BEHAVIOURAL RESPONSE TO INCOME TAXATION
A STUDY OF THE HUNGARIAN TAX SYSTEM

by
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Abstract

In the last few decades, there has been a growing literature on the behavioural effects of tax reforms. These studies measure the elasticity of taxable income (ETI) to changes in the marginal tax rate and find a significant positive effect. The ETI is especially important when governments reduce the tax rates substantially in order to boost their economic and tax revenues. Although there are signs that some countries do manage to improve on both fronts, it is hard to differentiate the behavioural response to tax changes from the effect of increased tax enforcement. This thesis addresses this gap by analysing the elasticity of taxable income both of employees and self-employed and by estimating the distribution of income underreporting throughout the total taxpayer population.

The first chapter estimates the elasticity of taxable income in Hungary. Taxpayer behaviour is analysed using a medium-scale tax reform episode in 2005, which changed marginal and average tax rates, but kept enforcement constant. Results suggest a relatively small but highly significant tax price elasticity of about 0.06 for the population earning above the minimum wage (around 70% of all taxpayers). This number increases to around 0.3 when we focus on the upper 20% of the income distribution, with some income groups exhibiting even higher elasticities (0.45). Using these results the impact of a hypothetical flat income tax scheme is quantified.

In the second chapter of this thesis, I analyse the elasticity of reported income to tax rates of the self-employed. The ETI captures several margins of adjustment. Most importantly, labour supply changes after tax reforms but taxpayers also adjust their income underreporting behaviour. Changes in concealment might be even more substantial in case of small enterprises as opposed to wage earners and within economies with extensive black economies. Hungary introduced a new type of tax for small enterprises with a substantially lower tax rate. I use this tax reform to analyse the elasticity of the self-employed. The overall ETI of the self-employed is about twice as large as for the total employee population (12%). I demonstrate that at least part of the income elasticity covers adjustment of income underreporting besides the adjustment of

real income-generating efforts, and the ETI falls to around half when also controlling for tax evasion (4-5%).

The third chapter of this thesis estimates the distributional implications of income tax evasion in Hungary. Tax evasion has serious implications for the income distribution, as it alters the disposable income of households through the altered payment of tax. In this exercise, gross incomes declared in the administrative tax returns are compared with incomes stated in a nationally representative household budget survey. Estimates show that the average rate of underreporting is 8-18%, but this conceals a big difference between the self-employed (who hide a greater part of their income) and employees. These rates are used in a tax–benefit microsimulation model to calculate the fiscal and distributional implications of underreporting. Tax evasion reduces households' personal income tax payment by about 8–20%. Poverty and inequality seem significantly higher if calculations are based on true income rather than its reported figure. Finally, tax evasion greatly reduces the progressivity of the tax system.

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First and foremost, I would like to thank my supervisor, Péter Benczúr, for his invaluable help and encouragement throughout my research. He was always available for discussions, provided continuous supervision and showed a great deal of understanding of my professional and private problems. He devoted a lot of time and effort to helping me turn my ideas into a dissertation. He taught me how to start a research project by posing the appropriate research question, setting up a structured model and conducting an empirical analysis. Without his support, I could not have finish my dissertation.

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Introduction

In the last few decades the literature on the behavioural effects of tax reforms has grown substantially. This literature focuses on the elasticity of taxable income (ETI) to changes in the marginal tax rate. The usual finding is a significant positive effect of marginal tax rate changes to taxable income. The ETI is especially important when governments reduce the tax rates substantially in order to boost their economic and tax revenues. Many Central and Eastern European countries are adopting flat tax schemes with this aim. There are signs that some countries manage to improve both their economic performance and tax revenues with tax reforms, but it is hard to differentiate the behavioural response to tax changes from the effect of increased tax enforcement. Whereas real behaviour response results in increased production through higher labour supply increased enforcement only results in higher tax revenues. Therefore the very nature of the behavioural response to tax changes is important to understand when designing tax reforms.

