Cheating in Europe: Underreporting of Self-Employment Income in Comparative Perspective

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Abstract: Various national studies have used the expenditure method (Pissarides & Weber 1989) to estimate income underreporting by the self-employed. Their differences in the model specifications and the collection of the underlying micro-data limit however their usefulness for international comparisons. This paper is the first to apply the expenditure method to a range of countries using harmonised microdata and a common model specification to maximise cross-country comparability. We considerably extend the number of countries studied with this method and contribute to the scarce comparative literature on tax non-compliance in general. Our estimates show substantial variation in income underreporting across countries with the highest country-level estimates exceeding 40% of self-employed household income on average. We also find some regional clustering, though the shares of underreporting do not appear to be related to the development level of the countries.

Keywords: income underreporting, self-employment, expenditure method, tax compliance

JEL codes: H26, E21, E26, H24

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1. Introduction

Estimates of the size of the unreported economy are important for tax policy and auditing schemes, and also for economic and social policy-making in general. This is particularly the case with underreporting of income by the self-employed, since it is likely to be relatively prevalent due to the lack of third-party reporting and the substantial discretion the self-employed have about the information they make available to the tax and statistics authorities. Slemrod (2007) reports data for the USA in 2001 showing that the tax gap, the share of the taxable base not reported to the tax authorities, is likely to be marginal for wage and salary income, while it is large for capital gains and very substantial for business-related income. The underreporting of income is likely to stem from both underreporting of gross income and over-reporting of deductions and other offsets. A study of randomised tax audits in Denmark documents that income underreporting was much more prevalent amongst the self-employed than among the employed and it is concluded that effective auditing of the self-employed is crucial for their compliance (Kleven et al. 2011).

The concerns about income underreporting of self-employed have only strengthened after the global financial crisis in the 2000s, since the subsequent recession led to notable changes in employment opportunities in many countries. In the UK, the jobs recovery after the recession has in large part been driven by growth in the number of self-employed (Hatfield 2015). In other EU countries, the share of the active population that is self-employed has remained stable but policy discussions often refer to a perceived need for more emphasis on entrepreneurship and self-employment (European Commission 2016). Increased emphasis on self-employment after the crisis and the absence of third party reporting underscore the importance of assessing how much the self-employed underreport income and evade taxation. Comparisons across countries can provide additional insights and context for policymaking and could be particularly valuable for European countries, as they share many economic and institutional features while their tax and auditing schemes are largely national.

The most widely used method to estimate income underreporting of the self-employed, the so-called expenditure method, originates from Pissarides & Weber (1989) and aims to infer income gaps from household expenditure patterns. While the method has been used for a number of countries in Europe and elsewhere (Schuetze 2002, Lyssiotou et al. 2004, Johansson 2005, Besim & Jenkins 2005, Engström & Holmlund 2009, Martinez-Lopez 2013, Hurst et al. 2014, Kukk & Staehr 2014, Paulus 2015, Ekici & Besim 2016, Kim et al. 2017, Engström & Hagen 2017, Kukk & Staehr 2017, Cabral et al. 2018, Nygård et al. 2018, Schmutz 2018), the applications have focussed on individual countries and feature substantial differences in model specifications and collection of underlying household micro-data. These differences seriously impede international comparisons based on national studies and there is a notable lack of comparative studies using harmonised data sources and a common methodology.

Our paper aims to fill that gap by using the 2010 European Union Household Budget Survey to estimate the extent of income underreporting by the self-employed in various EU countries in a common modelling framework. As a further contribution, we extend a relatively short list of countries covered previously and provide estimates of income underreporting by the self-

employed using the expenditure method for a large number of EU countries for which such estimates have not been available. The paper is also among the first to apply the expenditure method on data collected after the outbreak of the global financial crisis when many EU countries experienced deep recessions.

We contribute to the scarce comparative literature on tax compliance which uses various methodologies and microeconomic data sources. Previous results have often exhibited substantial heterogeneity even across neighbouring countries where the economic situation is relatively similar and have been puzzling in the sense that no clear correlation between the extent of unreported economic activities and the level of development has been found. For example, the results of a pan-European survey on the provision of undeclared work and the consumption of goods or services produced using undeclared work (Eurobarometer 2014) show no clear relationship between the levels of economic development of the countries and the extent of undeclared work. Hazans (2011) uses data from the European Social Survey for 2004–2009 and concludes that the share of informal employment varies substantially across countries and has no clear regional patterns.[1] In both of these surveys, respondents are directly asked about their undeclared activities, but the sensitivity of the topic may raise doubts about the validity and reliability of responses. It is therefore imperative and instructive to assess the extent of un(der)reporting of economic activities using alternative methods, including indirect ways of measurement such as the expenditure method.

Our estimates show that the share of income not reported by the self-employed is relatively large in many European countries and there is substantial variation across the countries. The baseline estimates of the average share of unreported self-employment income range from under 10 percent to more than 40 percent of true income across the sample countries. The results are consistent with previous studies using the expenditure method for individual countries where these overlap with our country coverage, and this seems to corroborate the results found in this study using data from the EU-HBS. There is some regional clustering with eastern European countries showing higher degrees of underreporting compared to countries in southern Europe. We also find that the estimates are robust to changes in the model specification, estimation method and the choice of instruments, but exhibit some sensitivity to sample restrictions and the criterion used to define self-employed households.

The rest of this paper is organised as follows. Section 2 briefly reviews previous studies of income underreporting by the self-employed using the expenditure method. Section 3 presents the empirical model and estimation methodology used in this paper. Section 4 discusses the dataset and features of the data. Section 5 presents the baseline results using different estimation methods. Section 6 contains various robustness checks. The results and their broader context are discussed in Section 7. Finally, Section 8 concludes.

[1] Surveys seeking to map public attitudes to tax morality also yield diverse results across countries in Europe. Lago-Peñas & Lago-Peñas (2010) use data for 2005 from the European Social Survey and show that a much larger share of respondents in Estonia and Portugal than in Belgium and Germany support the statement that citizens should not cheat on their taxes.

2. Studies using the expenditure method

Pissarides & Weber (1989), or P&W, devised an inventive method to estimate the extent of income underreporting by the self-employed relative to a reference group perceived to be less prone to underreporting. The main idea is that households are likely to report consumption expenditures correctly to the statistics authorities collecting data for the household budget survey, while some households may choose to underreport their income.

Household budget surveys typically require households to collect detailed data on their consumption spending using diaries or scanners, so consumption data are likely to be quite precise. However, household budget surveys typically do not require documentation of income data and this means that households can underreport their true income, an option which may be tempting if they have underreported income to the tax authorities and are concerned that income data reported to the statistics authorities may somehow be shared with the tax authorities. P&W argue that the self-employed are a group that may be particularly prone to this form of underreporting. If the self-employed and the employed have similar preferences for consumption, then it becomes possible to back out the share of income not reported by the self-employed.

The methodology has been used in a number of studies for individual countries, but has not been applied consistently to study and compare underreporting in a wide set of countries. Table 1 provides an overview of the key studies in the field, which mainly focus on European and North American countries. The share of unreported income in true income is typically reported as an interval because the variances of fluctuations in permanent income and the underreporting factors cannot be disentangled; see also the detailed discussion of the methodology in Section 3.

Table 1. Overview of key studies using the expenditure method

	Country	Database and time sample	Definition of self-employment	Unreported income as share of true income[a]
Pissarides & Weber (1989)	UK	Family Expenditure Survey, 1982	Share of business income ≥ 25%	Blue collar: 34–39% White collar: 22–35%
Schuetze (2002)	Canada	Family Expenditure Survey, 6 years within 1969–1992	Share of business income ≥ 30%	6–22%
Lyssiotou et al. (2004)	UK	Family Expenditure Survey, 1993	Main source of income from self-employment	Blue collar:[b] 27–29% White collar:[b] 8–21%
Johansson (2005)	Finland	Household Expenditure Survey, 1994–1996	Status as self-employed	One person self-employed: 9–19% Two people self-employed: 27–32%
Besim & Jenkins (2005)	Northern Cyprus	Households Consumption Expenditure Survey, 1998–1999	Status as self-employed; privately employed	Self-employed:[c] 11–13% Privately employed:[c] 10–14%
Engström & Holmlund (2009)	Sweden	Household Budget Survey, 1999–2004	Status as self-employed	Incorporated business: 14–15% Unincorporated business: 30–33%
Martinez-Lopez (2013)	Spain	Household Budget Surveys, 2006–2009	Status as self-employed	15–25%, sensitive to definition of the self-employed

	Country	Database and time sample	Definition of self-employment	Unreported income as share of true income[a]
Hurst et al. (2014)	USA	Consumer Expenditure Survey 1980–2003, Panel Study of Income Dynamics, 1980–1997	Status as self-employed	CEX: 25% PSID: 28-29%
Kukk & Staehr (2014)	Estonia	Household Budget Survey, 2002–2007	Business income ≥ 20%	62% when households with 0–20% business income excluded; lower if the cut-off is reduced
Paulus (2015)	Estonia	Estonian Social Survey and tax register, 2008	Status as self-employed	Survey: 20–44% Tax register: 48–71%
Ekici & Besim (2016)	Northern Cyprus	Households Consumption Expenditure Survey, 2008	Status as self-employed; privately employed	Self-employed:[c] 21% Privately employed:[c] 14%
Kim et al. (2017)	Russia, South Korea	Longitudinal Monitoring Survey 1994–2001 (Russia), Labour Income Panel Survey, 2000–2005 (Korea)	Status as self-employed	Russia: 28% Korea: 29%
Engström & Hagen (2017)	Sweden	Swedish Household Budget Survey, longitudinal tax database LINDA, 2003–2009	Self-employment income > 0	15-24%
Kukk & Staehr (2017)	Estonia	Household Budget Survey, 2002–2007	Share of business income ≥ 0%; status as self-employed	Share of business income: 43% Status as self-employed: 28% Self-employed with business income: 53–56%
Cabral et al. (2018)	UK	Living Costs and Food Survey, 2010-2012	Share of business income ≥ 25%, status as self-employed	Share of business income: 20% Status of self-employment: 22%
Schmutz (2018)	Switzer-land	Household Budget Survey, 2006-2011	Share of business income ≥ 25%; status as self-employed	Share of business income: 16-29% Status of self-employment: 13-25%
Nygård et al. (2018)	Norway	Survey of Consumer Expenditure, 2003-2009 & 2012	Status as self-employed; wage earners with possibility for tax evasion	Status as self-employed:[d] 13% Wage earners with possibility for tax evasion:[d] 3%

[a] Main estimates with instruments where available, reported as the share of true income.
[b] Lyssiotou et al. (2004) find larger underreporting using a non-parametric method and a demand system approach.
[c] The reference group consists of households where the household head is publicly employed.
[d] The reference group consists of wage earners deemed to be without possibility for evasion based on their educational background.
Sources: Updated and revised from Kukk & Staehr (2014) and Paulus (2015); see also Schmutz (2018).

