then they tend to be non-compliant and tax morale decreases (Benedek and Lelkes 2011, p. 553). The empirical main evidences concerned the potential total tax evaders: 9.4% (59 individuals out 626) in the constrained sector and 11.1% (65 individuals out 584) in the unconstrained sector. Among over-reporters in the unconstrained sector, the mean of percentage change (52.85%), containing measurement errors plus tax evasion, was not so much greater than the corresponding mean in the constrained sector (44.53%), involving an amount of 8.32% of tax evasion, which was presumably strongly underestimated. Among under-reporters in the unconstrained sector, the mean of percentage change (|−32.33%|) was more than the double of the corresponding mean in the constrained sector (|−14.52%|). Using the total target sample, the total tax evasion became 25.93%, which seemed comparable with other national estimates. The estimates of tax evasion through the models resulted lower than their corresponding raw ones, because modelling involves a squeeze of outlying values, but it describes differences among subgroups of taxpayers: 3.91% versus 8.32% and 6.49% versus 25.93%. In fact, the models for over-reporters and under-reporters presented a complex pattern depending on FI and age, but the derived estimates of tax evasion did not appear completely believable, as they represent the individual propensity to evade and refer to all individuals: evaders and not evaders.

The results obtained are valuable because they come from a rare opportunity to compare the income survey with corresponding income in the database of fiscal authorities. The simple procedures used above may be easily applied to other similar datasets, when they are available to researchers. There are at least three critical problems affecting the results, which may be solved using different approaches: (a) the characterization of the unconstrained sector, which may be obtained in a more complex way, using multiple variable criteria involving even SI and FI, (b) the definition of reference income and its corresponding extreme situations, (c) the management of outliers. Moreover, the models may be refined still further, but the future challenge consists in using different methods: for example, handling the true income as latent variable or using Bayesian methods to encompass estimation of the proportion of tax evaders and the amount of tax evasion.

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Appendix A

Appendix A.1. SESC-MO3 versus SHIW and other details

The survey on economic and social conditions of households in Modena (SESC-MO3, third wave) is structurally similar to the Survey on Household Income and Wealth (SHIW), which is carried out every two years by the Bank of Italy. It is also similar to the survey carried out by Istat as part of EU-SILC (European Union – Statistics on Income and Living Conditions). As in those surveys, for each sampling unit (the household), three supplementary units were selected as reserves. If the first unit refused to be interviewed or was definitely considered to be untraceable, the interviewer would contact the next unit on the list of three reserves, and so on. The process could end either because one unit on the list was interviewed or because all four units were contacted and all refused to be interviewed or were untraceable. At the end of the survey, four groups of selected units were obtained: respondents or interviewees, refusals, noncontacts or untraceable units, and unused reserves. The data are shown in Table A.1.1.

The success rate of the SESC-MO3 was 32.8% and it was lower than that of the SHIW (52.6%), while in the previous two waves the participation rates were comparable with those of SHIW. The greatest difference concerned the panel component, 49.6% versus 82.2%, but these low values in the SESC-MO3 presumably depended on the interval between the second and third wave, which was six years, while in the SHIW the intervals were always equal to two years. The slightly low success rate of the non-panel component in the SESC-MO3 may be derived by stress on the population generated by the frequent earthquake shocks happening during the period of the survey. Moreover, low participation rates in complex income and wealth surveys were common to other analogous investigations. In fact, for example, the response rates of the surveys carried out by the International Social Survey Program (ISSP) for the Federal Republic of Germany varied over time (1999-2005) and region (west, east), ranging from 34.7% to 51.8%. In 1994, the European Community Household Panel (ECHP) presented response rates varying by country: Luxemburg (40.7%), Germany (47.7%), Ireland (55.8%), Denmark (62.4%), Italy (90.7%), Spain (67.0%) and Greece (90.1%); but responding to the ECHP was mandatory, thus resulting in high participation rates.