The first chapter of this thesis addresses this gap by estimating the elasticity of taxable income in Hungary, one of the region's "outliers" in terms of not having a flat tax scheme. Since only tax rates changed during this reform and tax enforcement remained unchanged, the measured ETI estimates are only a result of the marginal tax rate changes. Taxpayer behaviour is analysed using a medium-scale tax reform episode in 2005, which changed marginal and average tax rates but kept enforcement constant. A Tax and Financial Control Office (APEH) panel dataset from 2004 to 2005 is employed with roughly 215,000 taxpayers. Results suggest a relatively small but highly significant tax price elasticity of about 0.06 for the population earning above the minimum wage (around 70% of all taxpayers). This number increases to around 0.3 when we focus on the upper 20% of the income distribution, with some income groups exhibiting even higher elasticities (0.45).

Using these results, this thesis quantifies the impact of a hypothetical flat income tax scheme. Calculations indicate that, while there is room for a parallel improvement of budget revenues and after-tax income, such gains are modest (2% and 1.4%, respectively). Moreover, such a reform involves important adverse changes in income inequality, and its burden falls mostly on lower-middle income taxpayers.

In the second chapter, I analyse the elasticity of reported income to tax rates of the self-employed. The ETI captures several margins of adjustment. Most importantly, labour supply is adjusted after tax rate changes, but taxpayers also adjust in their income underreporting behaviour. Changes in concealment might be even more substantial in the case of small enterprises as opposed to wage earners and within economies with extensive black economies. Hungary introduced a new type of tax for small enterprises with a substantially lower tax rate. I analyse the elasticity of reported income to tax rates of the self-employed based on this tax reform, also employing a large-scale APEH dataset containing individual tax report data. The overall ETI of the self-employed is about twice as large as for the total employee population (12%). I demonstrate that at least part of the income elasticity covers the adjustment of income underreporting besides the adjustment of real income-generating efforts, and the ETI falls to around half when also controlling for tax evasion (4-5%). This latter measure is the true labour supply elasticity of the self-employed.

In the third chapter, I estimate the distributional implications of income tax evasion in Hungary, based on a random sample of the administrative tax records of nearly 230,000 individuals. Income underreporting has a serious implication for income distribution as it alters the disposable income of households through the altered payment of tax. In this exercise gross incomes declared in the administrative tax returns are compared with incomes stated in a nationally-representative household budget survey (on the assumption that tax evaders are more likely to report their true income during an anonymous interview). Estimates show that the average rate of underreporting is 8-18%, although this conceals a substantial difference between the self-employed (who hide a greater part of their income) and employees.

The estimated underreporting rates are used in a tax–benefit microsimulation model to calculate the fiscal and distributional implications of underreporting, taking account of all major direct taxes and cash benefits, as well as their interactions. Tax evasion reduces households' personal income tax payment by about 8–20%. Poverty and inequality seem significantly higher if calculations are based on true income rather than its reported figure, suggesting that high-income households are likely to evade paying tax proportionately more. Finally, tax evasion greatly reduces the progressivity of the tax system.

Chapter 1

Hungarian Tax Changes in 2005: Estimation of the Elasticity of Taxable Income and Flat Tax Predictions

Joint with Péter Bakos[1] and Péter Benczúr[2]

1.1 Introduction

Motivated by their simplicity, easy administration and effective monitoring, "flat tax" experiments have become practically the rule in Central and Eastern European (CEE) countries. While they involve a large cut in personal income taxes and, thus, often have adverse implications for income inequality, such reforms tend to boost budget revenues. It is not immediately obvious, however, that this is evidence for some kind of a Laffer curve, since the introduction of a flat tax always comes with additional changes in tax rates (such as an increase in capital income tax rates). More importantly, there is often an increase in enforcement as well.[3]

One cannot easily separate the influence of these factors, even if it would be essential for the design of tax reforms in these countries.[4] If there is a substantial labour supply (more precisely: taxable income) response, that is indicative of the huge welfare gains from an overall shift away from labour income taxation, regardless of whether it is a flat tax or not. If, on the other hand, there is little labour supply response, the effect must stem primarily from increased enforcement, hence new reformers should concentrate