All studies focus on one particular country with the exception of Kim et al. (2017), who produce estimates for two countries, Russia and South Korea, though at different time periods and using nation-specific data sources. Cabral et al. (2018) and Schmutz (2018) provide

estimates for the UK and Switzerland, respectively, but also produce results for different regions with the countries considered.[2]

The majority of the studies use national household budget or expenditure surveys in which food consumption data are collected in detail. Paulus (2015) uses data from the Estonian version of the EU-SILC and register data from the Estonian tax authorities. Most of the published studies use data from before the mid-2000s although Cabral et al. (2018), Schmutz (2018) and Nygård et al. (2018) use datasets with some or all observations from after the global financial crisis and the subsequent recession. The data are typically cross-sectional and different waves are pooled so that the average rate of income underreporting over the sample period is computed.

The studies differ in the way they have defined or identified self-employed households. One approach is the one introduced by P&W who define households as self-employed if the reported share of business income in total reported income exceeds a given threshold. Schuetze (2002), Kukk & Staehr (2014, 2017) and Engström and Hagen (2017) use the same definition with different cut-off points. Lyssiotou et al. (2004) define households as self-employed if their main source of income is from self-employment. The second approach relies on the self-reported employment status of the household head and has been used by Besim & Jenkins (2005), Johansson (2005), Engström and Holmlund (2009), Martinez-Lopez (2013), Hurst et al. (2014), Paulus (2015) and Ekici & Besim (2016). Some studies have also considered the employment status of both adults (Johansson 2005), at least one member (Engström & Holmlund 2009, Cabral et al. 2018). Engström & Hagen (2017), Kukk & Staehr (2017), Cabral et al. (2018) and Schmutz (2018) compare the results across different definitions.

It is important to underscore that the estimates of underreporting by the self-employed are *additional to* the possible underreporting by the chosen reference group. Households in the reference group may indeed also underreport their income in the survey. The way the reference group is defined does not rule out that the households in this group also underreporting their income. The expenditure method cannot be used to estimate the possible underreporting by the reference group but only the *additional* underreporting of the self-employed relative to the reference group of wage earners.

Many studies use a reference group made up of households where the household head is employed. Some studies have imposed more restrictions on the reference group. Hurst et al. (2014) exclude households where the reference person is a wage earner but the spouse (if present) is self-employed. Besim & Jenkins (2005), Paulus (2015) and Ekici & Besim (2016) produce estimates where the reference group is restricted to public sector employees. Nygård et al. (2018) argue that wage earners that are educated within construction and repair work are able to work without reporting their income and therefore leave out these workers from the reference group.

[2] Cabral et al. (2018) find very different underreporting results across different regions in the UK, while Schmutz (2018) find very small differences across cantons in Switzerland.

The expenditure method relies on the permanent income hypothesis, which posits that consumption is a function of the permanent income of households. Many studies, including the one by Pissarides and Weber (1989), do not have access to a measure of permanent income and this leads to a knotty identification issue since the variances in underreporting and in temporary income across households cannot be disentangled. The expenditure method addresses this issue by imposing some assumptions about these variances and this makes it is possible to calculate upper and lower bounds for the share of true income that is not reported. Most studies cited in Table 1 only have data available on current income and therefore provide intervals for the share of income underreporting. Exceptions include Kim et al. (2017) and Engström & Hagen (2017) who have available panel data and therefore are able to compute proxy measures of permanent income, which makes it possible to produce point estimates of the extent of underreporting. Kukk & Staehr (2014, 2017) use a self-reported measure of regular income as an alternative. Other studies produce simplified point estimates by using various proxies of permanent income; see Besim & Jenkins (2005), Engström & Holmlund (2009), Martinez-Lopez (2013), Hurst et al. (2014), Ekici & Besim (2016) and Nygård et al. (2018).

When the results of earlier studies are considered, five features stand out. First, the studies generally find the shares of income unreported by the self-employed to be quite large, averaging around 20–30 per cent of true income across the studies. It should be noted however that estimates of the overall size of the shadow economy are also substantial (Schneider 2007, Alm & Embaye 2013) and a large share of the shadow economy is likely to be linked to business or self-employment income that is left unreported. The relatively large share of income underreporting reported in the published studies that use the expenditure method may however also reflect a publication bias, where studies with statistically and economically significant results end up being published while others may remain unpublished, emphasising further the importance of our comparative study.

Second, there is substantial variation in the estimates within and across different studies. The estimates vary for different samples such as white-collar and blue-collar workers, households with one person self-employed or two persons self-employed, incorporated or unincorporated businesses, the way self-employed households are defined, etc. The differences in the results across different sample groups suggest that the prevalence of income underreporting varies substantially depending on the method used to define the self-employed.

Third, although most studies pool data over several years and estimate the average underreporting of income, some studies provide estimates for several time periods. Engström & Holmlund (2009), Kukk & Staehr (2014) and Schmutz (2018) obtain relatively similar results for various sample periods. Schuetze (2002) obtains fairly stable results from 1969 to 1992 in Canada, although the extent of underreporting is found to be lower in 1974–1984, a time when the economy was hit by oil price shocks and recessions. Martinez-Lopez (2013) finds that income underreporting in Spain was higher during the economic boom in 2006–2007 than during the recession in 2008–2009.[3]

[3] Kim et al. (2017) find large variation in the year-by-year estimates for Russia in 2000–2005 and for South Korea in 1994–2001 but it is not straightforward to match the varying results with the business cycle.

Fourth, the variety of sample criteria and model specifications makes it virtually impossible to compare the results across countries; see also Schmutz (2018). The diversity in the results may stem from the use of different datasets and methodological choices or they may reflect genuine differences across the countries in the underreporting of income by the self-employed. This uncertainty may be eliminated in our study given that we use data that are harmonised across countries and run the estimations with the same model specification and with the same sample selection criteria.

Fifth, the results across the different countries do not suggest clear patterns across levels of development or regions. Table 1 shows that the estimates of the underreporting shares are substantial for countries with high per capita GDP such as the USA and the UK and smaller for a country such as Spain with substantially lower per capita GDP. Indeed, very small underreporting shares are found by Besim & Jenkins (2005) and Ekici & Besim (2016) for Northern Cyprus, one of the poorest regions in Europe. The diversity in the results across the countries is in line with the discussion in Section 1 pointing out that the estimates of under-reporting based on microeconomic data often do not bear any direct relation to the level of development or the economic and administrative structure of the countries considered.

3. Methodology and estimation

3.1. The expenditure method

The starting point for Pissarides & Weber (1989) is the estimation of a food consumption function or Engel curve using household data. Households are assumed to smooth their food consumption over time so that it depends on the permanent disposable income of the household. The Engel curve for household *i* can be expressed as follows:

$$\log c_i = \alpha + \beta \log y_i^{\mathrm{P}} + X_i \phi + \varepsilon_i \tag{1}$$

The variable c_i is the spending on food, y_i^{P} is the true permanent income of the household, X_i is a vector of control variables and ε_i is an error term. The control variables account for household characteristics that are likely to affect consumption, such as household composition and the age of household members. The term α is a constant, β is the marginal propensity to consume and ϕ is a vector of the coefficients of the control variables.

Some studies have an income variable available that may be a good proxy for permanent income but in EU-HBS only current income is available so we follow P&W and define the variable p_i as the fraction of true current income relative to true permanent income. The logarithm of true current income y_i can then be expressed as:

$$\log y_i = \log p_i + \log y_i^{\mathrm{P}} \tag{2}$$

The variable p_i is assumed to follow a log-normal distribution over the households in the sample. If the mean of $\log p_i$ is labelled μ_p, $\log p_i$ can be written as $\log p_i = \mu_p + u_i$, where the disturbance u_i satisfies the conditions that $\mathrm{E}[u_i] = 0$ and $\sigma_u^2 = \mathrm{Var}(u_i)$. The variance of the disturbance for the self-employed group ($\sigma_{u|S}^2$) is expectedly larger than the variance for the group of wage earners ($\sigma_{u|W}^2$), so $\sigma_{u|S}^2 > \sigma_{u|W}^2$, a feature we return to when we consider the possible range of the mean underreporting factor.

Given the way consumption data are reported to household budget surveys, it is conceivable that the households report their disposable income correctly, while they could hide part of their true disposable income, especially if they fear that data may be shared with the tax authorities. The factor by which the reported current income y_i' has to be multiplied to obtain the true current income y_i is labelled k_i so the relationship between true and reported current income can be written as:

$$\log y_i = \log k_i + \log y_i' \tag{3}$$

Household i underreports its true income if $k_i > 1$ and reports accurately if $k_i = 1$. It is assumed that the factor follows a log-normal distribution so that $\log k_i = \mu_k + \nu_i$ with $\mathrm{E}[\nu_i] = 0$ and $\sigma_\nu^2 = \mathrm{Var}(\nu_i)$. All households in the reference group of wage earners are assumed to have $k_i = 0$ so by definition $\sigma_{\nu|\mathrm{W}}^2 = 0$ for this group, while underreporting can occur in the group of self-employed, which means that $\sigma_{\nu|\mathrm{S}}^2 > 0$.

It follows from eq. (2) and (3) that the true permanent income y_i^{P} can be expressed in logarithmic form as:

$$\log y_i^{\mathrm{P}} = \log y_i' + \log k_i - \log p_i = \log y_i' + (\mu_k + \nu_i) - (\mu_p + u_i) \tag{4}$$

When the expression for the true permanent income in eq. (4) is inserted into eq. (1), the Engel curve becomes:

$$\log c_i = \alpha + \beta \log y_i' + \beta(\mu_k - \mu_p) + X_i\phi + \beta(\nu_i - u_i) + \varepsilon_i \tag{5}$$

We are interested in the average factor of income underreporting for the self-employed, which we denote $\bar{k} = \mathrm{E}[k_i \mid \mathrm{S}]$. The mean μ_p cannot be identified, but since p_i follows a log-normal distribution, we know that $\mu_{p|\mathrm{S}} - \mu_{p|\mathrm{W}} = -\frac{1}{2}(\sigma_{u|\mathrm{S}}^2 - \sigma_{u|\mathrm{W}}^2) \leq 0$ if we follow P&W and assume that the means of p_i are the same for the two groups. The inequality comes from the assumption about the different variances of u_i for the two groups.