The SESC-MO3 used a questionnaire requesting information on many variables and specifically those concerning net earnings, real estate, capital and financial assets over the last year to have the same reference period of the tax form, thereby increasing the length of the recall period and the probability of making errors (Moore et al. 2000; Biancotti et al. 2004), but also helping memory because the interviews were planned to be administered in the period May-October, which overlapped the period May-July of filing tax forms. The period was extended up to December owing to the difficulties deriving from the earthquake, which happened at the end of May, but this final interval was comparable with that of the Survey on Household Income and Wealth carried out by Banca d'Italia (2014): January-August.

The total size of the overall sample included 1960 individuals. With respect to the surveyed sampling units, i.e., the 835 interviewed households, 794 households remained in the sample after the matching: 689 with an Italian head of household out of 721 and 105 with a foreign head of household out of 114. Therefore, 32 Italian households and 9 foreign households were lost during the matching. The percentages of lost households were 4.4% (100×32/721) for Italian households and 7.9% (100×9/114) for foreign households. The unmatched cases refer to many different situations: individuals or households taking up residence in a new town or having fiscal domicile in another town or migrating somewhere else or dying before filing tax form.

Table A.1.1. Absolute Frequencies and Percentages of Households in the SESC-MO3[a] and SHIW[a] by type of sample component and by type of reaction

Type of sample\ Type of reaction	*n*[a] %[a]	Inter-viewees	Refusals	Non-contacts	Total units	In-eligible
SESC-MO3 2012[b]						
Panel	*n*[a]	416	213	211	840	3
	%[a]	49.6	25.3	25.1	100.0	0.4
Non-panel	*n*	419	562	723	1704	
	%	24.6	33.0	42.4	100.0	
SHIW 2014[b]						
Panel	*n*	4611	754	246	[c] 5611	262
	%	82.2	13.4	4.4	100.0	4.7
Non-panel	*n*	3540	3868	2468	[c] 9876	703
	%	35.8	39.2	25.0	100.0	7.1
Total						
SESC-MO3 2012[b]	*n*	835	775	934	2544	3
	%	32.8	30.5	36.7	100.0	0.1
SHIW 2014[b]	*n*	8151	4622	2714	[c] 15487	965
	%	52.6	29.8	17.5	100.0	6.2

Note: [a] SESC-MO3= Survey on Economic and Social Conditions of Households in Modena, third wave. SHIW= Survey on Household Income and Wealth (SHIW) in Italy, carried out by the Bank of Italy. *n* = Absolute frequencies. %= Row percentages.

[b] The year 2012 is the year in which the SESC-MO3 was carried out and the reference period is the year 2011, while the year 2014 of SHIW is the year of publication and the reference period is the year 2012.

[c] The total value does not include the value in the column of ineligible units, corresponding to non-existent households (tax register address no longer valid due to death, change of address or incorrect address). In the SESC-MO3, the ineligible units were included in the noncontact sample.

Appendix A.2: Independent variables and other details

Each independent variable used in the regression model is defined below.

The *types of tax forms* utilized for reporting FI were: the TF-730, TF-*Unico*, and TF-770. The TF-730 is more simplified and utilised by the majority of employed workers (59.8%). The TF-*Unico* is generally used by other categories of taxpayers (19.7%). Both of them contain all details regarding sources of income (land, buildings, employment, and other total taxable income), tax deductions and tax allowances (for a spouse, children, relatives, pension, etc.) that are relevant for the personal income tax form. The TF-770 form (16.2%), which is filed by employers for employees, contains information on the taxable income of employees and denotes here the potential FI of those who are exempt from filing a tax report (given that all the relevant information is provided by the employer). Therefore, this category should show lower FIs than the FIs of the other two categories. Moreover, with respect to the set of the three binary variables, as an example, it may be verified that the sum of their relative frequencies (column of means for the total in Table A2.1) resulted as (0.598 + 0.197 + 0.162 =) 0.957 involving 4.3% of missing values of type of tax form, given by 100×(1−0.957) = 100×0.043. Therefore, the type of tax forms generated three binary variables: TF730, TF-Unico, and TF770. Each one assumed the value of 1 when the individual used the indicated type of form and 0 otherwise. The TF730 category was assumed as the Reference Group (RG).