[1] ABN AMRO Bank N.V., London
[2] Magyar Nemzeti Bank and Central European University, Budapest
[3] See for example: Ivanova *et al* (2005) on Russia, and Moore (2005) on Slovakia.
[4] Gorodnichenko *et al* (2009) is an empirical attempt to measure the response of tax evasion to the Russian tax reform, using a household panel survey.

their efforts on enhancing tax discipline and use tax cuts to compensate taxpayers for harsher enforcement; again, regardless of whether this takes the form of a flat tax or not. Alternatively, a tax cut can serve as a focus point in switching to a 'high tax morale' equilibrium.[5]

This chapter aims to quantify the response of taxable income to changes in tax schedules in Hungary, which is one of the few countries in the CEE region without a flat tax. Although there are some studies aimed at describing the structure of the Hungarian tax system (Bakos *et al*, 2008), or redistributional aspects of flat tax schemes (Benedek and Lelkes, 2006), we are the first to study the elasticity of taxable income.[6] Using a medium-scale tax reform episode of 2005 and a large panel of personal income tax files, we obtain an estimate for the behavioural response of taxable income to the marginal and average tax rate, *keeping tax enforcement unchanged.*

In particular, we use Tax and Financial Control Office (APEH) panel data for the years 2004 and 2005, with roughly 480,000 raw observations. This allows us to compare taxpayer behaviour before and after the 2005 tax changes. This reform episode reduced the number of personal income tax brackets from three to two, increased the employee tax credit, raised the maximum annual amount of pension contribution and introduced a gradual, income-dependent phase-out of certain tax allowances (also raising marginal tax rates for some). Together with the "bracket creep" of not adjusting tax brackets to inflation, these led to various changes in marginal and average tax rates, without any major change in tax enforcement.[7]

The feature that marginal (and average) tax rates are heavily influenced by the deduction status of the taxpayer has important implications. On the one hand, it makes it even more important to use actual tax data, as opposed to household surveys: without detailed information on tax deductions, one cannot calculate the marginal tax rates correctly. On the other hand, the deduction status introduces an income-independent source of exogenous variation in tax rate changes, allowing a separation of the impact of marginal and average tax rates and base year income controls even in a two year panel.

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[5] This point is further elaborated in Papp and Takats (2008).

[6] There is some preceding empirical literature on the behavioral effects of taxation in Hungary. Examples include: Semjén and Tóth (2004), and Vidor (2005). Mosberger (2010) and Kiss (2010) extend our analysis to the 2006-07 tax changes.

[7] Hungary has recently strengthened its employment legislation in order to reduce tax evasion. This campaign, however, started only in 2006 (see for example Eppich and Lőrincz, 2007).

Our focus on taxable income as opposed to labour supply itself is motivated by a long research line in public economics (Feldstein, 2002). The early research focusing on the effect of taxation on labour supply – as reviewed by Heckman (1993) – suggested that the labour supply of primary earners is rather insensitive to tax rates. Following the seminal paper of Feldstein (1995), a new body of literature has emerged which has analyzed the broader context of labour supply. This approach is based on the observation that taxable income can vary not only with the labour supply, but also with work effort, household investment, tax-deductible activities, the form of compensation, or with a change in tax compliance. Moreover, all these components are crucial for assessing the deadweight loss of taxation and for revenue predictions of tax reforms. As summarized and surveyed by Gruber and Saez (2002), there is ample evidence that taxable income is quite sensitive to taxation.