The term $\beta(\mu_k - \mu_p)$ in eq. (5) is replaced by γD_i, where D_i is a dummy variable taking the value $D_i = 1$ for households that are self-employed and $D_i = 0$ for households in the reference group. The coefficient γ shifts the intercept for the self-employed relative to the wage earners. The substitution implies that $\gamma = \beta(\mu_k + \frac{1}{2}(\sigma_{u|\mathrm{S}}^2 - \sigma_{u|\mathrm{W}}^2))$, where we have used $\mu_{p|\mathrm{S}} - \mu_{p|\mathrm{W}} = -\frac{1}{2}(\sigma_{u|\mathrm{S}}^2 - \sigma_{u|\mathrm{W}}^2)$. Rearranging the terms, the mean underreporting factor by the self-employed, $\bar{k}$, can then be expressed as:

$$\bar{k} = \mathrm{E}[k_i \mid \mathrm{S}] = \exp\left(\frac{\gamma}{\beta} + \tfrac{1}{2}(\sigma_{\nu|\mathrm{S}}^2 + \sigma_{u|\mathrm{W}}^2 - \sigma_{u|\mathrm{S}}^2)\right) \tag{6}$$

The mean underreporting factor for the self-employed is the exponential of the coefficient of the self-employment dummy over the marginal propensity to consume plus an adjustment term comprising the variance of the underreporting of the self-employed and the variances of the transitory income for both groups. The variance terms are not known, so it is generally not possible to compute a point estimate of the mean underreporting factor $\bar{k}$. However, P&W

show that it is possible to establish a range within which $\bar{k}$ must lie under various assumptions.

It follows from eq. (5) that the reported income is endogenous as the error term is $\beta(v_i - u_i) + \varepsilon_i$. This suggests that the reported current income should be instrumented in the food regression. The instrumentation may be carried out for the two groups separately, in which case there would be residuals ξ_i with variances related to the variance $\sigma^2_{u|S}$ and $\sigma^2_{u|W}$.

The residual variance from the reduced form regressions for income, ξ, is the sum of three error components: i) deviations in current income from permanent income; ii) deviations of current income from permanent income u_i; and iii) deviations of reported income from current income v_i. Under the assumption that the variance of permanent income is the same for the self-employed and for wage earners, the difference between the variance of the residuals for the self-employed $\sigma^2_{\xi|S}$ and the variance of the residuals for the wage earners $\sigma^2_{\xi|W}$ can be written as:

$$\sigma^2_{\xi|S} - \sigma^2_{\xi|W} = \sigma^2_{u|S} + \sigma^2_{v|S} - 2\text{Cov}(u, v|S) - \sigma^2_{u|W} \tag{7}$$

We follow P&W and derive lower and upper bounds for $\bar{k}$ under the assumption that $\text{Cov}(u, v|S) = 0$, which implies that for the self-employed there is no relationship between the deviations of current income from permanent income u_i and the deviations of reported income from current income v_i. The *lower bound* for underreporting factor can then be found as $\bar{k}_L = \exp(\gamma/\beta - \frac{1}{2}(\sigma^2_{\xi|S} - \sigma^2_{\xi|W}))$, which follows when we use that the lowest possible value of the variance $\sigma^2_{v|S}$ is 0 and insert this into eq. (7), and then insert the resulting relationship into eq. (6). The *upper bound* is $\bar{k}_U = \exp(\gamma/\beta + \frac{1}{2}(\sigma^2_{\xi|S} - \sigma^2_{\xi|W}))$ which emerges from eqs. (7) and (6) when we use that $\sigma^2_{u|W}$ can at most take the value $\sigma^2_{u|S}$. In conclusion, the mean underreporting factor of the self-employed is bounded by the following interval:

$$\bar{k} \in \left[\bar{k}_L, \bar{k}_U\right] = \left[\exp\left(\frac{\gamma}{\beta} - \frac{1}{2}(\sigma^2_{\xi|S} - \sigma^2_{\xi|W})\right), \exp\left(\frac{\gamma}{\beta} + \frac{1}{2}(\sigma^2_{\xi|S} - \sigma^2_{\xi|W})\right)\right] \tag{8}$$

The lower bound $\bar{k}_L$ may be considered a quite extreme or unlikely outcome given that it requires that $\sigma^2_{v|S} = 0$, implying that the underreporting factor is identical for all self-employed households. The lower bound is clearly a very conservative estimate with little practical relevance.

A special case emerges when the variances of the residuals in the instrumentation step are identical for the two groups, narrowing the bounds into a simple point estimate calculated as:[4]

$$\bar{k}_0 = \exp\left(\frac{\gamma}{\beta}\right) \tag{9}$$

[4] This special case is also considered by e.g. Besim & Jenkins (2005), Engström & Holmlund (2009), Martinez-Lopez (2013), Hurst et al. (2014) and Ekici & Besim (2016).

In studies following the P&W approach it is customary to report not the underreporting factor but the underreporting share, which is the share of true income not reported. The under-reporting factors in eqs. (8) and (9) can be converted into the shares of true income not reported using the formulas:

$$\begin{aligned} &\text{“Lower share”} = (\bar{k}_L - 1)/\bar{k}_L \\ &\text{“Upper share”} = (\bar{k}_U - 1)/\bar{k}_U \\ &\text{“Simple share”} = (\bar{k}_0 - 1)/\bar{k}_0 \end{aligned} \tag{10}$$

When considering the different measures of the share of income underreporting in eq. (10), it is important to bear in mind that they all pertain to the same underlying estimation results and merely are derived under different assumptions about the variances of the underreporting and income processes.

3.2. Estimations methodology

Rewriting the Engel curve in eq. (5) by replacing $\beta(\mu_k - \mu_p)$ with γD_i and collecting the three error terms into one labelled η_i, the final empirical specification for the consumption equation is:

$$\log c_i = \alpha + \beta \log \hat{y}_i' + \gamma D_i + X_i'\phi + \eta_i \tag{11}$$

where the instrumented income variable is denoted $\hat{y}_i'$. The income equation contains the same explanatory variables as the consumption equation and additional variables or instruments. Using the instrumental variable approach serves three purposes. First, it provides the measures of the variances of the income shocks for the two groups that are needed for computing the underreporting share. Second, it addresses the possible endogeneity of the income variable, as emphasised by P&W. Third, the disposable income variable may be subject to measurement errors in survey data, as stressed by Lamarche (2017) in his study comparing income data in EU-SILC and EU-HBS. The choice of instruments in the income regression is evidently important and is discussed in detail in Section 5. It entails several compromises framed by data availability and the exclusion restrictions, all of which are complicated by the large number of countries in our sample.

The two equations are estimated simultaneously using the maximum likelihood (ML) method. As in Paulus (2015), this allows us to calculate standard errors for the lower and upper bounds of the share of income underreporting, which have been lacking in other studies. Technically, we specify a structural equation model (SEM) with two equations (consumption and income) and allow certain parameters to differ between the employed and the self-employed (intercepts, variance and covariance of the error term). One advantage of this is that it allows us to obtain the residual variance of income for the two groups in a straightforward way. The estimated elasticity of consumption and the coefficient of the self-employment dummy are used together with the estimated variances of the error terms of the two income regressions to compute the various underreporting factors as expressed in eqs. (8) and (9), and subsequently the shares of income underreporting using eq. (10).

4. Dataset and the properties of the data

The underreporting by the self-employed is computed using the 2010 wave of the EU Household Budget Survey. As of 2018 this is the only wave of EU-HBS which is harmonised across countries. The choice of dataset is dictated by it having sufficiently detailed data on consumption, income, employment status and background characteristics for most EU countries.[5] The availability of data in EU-HBS conditions the specification of the empirical model.

The EU-HBS for 2010 provides harmonised data for 25 EU countries collected by national statistics offices.[6] In addition to detailed information on each consumption category, the survey contains information on household net income, the employment status of the household members, and demographic and socio-economic characteristics. However, the data available vary across the countries and this constrains our cross-country analysis to those countries for which the core variables needed to apply the expenditure method are available. We follow the standard approach taken in other studies and define food consumption as consisting of spending on food eaten at home (COICOP category 01) and outside the home (called catering services in the EU-HBS). National statistics offices use detailed diaries to collect data on expenditures though in some cases this is limited to certain categories only such as food consumption (Eurostat 2015).

The method of collecting data on income varies somewhat across countries, as data are collected at a more detailed level in some countries than they are in other countries. Income data are missing for Italy, while gross income was collected for Slovakia and disposable or net income subsequently imputed (Eurostat 2015). Italy and Slovakia are consequently excluded from the sample. For the other countries, we use annual monetary disposable income.

The response rate for Belgium is extremely low at 5 per cent compared to the median response rate of 56 per cent, and there is no information about the main source of income in the dataset for Luxembourg, so these countries are also excluded. Data on education, which is used as one of the main instruments (see below), are not available for Denmark, Finland, Malta, Sweden, Slovenia, or the UK, and are missing for a large proportion of some 40 per cent of the sample in France. Moreover, Denmark and Sweden only have partial information on the characteristics of the spouse. That leaves us with 14 countries for the analysis: Bulgaria (BG), Cyprus (CY), the Czech Republic (CZ), Estonia (EE), Greece (EL), Spain (ES), Croatia (HR), Hungary (HU), Ireland (IE), Lithuania (LT), Latvia (LV), Poland (PL), Portugal (PT) and Romania (RO).[7]

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[5] We also considered using other databases but found the EU-HBS to be the most appropriate. There are two potential datasets containing harmonised survey data across European countries: the EU Statistics on Income and Living Conditions (EU-SILC) for the EU countries and the Household Finance and Consumption Survey (HFCS) for the euro area countries. These two datasets have however very limited information on food consumption and the HFCS has quite small sample sizes in several of the countries.

[6] The 2016 October release of EU-HBS we are using provides no data for Austria, Germany or the Netherlands.

[7] Data in the EU-HBS 2010 are for 2010 for all countries in our sample except Cyprus, Ireland and Lithuania, where the survey was collected in 2008–2009, 2009–2010 and 2008 instead.

The standard approach in the literature is to restrict the sample to households with two adults where at least the household head is working. This ensures that the households exhibit a fairly similar family structure, as this may affect the composition of expenditures. Our sample consists of two-adult households where the household head is working and earnings are the main source of income of the household. In common with several previous studies, we further restrict the sample to households where the household head is of working age, 24–59, to ensure more homogenous preferences for consumption.[8]

As discussed in Section 2, two different methods may be used to define or categorise the group of households deemed particularly prone to income underreporting, either the self-reported employment status of the household head or the share of business income in total household income. The EU-HBS does not contain information on business income and it is not possible to calculate the share of reported business income from total income, but the households report their main source of income as being either wage/salary, income from self-employment, property income, pensions/retirement benefits, unemployment benefit or other current benefits/other income. We define a household to be self-employed, and hence possibly prone to underreporting, if the following two criteria are both satisfied: i) the household reports income from self-employment to be the main source of income, and ii) the household reports at least one of the spouses to be self-employed.