Age and *Fiscal Income* (FI) were introduced into the model through a second-degree polynomial form ($a x^2 + b x + c$) to capture some nonlinearities in the behaviours of individuals of different ages and FI values. The vertex of the quadratic function is given by $x_T = -b / 2a$, representing the turning point. The original FI values were divided by 50,000. In symbols, $x_{\mathrm{FI}} = \mathrm{FI}/50{,}000$. Therefore, for example, in the sample of over-reporters in the constrained sector, the increase of $\ln\left(+\%\,\mathrm{C}_i\right)$ with respect to FI turned around at $x_T = -(-6.058)/\ [2\times(3.484)]\approx$ 0.8694 corresponding to FI= $x_T \times 50{,}000 = 0.8694\times 50{,}000 = 43{,}470$€.

Gender was transformed into the dichotomous variable “men”, assuming 1 for men and 0 for women. The latter formed the RG. The proportion of men was 0.472 (in the column of total mean of Table A2.1) and that of women was 0.528 given by (1−0.472).

Foreigners were labelled by one and zero otherwise.

Education Level (EL) was summarised by the usual four categories, each one generating a dichotomous variable: primary (assumed as the RG), lower secondary, upper secondary, and tertiary education. Herein below, the generation of dichotomous variables will be implicitly assumed.

Marital Status (MS) included four categories: single, married (RG), divorced, and widowed.

Activity Status and Occupation (ASO) resulted from the combination of the two concepts and was recoded into ten categories: entrepreneurship (1.5%), manager (2.8%), officials or (chief) executives (5%), self-employed (3.9%), teacher (5.4%), employee (21.4%), labourer (18.7%), unemployed (3.4%), retiree (36%), and inactive (2.1%). The latter category together with unemployed were assumed as RG and termed “inactive” only, given their low frequencies, but for the models in the constrained- and unconstrained-sector the retiree was added to RG because the frequencies of unemployed and inactive were negligible.

Sector of Activity (SA) presented modalities based on the statistical classification of economic activities (NACE Rev. 2 2008, from the French *Nomenclature statistique des Activités économiques dans la Communauté Européenne*), but they underwent a slight modification/ adaptation. They were grouped according to an ordinary categorisation. The Section C (manufacturing) was split into two groups to obtain a suitable aggregation in keeping with the local economy. The first group was termed "mechanical engineering industry" (8.8%) and included the divisions (two-digit numerical codes) from 25 (manufacture of fabricated metal products, except machinery and equipment) to 30 (manufacture of other transport equipment) and 33 (repair and installation of machinery and equipment). The second group was termed "Other manufacturing" (7.0%) and included the other divisions of Section C. Sections G, H, and I were grouped and termed "trade & transport" (10.1%). Section K became "bank & insurance" (3.4%). Sections J, L, M, N, R, and S were grouped and named "services" (6.1%). The terms service sectors or services are generally referred to economic activities covered by Sections G to S of NACE Rev. 2 (2008), but a distinction more detailed than the standard grouping was adopted to account for specificities of the local distribution of employment. Section P remained with the original denomination, which was "education" (7.1%), and Section Q was simply termed "health" (4.0%). Section O was briefly named "public administration" (5.2%). The remaining Sections were grouped in the modality "other sectors" (6.7%). The sum of the percentages was 58.4% because the economic activities pertained to people in activity only. In fact, in the sample there were unemployed (3.4%), retired (36.0%), and inactive (2.1%). The sum of all percentages became 100% rounding to nearest whole number. The categories of services and "other sectors" were assumed as RG, but education was assumed as RG for the models in the constrained sector, because the latter included only three sectors: education, health, and public administration.

Tenure Status of Households (TSH) distinguished between owners (RG), tenants or subtenants paying rent at prevailing or market rate, free accommodations, and other special situations.

Non-Cooperation for SI/FI was a binary variable indicating people who refused to give information about SI to interviewer or FI to fiscal authorities; in that case its value was 1 and 0 otherwise.