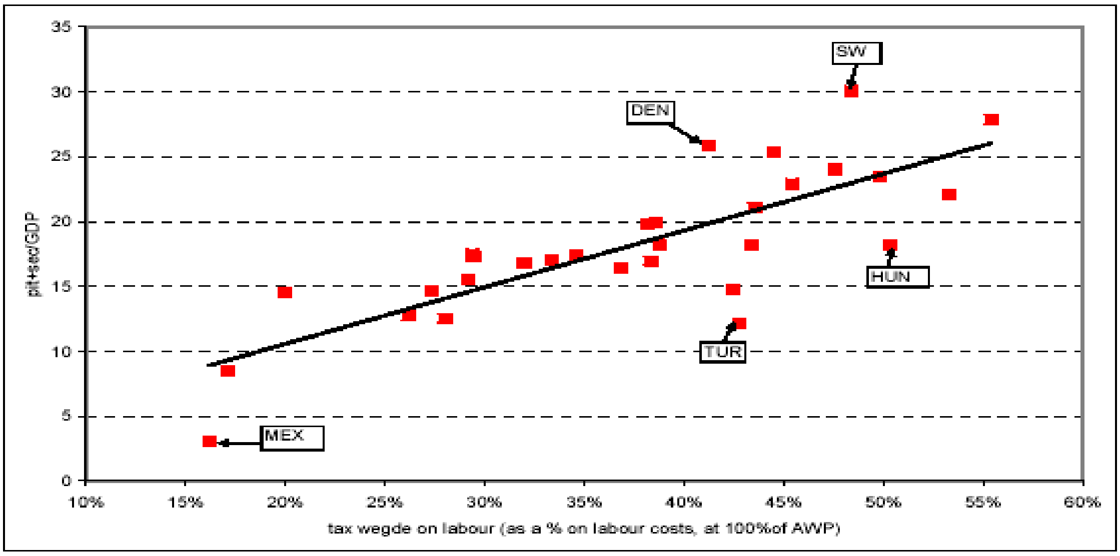
Taxable income can adjust through three main channels: (i) taxpayers work more, better or more intensively and thus produce higher income; (ii) taxpayers declare a bigger portion of their total earnings, i.e., there is a decrease in tax deductions, avoidance and tax evasion; and (iii) there is a shift between wage income and other sources of income (capital income, fringe benefits). While one cannot fully separate these three elements based on tax file data, we can eliminate many possibilities by looking at the specifics of the Hungarian tax code and analyzing the heterogeneity of our results to various individual characteristics.

Besides data availability and the important feature of the analyzed episode that there were changes in tax rates *without changes in enforcement*, the relationship of taxable income and labour tax rates in Hungary is an interesting issue in its own right. In an OECD comparison, Hungary has the third highest overall labour tax wedge; while its labour income tax revenue per GDP ratio is around the OECD median (see Figure 1).

This aggregate cross-section evidence suggests an important elasticity of taxable income to taxation in Hungary. Maybe surprisingly, our Hungarian estimates indicate that the elasticity of taxable income to marginal tax rates is quite low for the upper 70% of wage earners (those earning at least the minimum wage) – in contrast to the canonical US findings of around 0.4 (Gruber and Saez, 2002), it is around 0.06. This means that wage income taxation leads to little welfare losses, but for a large enough change in marginal tax rates, even these low elasticities imply a substantial change in taxable income.

Moreover, the elasticity is much higher for the upper 20% of the income distribution (0.34), and for some groups, it is as high as 0.45, meaning that high marginal tax rates lead to substantial distortions in certain income ranges.

Figure 1.1 Labour tax wedges and labour income tax revenue per GDP ratios in OECD countries



Source: Krekó and P. Kiss (2007), OECD 2004, 2005.

The population average coefficient of *average tax rates* (the income effect) is zero for the upper 70% of the income distribution, but, unlike Gruber and Saez (2002), we find a very significant and substantial income effect for the upper 20% (-0.27). This means that *uncompensated* taxable income elasticity is around 0.06 in both income subsamples – an increase in average tax rates makes taxpayers poorer and induces them to generate more income ("work more"), almost matching the reduction due to higher marginal tax rates. This can be quite important for a flat tax reform, as it decreases both the marginal and the average tax rate for the top of the income distribution. If there is a strong income effect, it goes against the substitution effect, limiting the overall boost to the economic activity of top earners.

Now consider a flat tax experiment that is designed to be revenue-neutral without any behavioural response. This means that there is some increase in marginal and average tax rates for low and middle-income taxpayers; while for high income taxpayers, there is some decrease in average tax rates and a substantial decrease in marginal tax rates. Taking into account the heterogeneity of compensated elasticities and income effects over the income distribution, one can expect a non-negligible increase in total income and also in income inequality. Indeed, our hypothetical flat income tax[8] simulation shows a parallel improvement in budget revenues and after-tax income (2% and 1.4%, respectively). While positive, these improvements are rather modest. Moreover, there are important changes in income distribution, and the overall burden falls heavily on taxpayers in income deciles 5-7.