The definition criteria for the reference group are equally important. Households which are not prone to income underreporting are expected to be those where the main source of income is from wages or salaries and neither spouse is reported to be self-employed. Households where the main source of income and the self-reported type of employment appear to contradict each other are excluded from the sample altogether.[9]

Figure A.1 in the appendix shows the size of the samples for the countries used in the baseline estimations in Section 5. The size of the full estimation sample varies substantially across the countries, with more than 5,000 households for Spain, Poland and Romania but fewer than 1,000 households in half of the countries. The number of self-employed is above 1,000 for Spain, Poland and Romania, but below 100 for countries such as Bulgaria, the Czech Republic, Estonia and Latvia.

The relatively small estimation samples for several countries make it difficult to obtain precise estimates and this complicates the interpretation of the results. We decided not to restrict the sample further. One common restriction is to exclude households that work in agriculture as they can grow and consume food which may not be reflected in the income and spending data. We considered excluding the households where the head is reported to be a farmer or an agricultural worker, but this would further restrict the sample of the countries in the analysis. Moreover, the data on detailed employment status are missing for some house-

[8] We also exclude outliers from the sample using the Chauvenet's criterion, identifying observations for which the data on food consumption or income of the household deviate substantially from the respective log-normal distributions. This reduces the number of observations in the sample by only 0.62 per cent as 0.38 per cent are considered outliers using income data and 0.25% using food consumption data.

[9] Kukk & Staehr (2014) find underreporting of income even by households which have only small shares of business income.

holds in several countries, and this would restrict the sample further. We prefer to retain as many households and as many countries as possible in the sample and so we do not use the self-reported information about farmers in the baseline estimations but provide robustness checks with the farmers excluded in Section 6 for the countries where this information is available.

Figure A.2 in the appendix shows the share of self-employed households as a percentage of the total number of households in the sample for each country. The prevalence of the self-employed among working households varies greatly across the sample countries. In Greece, the share of the self-employed is over 30 per cent, while in Hungary, Estonia and Ireland it is 10 per cent or less. The ranking of the countries by the share of the self-employed is similar to the rankings using employment data from the Labour Force Survey (Eurostat) and from the National Accounts (AMECO).[10]

Table A.1 in the appendix shows the mean of the log food consumption and of the log income for employed and self-employed households and for the difference between the two groups. The statistics reveal substantial differences in the reporting of food consumption and disposable income across the sample countries. In many countries the self-employed report higher food consumption than the employed, while the self-employed report lower income than the employed.

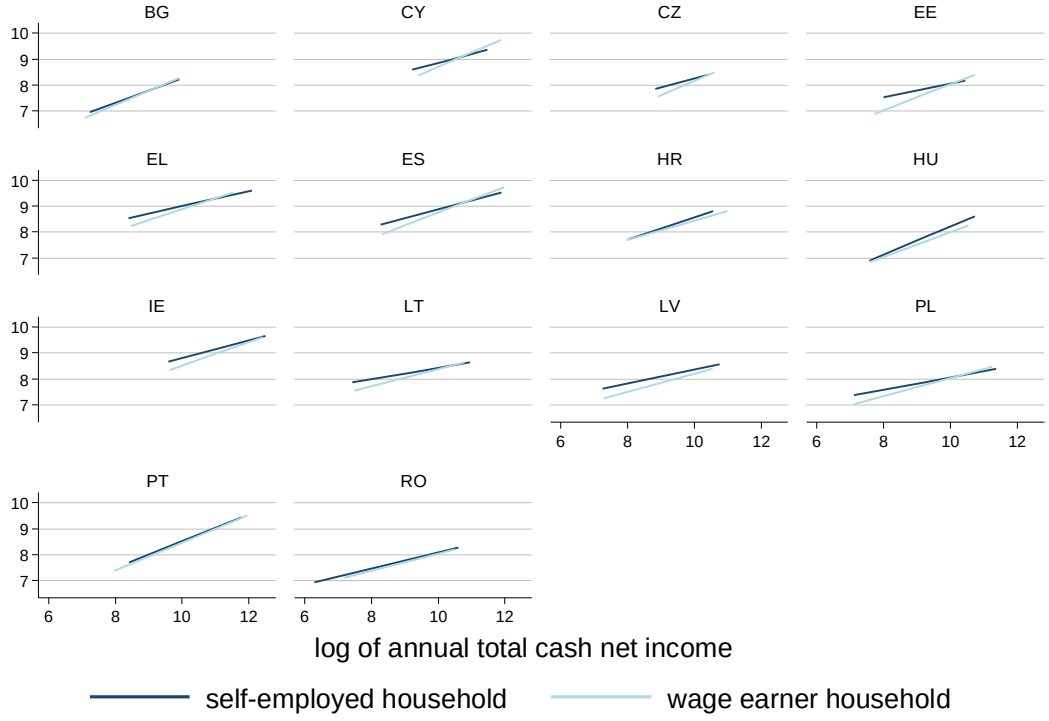
Figure 1 shows the fitted linear relationships between reported disposable income and food consumption for self-employed households and for employed households. The lines depict the predictions of a linear regression of disposable income on food consumption for the households in each of the groups. For all countries the self-employed report higher food consumption than the wage earners at all or most income levels. In most countries the slope depicting the relationship between consumption and income is slightly smaller for the self-employed than for the wage earners. Hurst et al. (2014) and Engström & Hagen (2017) find similar patterns for households in the USA and Sweden respectively. At high income levels, the differences in the food consumption of the self-employed and wage-earners are small.[11]

The unconditional results in Figure 1 (and Table A.1) point to notable differences in the patterns of food consumption between the self-employed and wage earners, but also suggest that there is notable heterogeneity across the sample countries. The expenditure method makes it possible to investigate these differences and reach estimates of the extent of income underreporting by the self-employed relative to the underreporting by wage earners.

[10] Data from Eurostat LFS (detailed annual survey results, code: *lfsa*) and AMECO (code: *NSDT*).

[11] This may be seen using the LOWESS method; the results are not reported here but available upon request.

Figure 1. Linear Engel curves for household food consumption



Source: Authors' calculations using the EU-HBS. *Notes*: Linear fit of log household food expenditures (at home and outside) on log household total disposable income using sample weights and excluding outliers in log expenditures and incomes (Chauvenet's criterion). The sample consists of couples with earnings as the main source of income where the household head is employed and 24-59 years old. Self-employed households are based on self-reported employment status and the main source of income.

5. Baseline estimations

For the baseline we estimate eq. (11) using the IV-ML procedure explained in Subsection 3.2. Reported current income is instrumented and the food regression is then estimated using the instrumented income variable, the dummy variable for self-employment and various control variables. The different underreporting factors and their associated shares are computed using the estimated coefficients from the food regression with instrumented income and the variances from the income regressions.

For the instrumentation of the reported income we use variables for the educational attainment and gender of the household head and their interactions with a dummy for the self-employed household, together with all the explanatory variables from eq. (11). Estimations of Mincer regressions generally find that the level of education is a suitable instrument for income. We considered using more instruments such as part time work, temporary work contract, occupation, industry, region, or being an immigrant, but these variables are missing for several countries, and would result in a loss of countries. The robustness of the estimation results to partly varying instruments is examined in Section 6.

The control variables in the food regression are the five-year age groups of the household head and the spouse, the number of children within the age groups 0–4, 5–9, 10–14 and 15–24 excluding those aged 20–24 who are employed. We do not add more control variables to the

baseline model since this would reduce our sample unduly. In the robustness analysis, we test the sensitivity of the estimations for smaller sets of countries by adding more covariates.

As discussed in Section 3 we consider three different underreporting factors and their corresponding shares of unreported income. A special measure of the underreporting factor can be computed solely from the estimated elasticity of consumption, β, and the coefficient of the dummy variable, γ, using eq. (9). The lower and upper bounds of the underreporting factor can be found from estimates of β and γ and the variances of the residuals from the instrumentation of income, $\sigma^2_{\xi|W}$ and $\sigma^2_{\xi|S}$, using eq. (8). In all cases, the factors are converted to shares of unreported income in true income using eq. (10).

Table 2 presents the results of the baseline estimations using IV-ML estimation. The endogeneity test reported in column (8) suggests that income is an endogenous variable except for Bulgaria, Cyprus, Croatia, Ireland and Lithuania. We instrument however the income variable even in the cases where the test does not reveal endogeneity because the income may be subject to measurement error and because we aim to use the same model specification for all countries.

The diagnostics for the instrumentation are shown in columns (9)–(11). The instruments are generally statistically significant (not shown) and help explain 30–50 per cent of the variation in the income variable. The *F*-statistic indicates that the instruments are suitably correlated with the instrumented variable. The results of the Hansen *j*-test confirm the validity of the over-identifying instruments for all of the sample countries except Poland and Romania and with Spain as borderline case. For these countries, we could use additional instruments but we prefer to retain the same model specification for all countries so as to maintain the comparability of the results. We provide estimations with a smaller and wider set of instruments and without instrumentation in the robustness analyses in Subsection 6.1.

Columns (1) and (2) in Table 2 show the estimated values for the elasticity of food consumption to current income, β, and the coefficient of the self-employment dummy, γ. The elasticity of food consumption to current income varies between 0.3 and 0.7 across the countries. This range is in line with the findings in the studies in Table 1 where typical estimates are 0.2–0.3 for high income countries and 0.4–0.6 for emerging economies. The estimated coefficient of the self-employment dummy varies between 0 and 0.2 but it is not statistically significant for four of the sample countries.

The simple share is shown in column (3). The estimated share is statistically insignificant for the same countries for which the self-employment dummy is insignificant, i.e. Bulgaria, Cyprus, Croatia and Portugal. The largest simple shares of above 30 per cent are found for Latvia and Ireland, while shares of between 20 and 30 per cent are found for the Czech Republic, Estonia, Hungary and Lithuania. Lower but still statistically significant simple shares of between 10 and 20 per cent are obtained for Greece, Spain, Poland and Romania. We will discuss these results in greater detail in Section 7.