The reference group, in synthesis, was constituted by individuals being women, Italian, primary school educated, married, inactive, workers in other sectors of activity, owners for tenure status of household, in a building with a number of flats greater than ten, cooperative in providing information about SI/FI. However, the reference groups of the activity status and occupation (ASO) and the sector of activity (SA) depended on the frequencies of the categories indicated in the Table A2.1. If the designated reference groups showed low or null frequencies, then they had been combined with other categories. For example, in the models for unconstrained sectors, the retirees were combined with the inactive persons and acted as reference group, but both had not been attributed a sector of activity and this fact may affect the designation of the RG of the sector of activity.

Table A2.1. Descriptive statistics of regressors by type of fiscal sector

Type of Sector	CS: *n*=626		US: *n*=584		Total: *n*=1210	
Variable	Mean	SD	Mean	SD	Mean	SD
TF-730 (RG) [a]	0.679	0.467	0.512	0.500	0.598	0.490
TF-770	0.133	0.339	0.265	0.442	0.197	0.398
TF-Unico	0.153	0.361	0.171	0.377	0.162	0.369
Fiscal Income: FI1 = (FI/50000)	0.352	0.251	0.366	0.309	0.358	0.281
Fiscal Income: FI2 = (FI/50000)^2	0.187	0.370	0.229	0.435	0.207	0.403
Man (RG = Woman)	0.399	0.490	0.550	0.498	0.472	0.499
Age1 = (age/50)	1.286	0.302	0.838	0.238	1.070	0.353
Age2 = (age/50)^2	1.744	0.750	0.759	0.411	1.269	0.784
Foreigner (RG = Italian)	0.024	0.153	0.202	0.402	0.110	0.313
EL: Primary (RG)	0.254	0.436	0.048	0.214	0.155	0.362
EL: Lower secondary	0.163	0.370	0.214	0.411	0.188	0.391
EL: Upper secondary	0.310	0.463	0.509	0.500	0.406	0.491
EL: Tertiary	0.273	0.446	0.229	0.421	0.252	0.434
MS: Single	0.125	0.331	0.327	0.470	0.222	0.416
MS: Married (RG)	0.626	0.484	0.579	0.494	0.603	0.489
MS: Divorced	0.070	0.256	0.077	0.267	0.074	0.261
MS: Widowed	0.179	0.384	0.017	0.130	0.101	0.301
ASO: Entrepreneur			0.031	0.173	0.015	0.121
ASO: Manager	0.026	0.158	0.031	0.173	0.028	0.165
ASO: Official | Executive	0.035	0.184	0.065	0.247	0.050	0.217
ASO: Self-Employed	0.016	0.125	0.063	0.244	0.039	0.193
ASO: Teacher	0.104	0.305	0.000	0.000	0.054	0.226
ASO: Employee	0.107	0.309	0.329	0.470	0.214	0.410
ASO: Labourer	0.029	0.167	0.356	0.479	0.187	0.390
ASO: Unemployed	0.000	0.000	0.070	0.256	0.034	0.181
ASO: Retiree	0.684	0.465	0.012	0.109	0.360	0.480
ASO: Inactive (RG)			0.043	0.203	0.021	0.142
SA: Mechanical Engineering Industry			0.182	0.386	0.088	0.283
SA: Other Manufacturing			0.146	0.353	0.070	0.256
SA: Trade & Transport			0.209	0.407	0.101	0.301
SA: Bank & Insurance			0.070	0.256	0.034	0.181
SA: Services			0.127	0.333	0.061	0.240
SA: Education	0.137	0.345			0.071	0.257
SA: Health	0.078	0.269			0.040	0.197
SA: Public Administration	0.101	0.301			0.052	0.222
SA: Other Sectors (RG)			0.139	0.346	0.067	0.250
TSH: Tenant	0.142	0.350	0.286	0.452	0.212	0.409
TSH: Owner (RG)	0.791	0.407	0.584	0.493	0.691	0.462
TSH: Free	0.034	0.180	0.077	0.267	0.055	0.227
TSH: Other	0.034	0.180	0.053	0.224	0.043	0.203

Note: [a] CS= Constrained Sector. US= Unconstrained Sector. TF= Tax Form. RG= Reference Group in the regression model. EL= Education Level. MS= Marital Status. ASO= Activity Status and Occupation. SA= Sector of Activity from NACE Rev. 2 (2008). TSH= Tenure Status of Household.