Table 2. IV-ML estimations of the share of unreported income in true income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	β	**γ**	**Simple share**	**Lower share**	**Higher share**	**Obs. total**	**Obs. self-employed**	**Endogen-eity**	**Partial R^2**	***F*-statistic**	**Hansen *j*-test**
BG	0.524***	0.047	0.086	0.074	0.098	463	54	0.939	0.151	14.2	0.715
	(0.103)	(0.055)	(0.103)	(0.104)	(0.110)						
CY	0.398***	0.038	0.091	0.080	0.102	788	104	0.342	0.207	25.6	0.958
	(0.093)	(0.054)	(0.118)	(0.122)	(0.114)						
CZ	0.563***	0.139***	0.219***	0.193***	0.244***	638	77	0.054	0.143	26.0	0.348
	(0.108)	(0.037)	(0.051)	(0.054)	(0.049)						
EE	0.690***	0.171**	0.220**	0.186*	0.251**	911	89	0.063	0.171	21.4	0.873
	(0.113)	(0.080)	(0.095)	(0.105)	(0.096)						
EL	0.502***	0.075**	0.139**	0.021	0.242***	725	248	0.014	0.191	20.6	0.426
	(0.074)	(0.034)	(0.067)	(0.077)	(0.065)						
ES	0.515***	0.075***	0.135***	0.107***	0.163***	7,071	1,402	0.017	0.214	148.1	0.088
	(0.031)	(0.021)	(0.036)	(0.037)	(0.036)						
HR	0.368***	0.067	0.168	0.140	0.195*	514	97	0.931	0.256	29.6	0.505
	(0.079)	(0.051)	(0.113)	(0.117)	(0.111)						
HU	0.555***	0.152***	0.240***	0.222***	0.257***	2,296	192	0.000	0.325	77.9	0.729
	(0.043)	(0.026)	(0.039)	(0.040)	(0.038)						
IE	0.468***	0.168***	0.301***	0.251***	0.348***	1,350	137	0.109	0.254	30.2	0.116
	(0.063)	(0.037)	(0.053)	(0.058)	(0.050)						
LT	0.414***	0.122**	0.255***	0.200*	0.306***	1,674	220	0.401	0.156	23.0	0.240
	(0.079)	(0.048)	(0.097)	(0.109)	(0.092)						
LV	0.565***	0.243***	0.350***	0.258**	0.430***	628	78	0.020	0.176	12.5	0.107
	(0.112)	(0.080)	(0.105)	(0.123)	(0.094)						
PL	0.416***	0.062***	0.138***	0.068***	0.203***	11,208	2,294	0.000	0.213	282.9	0.002
	(0.015)	(0.010)	(0.022)	(0.025)	(0.022)						
PT	0.700***	0.080	0.108	0.051	0.162**	2,065	303	0.000	0.364	67.4	0.300
	(0.066)	(0.068)	(0.084)	(0.092)	(0.081)						
RO	0.374***	0.067***	0.165***	0.068	0.252***	5,923	1,027	0.000	0.285	138.6	0.017
	(0.016)	(0.017)	(0.035)	(0.040)	(0.033)						

Source: Author's calculations using the EU-HBS. *Notes:* IV-ML estimations where education levels and gender of the reference person (and interactions) are used as instruments for the income variable. Robust standard errors are reported in brackets under the coefficient estimates. Superscripts ***, ** and * indicate that the coefficient is statistically different from 0 at the 1%, 5% and 10% levels respectively. *p*-values are reported for the endogeneity test in column (8) and the Hansen *j*-test in column (11).

Columns (4)–(5) in Table 2 show the estimates of the lower and upper underreporting shares. We find, as expected, that the variance of the income residuals for wage earners is smaller than the variance for the self-employed ($\sigma^2_{\xi|W} < \sigma^2_{\xi|S}$) for all countries except Bulgaria and Cyprus, for which the differences are generally very small (not reported).

The lower bound denotes, under various assumptions, the lowest value of the share of unreported income that can be obtained and the highest bound denotes the highest possible value. As discussed in Subsection 3.1 the assumptions required to attain the lowest bound are quite improbable in practice and arguably mostly of theoretical interest. The upper bound is reached when the variance of the transitory income for the wage earners is the same as the variance for the self-employed.

For many of the countries the difference between the upper and the lower share estimates is comparatively small. The main exceptions are Greece, Lithuania, Poland, Portugal and Romania where the difference is above 10 percentage points. For Greece, Portugal and Romania the estimate of the lower share is neither statistically nor economically significant.

The comparison across the countries is complicated by the substantial uncertainty with which the underreporting is estimated. The occasionally large range between the estimated lower and upper underreporting shares and the standard errors of the share imply that any estimation results are subject to substantial uncertainty and are therefore difficult to compare. Consequently, we focus on the simple shares of income underreporting when we consider the robustness of the results in Section 6 and discuss the results in detail in Section 7, while keeping in mind that this represents a generalisation since the range between the upper and the lower bounds of the estimates is substantial in some cases.

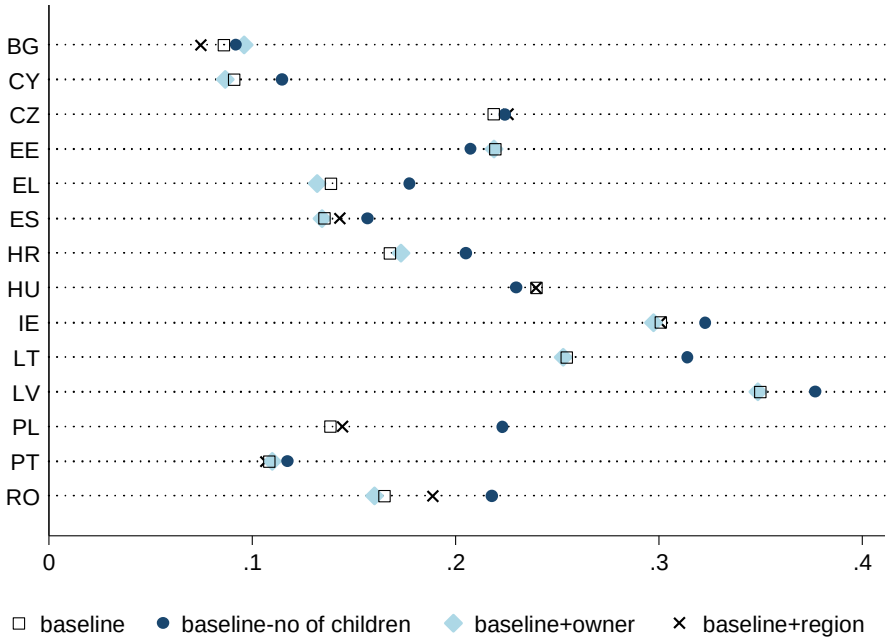
6. Robustness checks and alternative specifications

In this section, we run robustness checks using alternative sets of covariates, instruments, samples and definitions of the self-employed. Throughout we compare with the baseline estimates of income underreporting using the simple share defined in eq. (10).

6.1. Co-variates and instruments

There are hardly any socio-economic variables left in the EU-HBS that could suitably be used as additional covariates in our model without serious attrition of the number of countries. Even so, we can demonstrate the effect of a few alternative sets of covariates. Figure 2 shows the share of unreported income when the number of children in various age groups is excluded (the circle-shaped marker) and when a dummy for home ownership (diamond) or regional dummies are added (cross). In the latter two cases we start seeing substantial attrition of countries as these variables are only available for 11 and 8 countries respectively. The estimated shares of underreported income are somewhat sensitive to the exclusion of the number of children from the set of covariates. However, the results are generally very close to those of the baseline (square) for all specifications and countries when more covariates are added to the model and we can conclude that the estimations are not critically affected by the choice of covariates.

Figure 2. Estimates of the simple share of unreported income with alternative covariates

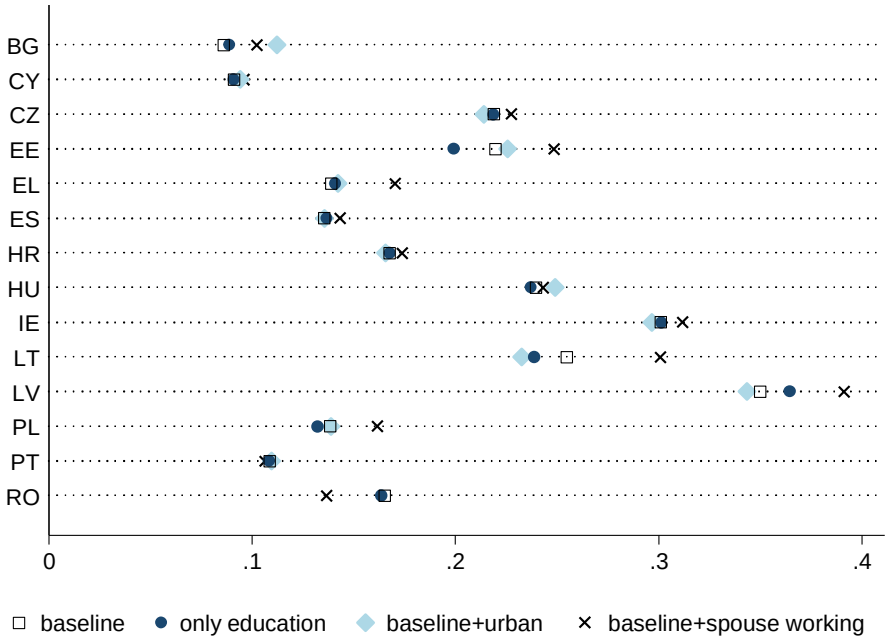


Source: Authors' calculations using the EU-HBS. *Notes:* The share of unreported income is calculated from eq. (9).

As another type of robustness check, we run the estimations with different sets of instruments. Figure 3 shows the results. The share of unreported income in the baseline specification (square) is initially compared to the calculations when the education of the household head is used as the only instrument for income (circle). In further specifications, we added a dummy to the baseline model for living in an urban region, for which data are available for 13 countries, as an additional instrument alongside the baseline instruments (diamond) to capture the different earning opportunities of rural and urban areas (Macours & Swinnen 2008). We also examined the effect of expanding the baseline instruments with a dummy for a working spouse (cross). The share of unreported income is again very similar for different model specifications, revealing that the results are not driven by the choice of instruments.[1]

[1] The smallest differences (not shown here) were obtained, when we supplemented the baseline instruments with a dummy for the reference person or the spouse being an immigrant for those countries where this was available, which would allow the earning dynamics to be different for natives and non-natives (Dustmann et al. 2010).

Figure 3. Estimates of the simple share of unreported income with alternative instruments



Source: Authors' calculations using the EU-HBS. *Notes:* The share of unreported income is calculated from eq. (9).

Finally, we follow other studies that apply the expenditure method and examine how far the results change if the Engle curve in eq. (10) is estimated without instrumentation of the income variable. As discussed in Subsection 3.2, we nevertheless estimate the model using maximum likelihood as this allows us to compute standard errors for the estimates of the upper and lower bounds.[2] The results are shown in Table A.2 in the appendix. Omitting instrumentation has a relatively modest effect on the underreporting results for most countries.[3] The simple share of income underreporting is typically larger when the income is not instrumented than when income is instrumented. The differences are above 5 percentage points for the Baltic states, Greece, Poland and Romania, countries with either particularly large or particularly small underreporting estimates. If the estimated lower and upper bounds and their associated standard errors are considered, the differences between the cases with and without instrumentation become negligible.

6.2. Alternative sample restrictions

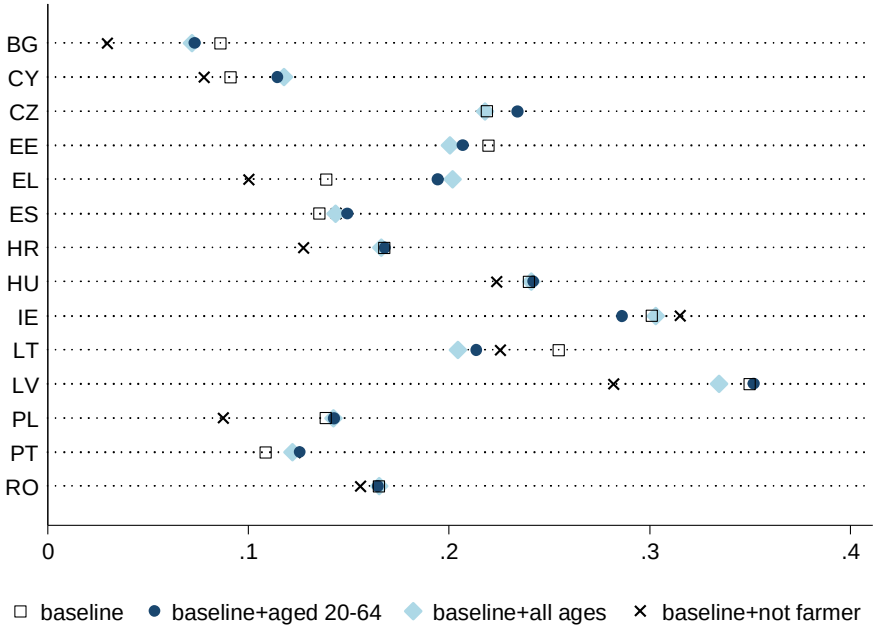
In the baseline model, we restrict the sample to couples with or without children, where the head of the household is working and 25–59 years old. To analyse the sensitivity of the results to this particular restriction, we compare the results with alternative estimation samples. Figure 4 shows the estimated share of income underreporting when the sample is extended to household heads aged 20–64 (circle) and all couples with a working household head (diamond). In most countries, the estimates are slightly lower when the age of the household

[2] The education and gender dummies are included as additional explanatory variables in the income regression in order to keep the estimations consistent with the IV-ML estimations in Section 5.

[3] The elasticity of food consumption is generally smaller when household income is not instrumented, which is not surprising as the predicted food consumption is closer to permanent income and food consumption follows permanent income more closely than current income due to consumption smoothing.

head is not restricted, which is reasonable given that older households typically receive pensions and their share of business income may consequently be lower than it is for wage earners. Greece stands out as the estimated share of unreported income is substantially *larger* when all age groups are included, rising from 14 per cent to 20 per cent.

Figure 4. Estimates of the simple share of unreported income with alternative samples



Source: Authors' calculations using the EU-HBS. *Notes:* The share of unreported income is calculated from eq. (9).

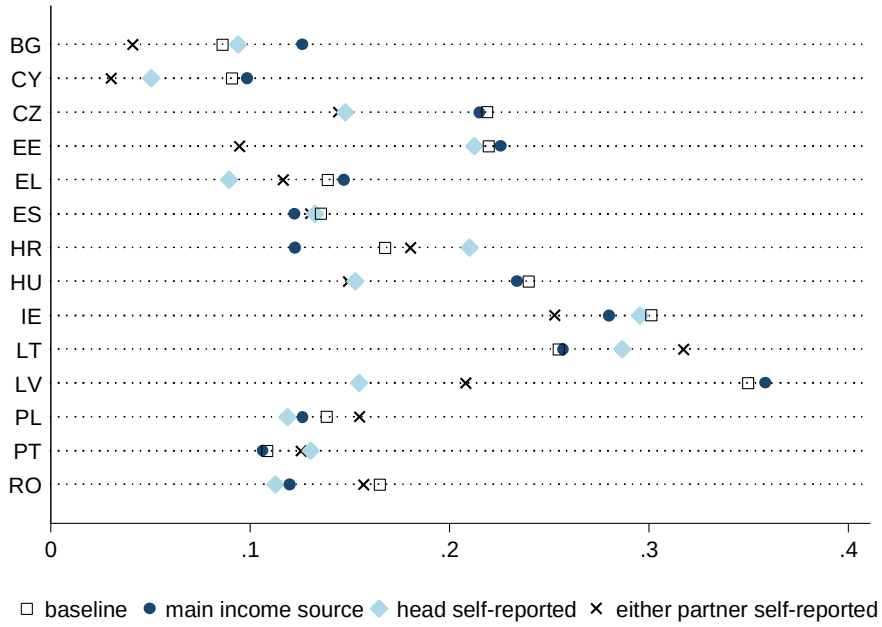
Finally, we return to the age restriction of the baseline estimation but exclude households where the household head is reported as being a farmer (cross). We obtain slightly or somewhat lower estimates of the simple share of underreporting for all countries for which data are available with the exception of Ireland. Note, however, that restricting the sample to households where the head is not a farmer leads to the attrition of several countries. Moreover, the exclusion of farmers from the sample implies a substantial reduction in observations, particularly for some of the countries where the number of observations is already relatively small, and this means that the results are estimated with larger uncertainty than in the baseline (not shown).

6.3. Definition of the self-employed

The way in which the group of self-employed and the reference group of wage earners are defined may potentially affect the underreporting results. Kukk & Staehr (2017) examine this in detail for Estonia and obtain very different results depending on whether income or the reported self-employment status is used. Paulus (2015) and Ekici & Besim (2016) also show that the results are substantially affected by the way the underreporting and the reference groups are defined. Contrary to these results, Pissarides & Weber (1989) posit that their results are broadly similar regardless of how the self-employed are defined. Engström & Hagen (2017) reach very similar results for Sweden regardless of the criteria used for sample selection.

Figure 5 shows the results when different definitions are used. In the baseline specification, the self-employment group is selected using two criteria concurrently: i) the household reports income from self-employment to be the main source of income and ii) the household reports that at least one of household members is self-employed. The reference sample includes only households where the household reports wages as the main source of income and none of the household members is self-employed. As the first alternative definition we use only criterion i) and *all* other households are in the reference group (circle), meaning that the reference group and the sample overall is slightly broader than the reference group used in the baseline estimations. The results when only the main income source is used to identify the self-employed are typically close to the baseline results, with Bulgaria, Croatia and Romania as partial exceptions.

Figure 5. Estimates of the simple share of unreported income with alternative definitions of self-employed households



Source: Authors' calculations using the EU-HBS. *Notes:* The share of unreported income is calculated from eq. (9).

Next, we define the self-employed households as those where the household head reports to be self-employed regardless of the main source of household income, while the rest of the sample is in the reference group (diamond). The estimates are in most cases lower than those of the baseline, which is an expected result since in this case the self-employment group may also include households with low self-employment income. The difference between the baseline and the self-reported status of the household head is particularly large for the Czech Republic, Hungary and Latvia.

Finally, we define households as self-employed if either of the household members is self-employed (cross), with the rest of the sample again considered as the reference group. This definition implies that the self-employment income in the household can be very low and we indeed find that the share of unreported income differs substantially in many cases from the baseline, with Latvia as the most extreme example.

7. Discussion of the results

The baseline estimations in Section 5 use a common specification for all the 14 EU countries for which sufficient data are available in the EU-HBS. The results show that the share of underreported income exhibits substantial heterogeneity across the countries. The robustness checks in Section 6 indicate that the results are generally robust to the choices of co-variates and instruments and the types of households included in the sample, but also that the results are somewhat sensitive to the way the self-employment and reference groups are defined.

Previous studies are only available for two of the 14 EU countries in the sample, Spain and Estonia. Our underreporting results for Spain are very close to those reported in Martinez-Lopez (2013), and indeed the estimated income elasticity and the coefficient of the dummy variable reported in Table 2 are also very similar. This congruence is reassuring given that our study and Martinez-Lopez (2013) use household budget data from time periods close to each other and define the self-employed and the reference group in broadly similar ways.

Several studies provide underreporting estimates for Estonia using the expenditure method. The most comparable result appears in Kukk & Staehr (2017), who use data from the household budget survey for 2002–2007 and estimate the share of unreported income to be around 28 per cent of true income when the self-employed are identified using employment status.[4] Paulus (2015) uses the Estonian SILC for 2008 and runs estimations in which the self-employed are identified by their reported employment status. The share of underreported income is found to be 20–44 per cent of true income. The upshot is that the results for Estonia in this study are in the lower tail of the results in previous studies.

A striking feature of the results in the current study is that some of the lowest shares of income underreporting are found for southern European countries such as Bulgaria, Greece, Portugal and Romania. We have not found any studies applying the expenditure method for these countries, making direct comparison impossible. Besim & Jenkins (2005) and Ekici & Besim (2016) consider the case of Northern Cyprus. In both papers the reference group consists of households for which the household head is *publicly* employed, making comparison with other studies difficult. However, the differences between the underreporting by the privately employed and the self-employed, both relative to the reference group of publicly employed, are small. This suggests that the share of underreporting by the self-employed would be marginal if *all* employed households were used as the reference group. The results for Northern Cyprus would thus seem in line with the low estimates we obtain for Bulgaria, Greece, Portugal and Romania.

Overall, the estimates of income underreporting in this study appear to be somewhat lower than those in the studies referenced in Table 1 in Section 2, bearing in mind that the latter cover mostly different countries and in most cases periods before the outbreak of the global financial crisis. These studies typically find underreporting shares of 20–30 per cent of true income or even more, with the main exceptions being the low estimates for Northern Cyprus

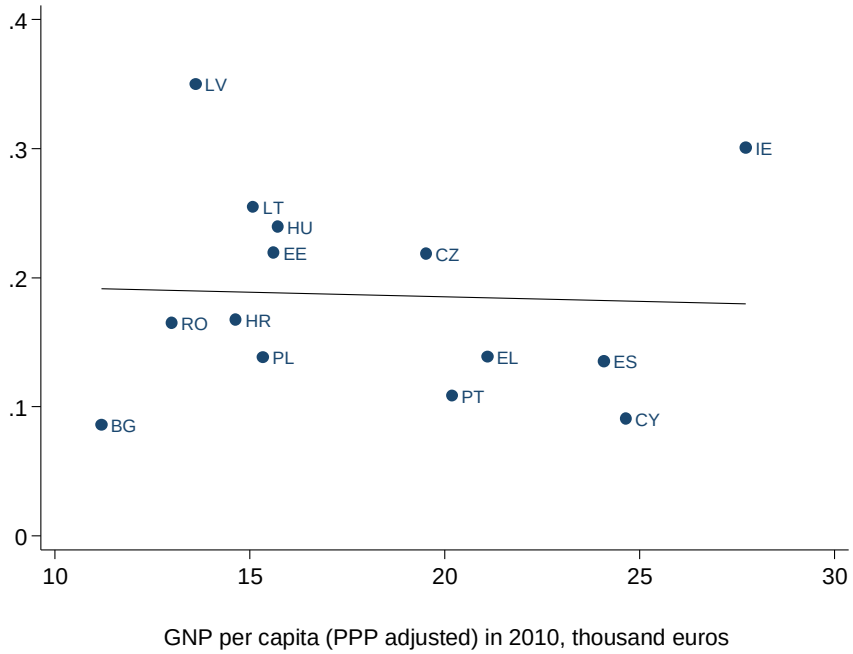
[4] Kukk & Staehr (2014, 2017) find substantially higher underreporting shares if other definitions of the self-employed and the reference group are used.

in Besim & Jenkins (2005) and Ekici & Besim (2016). There may be several reasons for the comparatively small estimates in this study.

First, other studies focus on one country and will typically have access to more information from country-specific surveys. The analysis in Section 6 showed indeed that changes in the specification affect the results differently for the 14 EU countries in our sample. Second, the estimates in this study also refer to a later time period than most of the studies of individual countries. We use a snapshot from a year after the outbreak of the global financial crisis and the crisis had very different consequences for various households within a country and across countries (Pissarides 2013). Third, previously published results could exhibit a publication bias, where countries with higher estimates of the extent of income underreporting may have been more likely to result in a publication within the total pool of attempts with the expenditure method.

The discussion of previous national studies in Section 2 noted a lack of relationship between the extent of estimated income underreporting and the level of economic development across countries. Our findings show substantial heterogeneity in the underreporting results together with varying level of economic development across the 14 EU countries in the sample and thus corroborate that further. For such a comparison across countries, we use the simple share estimates as it is not straightforward to rank countries unambiguously using the bound estimates. Figure 6 plots the simple share of income underreporting from Table 2 against the gross national product per capita adjusted for purchasing power (PPP).

Figure 6. Estimates of the simple share of unreported income and GNP per capita (PPP)



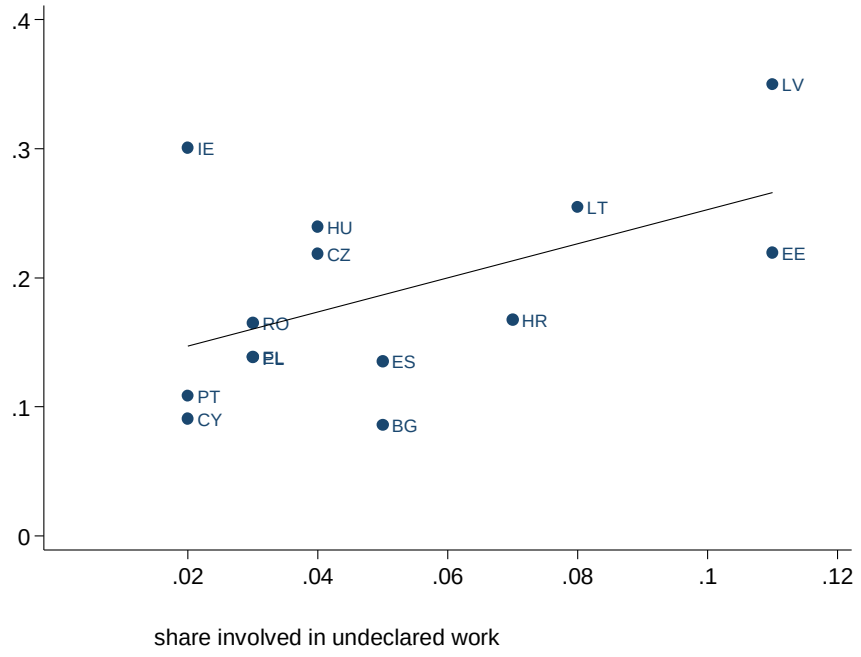
Source: Authors' calculations using the EU-HBS and AMECO (code: *HVGNP*).

The figure reveals no discernible relationship between the income level and the simple share of underreported income as evidenced by the fitted line being essentially flat. Latvia, which is among the countries with the lowest GDP per capita, stands out for having the highest simple share of income underreporting but it is followed by Ireland, which is the sample country with

the highest GNP per capita. Likewise, the income levels of Bulgaria and Latvia are relatively similar but the estimates of the share of unreported income vary markedly. The economic development level of the countries does not seem to be reflected in the underreporting by the self-employed in our estimations. It is important to recall, however, that the income underreporting estimated using the expenditure method is in addition to or on top of the possible underreporting by the reference group. If income underreporting among the wage earners is extensive, overall income underreporting in a country may still be substantial, even if the difference between wage earners and the self-employed is limited.

The absence of clear-cut patterns for the level of economic development appears to be common for studies that use microeconomic data to estimate the prevalence of undeclared work, tax evasion or other unreported activities. Interestingly, there is also notable correlation between our simple share of income underreporting and the share of people who state that they had been involved in undeclared work when they were interviewed in 2013 for a Special Eurobarometer (Eurobarometer 2014).[5] Figure 7 shows a cross-plot of the two measures.

Figure 7. Estimates of the simple share of unreported income and the share of undeclared work



Source: Authors' calculations using the EU-HBS and Eurobarometer (2014, question: *QE14*).

In line with initial assumptions about wage earners (our reference group), the prevalence of undeclared work by the employed in Eurobarometer is also much lower than our estimate of income underreporting by the self-employed for every country. The cross-country correlation between the two measures warrants further investigation. At this stage it is worth noting that both measures are derived from surveys where individuals are interviewed. There may be differences in the way individuals in various countries regard the statistics authorities and consequently in the truthfulness in which they provide answers to surveys.

[5] In Eurobarometer (2014), dependent employees were asked "Apart from a regular employment, have you yourself carried out any undeclared paid activities in the last 12 months?" (question: *QE14*).

Unlike microdata based estimates, studies of the overall size of the shadow economy using macroeconomic data typically find that the size is inversely related to income level, though still with notable exceptions (Buehn & Schneider 2012, Alm & Embaye 2013).[6] Among others, this is demonstrated for the VAT gap, which has been estimated to be small for the North European countries and substantial for many South and East European countries (Poniatowski et al. 2016). There are however exceptions as some Central-East European countries (Slovenia, Croatia and Estonia) are found to have smaller VAT gaps than several West European countries (the Netherlands and France).[7]

It is however possible to recognise some broad regional patterns in our results. Six countries have simple shares of unreported income above 20 per cent of true income. Besides Ireland and the Baltic states, the other two are the Czech Republic and Hungary, two neighbouring countries from central Europe. The rest of the countries may be brought together in a group with a simple share of unreported income between 8 and 18 per cent. This group consists of Bulgaria, Spain, Greece, Croatia, Cyprus, Poland, Portugal and Romania, all countries in southern Europe except for Poland. Within this group, there appear to be two clusters; one consisting of the post-communist countries with relatively low per capita income and one consisting of the countries without a communist experience and higher per capita income.

We have also examined how far it is possible to relate our underreporting results to various measures of tax pressure, governance quality and institutional development, but we have not found any such relationship. The Worldwide Governance Indicators project run by the World Bank makes data available on government effectiveness, regulatory quality, the rule of law, and corruption control.[8] The variables typically correlate with the level of economic development and in this light it is not surprising that we failed to find any relationship between these governance proxies and our estimates of the shares of income underreporting (not shown). We do not find any association between the tax rates in Eurostat (2013) and the estimated shares of underreporting although in a few cases we obtain counter-intuitive results which reflect the typically negative correlation between income levels and tax pressures (not shown).

8. Concluding remarks

Various studies have sought to provide estimates of income underreporting by the self-employed using the expenditure method (Pissarides & Weber 1989) but consider countries individually. This paper contributes to the literature on tax non-compliance by being the first to provide comparative estimates with the expenditure method across a large number of countries, in this case 14 EU member countries. The data come from the 2010 wave of the European Household Budget Survey made available by Eurostat. The comparison is aided by the countries sharing many institutional features, and data in all EU countries being collected

[6] Studies do however find very different results for the same countries, even if they use the same methodology. For example, Schneider (2007) estimates that the shadow economy in Estonia amounted to 40 per cent of true GDP in the early 2000s, while Tafenau et al. (2010) using essentially the same methodology estimate the share to be 16-17 per cent in the mid-2000s.

[7] Comparative studies of the revenue loss from firms' tax avoidance, but not necessarily tax evasion, include Bartelsman et al. (2003) and Cobham & Janský (2017).

[8] Data can be downloaded from http://info.worldbank.org/governance/wgi/index.aspx#home.

using a fairly standardised methodology. Households, including self-employed households, have little reason or incentive to underreport their income to the statistics authorities unless they have not truthfully reported their full income to the tax authorities (Pissarides & Weber 1989). This suggests that the estimated underreporting of income to the statistics authorities will be positively correlated with underreporting to the tax authorities and the estimates are thus of substantial academic and policy relevance.[9]

Our estimates using these data show substantial variation of income underreporting across countries with the highest country-level baseline estimates exceeding 40% of self-employed household income on average. With countries in eastern Europe showing higher degrees of underreporting than southern European countries, we also find some regional clustering. However, no clear patterns emerge across levels of economic and institutional development, in line with the results in earlier studies for individual countries. In a broader context the variability of the underreporting estimates in our study is consistent with the findings in most other studies which use microeconomic data to estimate the prevalence of undeclared wages, tax evasion or other unreported activities. To maximise comparability, we opted for the same specification of the estimation models for all 14 countries. The results are robust to changes in the model specification and the choice of instruments, though the way in which the self-employed households are defined do affect the results somewhat.

Arguably the most surprising result is that the estimates for some southern European countries are relatively low. This result may however be in accordance with a few earlier studies using the expenditure method to estimate the extent of underreporting in individual countries (where these overlap with our country selection). Moreover, it is important to recall that the measure of underreporting estimated using the expenditure method is a relative measure and should be interpreted as being in addition to the possible underreporting by the reference group. There may also be differences in the way individuals in different countries provide answers to the statistics authorities. Future analyses could seek to include more high-income countries from western Europe, as additional data become available (e.g. the next round of the EU-HBS). Comparative estimates over several periods will undoubtedly provide additional insights, including knowledge of the factors driving income underreporting and tax evasion by the self-employed.

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[9] Hurst et al. (2014) apply the expenditure method to US data and get very similar results with two different surveys, the Consumer Expenditure Survey and the Panel Study of Income Dynamics, suggesting that the households report data in a consistent manner in the survey and potentially in other contexts. Paulus (2015) uses the Estonian SILC data linked with tax records and finds that there is a certain overlap between the reporting of income to the two entities.

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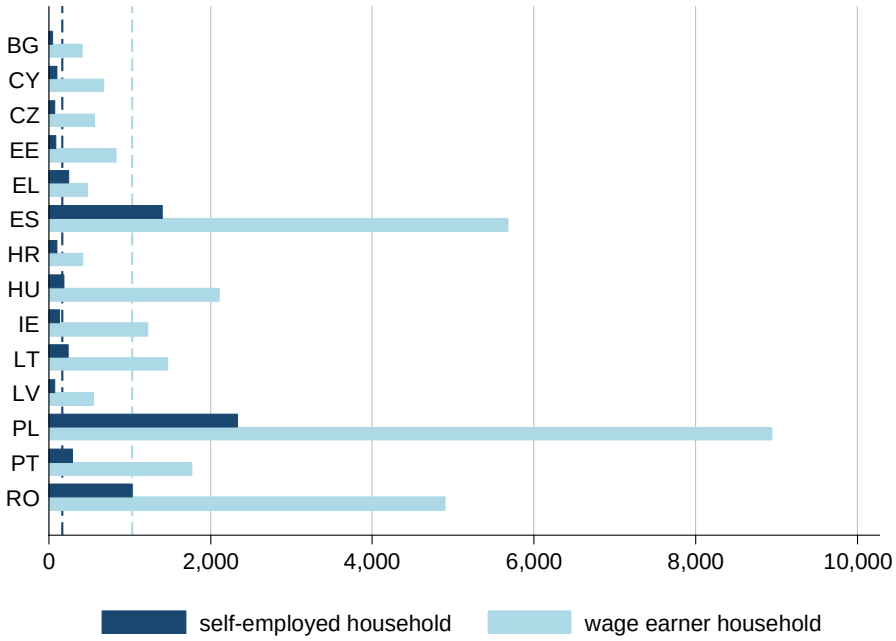
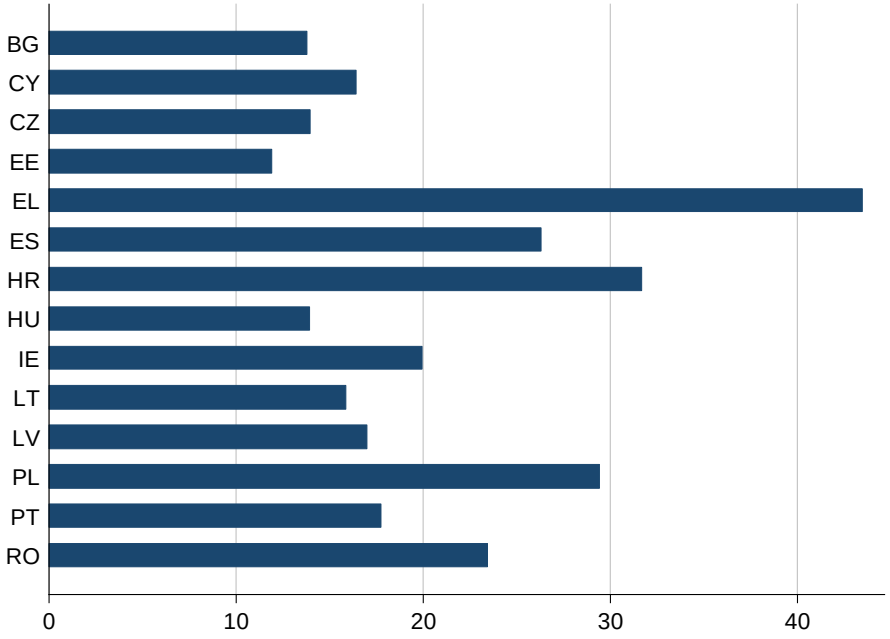
Appendix

Figure A.1. Number of self-employed and wage earner households in the estimation sample



Source: Authors' calculations using the EU-HBS. *Notes*: Vertical dashed lines mark median values. The sample consists of households with couples that report earnings as their main source of income and the household head as being employed and 24-59 years old. Households are defined as self-employed if income from self-employment is reported to be the main source of income and at least one of the spouses is reported to be self-employed.

Figure A.2. Percentage of self-employed households in the estimation sample



Source: Authors' calculations using the EU-HBS. *Notes:* The sample consists of households with couples that report earnings as their main source of income and the household head as being employed and 24-59 years old. Households are defined as self-employed if income from self-employment is reported to be the main source of income and at least one of the spouses is reported to be self-employed.

Table A.1. Log food consumption and log reported income for self-employed and employed households

	Mean log food consumption			Mean log reported income		
	Employed	**Self-employed**	**Difference**	**Employed**	**Self-employed**	**Difference**
BG	7.496	7.585	-0.089	8.490	8.575	-0.084
	(0.022)	(0.055)	(0.060)	(0.024)	(0.078)	(0.082)
CY	9.009	8.976	0.033	10.577	10.336	0.241
	(0.021)	(0.051)	(0.055)	(0.017)	(0.044)	(0.047)
CZ	8.033	8.108	-0.075	9.765	9.600	0.164
	(0.014)	(0.031)	(0.034)	(0.012)	(0.044)	(0.046)
EE	7.648	7.886	-0.238	9.309	9.348	-0.039
	(0.029	(0.079)	(0.084)	(0.020)	(0.072)	(0.075)
EL	8.907	9.069	-0.161	10.086	10.241	-0.155
	(0.022)	(0.029)	(0.036)	(0.026)	(0.050)	(0.057)
ES	8.813	8.907	-0.094	10.140	10.113	0.027
	(0.010)	(0.019)	(0.021)	(0.008)	(0.018)	(0.020)
HR	8.270	8.280	-0.010	9.548	9.388	0.159
	(0.024)	(0.052)	(0.058)	(0.024)	(0.058)	(0.063)
HU	7.598	7.744	-0.147	9.169	9.143	0.026
	(0.012)	(0.037)	(0.039)	(0.011)	(0.038)	(0.040)
IE	8.952	9.050	-0.099	11.003	10.783	0.220
	(0.014)	(0.058)	(0.060)	(0.012)	(0.066)	(0.067)
LT	8.109	8.263	-0.154	9.196	9.104	0.092
	(0.016)	(0.033)	(0.036)	(0.017)	(0.072)	(0.074)
LV	7.847	8.118	-0.271	9.012	8.933	0.079
	(0.023)	(0.098)	(0.101)	(0.028)	(0.130)	(0.133)
PL	7.767	7.911	-0.144	9.231	9.346	-0.115
	(0.005)	(0.009)	(0.010)	(0.006)	(0.015)	(0.016)
PT	8.437	8.396	0.041	9.958	9.783	0.175
	(0.025)	(0.054)	(0.060)	(0.019)	(0.053)	(0.056)
RO	7.574	7.428	0.146	8.585	7.903	0.681
	(0.006)	(0.015)	(0.016)	(0.008)	(0.028)	(0.029)

Source: Authors' calculations using the EU-HBS. *Notes:* Food consumption includes catering outside the home. The mean values are estimated with survey weights and refer to the estimation samples used in Section 5. The standard errors of the mean estimates are in brackets.

Table A.2. ML estimations of the share of unreported income in true income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	β	**γ**	**Simple share**	**Lower share**	**Higher share**	**Obs. total**	**Obs. self-employed**
BG	0.510***	0.048	0.090	0.079	0.102	463	54
	(0.032)	(0.052)	(0.094)	(0.096)	(0.101)		
CY	0.479***	0.057	0.113	0.102	0.124	788	104
	(0.043)	(0.053)	(0.096)	(0.101)	(0.093)		
CZ	0.414***	0.115***	0.243***	0.218***	0.267***	638	77
	(0.042)	(0.033)	(0.063)	(0.067)	(0.061)		
EE	0.459***	0.165**	0.302**	0.273**	0.330***	911	89
	(0.050)	(0.076)	(0.121)	(0.126)	(0.122)		
EL	0.360***	0.093***	0.227***	0.121	0.319***	725	248
	(0.028)	(0.031)	(0.072)	(0.082)	(0.067)		
ES	0.441***	0.072***	0.150***	0.122***	0.177***	7,071	1,402
	(0.015)	(0.021)	(0.041)	(0.042)	(0.040)		
HR	0.374***	0.068	0.167	0.139	0.194*	514	97
	(0.041)	(0.050)	(0.111)	(0.115)	(0.109)		
HU	0.441***	0.150***	0.289***	0.273***	0.305***	2,296	192
	(0.023)	(0.026)	(0.044)	(0.045)	(0.042)		
IE	0.388***	0.147***	0.315***	0.267***	0.360***	1,350	137
	(0.026)	(0.034)	(0.060)	(0.065)	(0.057)		
LT	0.297***	0.124***	0.342***	0.295**	0.387***	1,674	220
	(0.028)	(0.047)	(0.109)	(0.119)	(0.104)		
LV	0.341***	0.214***	0.466***	0.393***	0.531***	628	78
	(0.037)	(0.068)	(0.120)	(0.138)	(0.107)		
PL	0.328***	0.074***	0.201***	0.136***	0.262***	11,208	2,294
	(0.007)	(0.010)	(0.024)	(0.026)	(0.024)		
PT	0.522***	0.045	0.083	0.025	0.139	2,065	303
	(0.047)	(0.066)	(0.114)	(0.122)	(0.110)		
RO	0.320***	0.032**	0.096**	-0.009	0.190***	5,923	1,027
	(0.010)	(0.015)	(0.041)	(0.048)	(0.038)		

Source: Authors' calculations using the EU-HBS. *Notes:* ML estimations. Robust standard errors are reported in brackets under the coefficient estimates. Superscripts ***, ** and * indicate that the coefficient is statistically different from 0 at the 1%, 5% and 10% levels respectively.