Comparing our results to those of the US literature, we obtain comparable elasticities for high income taxpayers and much smaller elasticities for the entire sample. In our view, the difference between the two overall elasticity results can be traced to differences in tax schemes. In the US, most deductions are applied to taxable income, and as Gruber and Saez (2002) highlight, the taxable income sensitivity is, to a large extent, from such itemized deductions. In Hungary most of the deductions in the personal income scheme are subtracted directly from the tax itself, which does not affect taxable income. Self-employed individuals (entrepreneurs), on the other hand, are able to deduct various expenses from their tax base, and there is indirect evidence that they do so excessively (Krekó and P. Kiss, 2007). However, the majority of entrepreneurial income is taxed separately in Hungary. It is less surprising to find a low elasticity for taxable income (which only contains income falling under the personal income tax scheme). In fact, the more surprising finding is that high-income individuals exhibit substantial elasticities even without having access to deductions from the tax base.

This chapter is organized as follows. Section 2 reviews the most relevant empirical literature in some details. The next section explains our empirical approach; section 4 presents and discusses our main results. Section 5 performs three revenue prediction exercises, and section 6 concludes the analysis. Finally, the Appendix contains some omitted details.

[8] Our hypothetical flat tax system is a bit different from a "textbook flat tax": it provides tax exemption up to the minimum wage, but levies a uniform social security contribution on all income. Actual flat tax schemes are often similar (for example in Slovakia and Russia).

1.2 Related literature

The key parameter of interest is the elasticity of taxable income with respect to the change in the *tax price* (net-of-tax income per marginal pretax dollar, i.e., one minus the marginal tax rate). The elasticity estimates are diverse, ranging from Feldstein's (1995) result at the high end to close to zero at the low end. This variety reflects the different approaches applied in these papers such as the different definition of income, sample and source of identification. Below we give a brief overview of the evolution of the consensus US estimates for taxable income (see Gruber and Saez, 2002, for details), and comment on some international results.

The applied empirical strategy is very similar in all these papers. They estimate the effect of the tax price on the taxpayers' income (in logs):

$$y_{it} = c_i + \gamma_t + \alpha_t x_i + \beta \log(1 - MTR_{it}) + u_{it}, \tag{1}$$

where y_{it} is taxable income, MTR_{it} is the marginal tax rate, c_i is the fixed effect for individual i and γ_t is a time-specific effect. The variables in x_i are individual characteristics that do not vary over time, but may have a time-varying effect on y_{it} (like wealth, entrepreneurial skills, regional dummies). Finally, β is the elasticity of taxable income, the key parameter of interest. Equation (1) is estimated in first differences.

Lindsey (1987) analyses the U.S. personal tax cuts from 1982 to 1984, measures the response of taxpayers to changes in income tax rates and uses the results to predict the revenue maximizing rate of personal income taxation. The paper finds large tax elasticities: the results of the constant elasticity specification are always above one. Because of data limitations, he does not use panel data; instead, he compares taxpayers in similar income percentiles for different time periods. The main limitation of this approach is that it assumes a static income distribution over the investigated period.

To overcome this problem, Feldstein (1995) uses a US Treasury Department panel of more than 4000 individual's tax returns before and after the 1986 tax reform. The analysis compares tax returns for 1985 and 1988 and finds an elasticity of at least one.

Auten and Carroll (1999) also analyze the effect of the 1986 tax reform using a larger panel of tax returns of 14,425 taxpayers. They report a significantly lower (0.6) tax-price elasticity. Besides data issues, the major reason for the difference is the inclusion of additional controls ("nontax factors") past income in particular. This highlights the need for controlling for individual income profiles (mean reversion).

Gruber and Saez (2002) use a long panel of tax returns over the 1979-1990 period with roughly 46,000 observations. They relate changes in income between pairs of years to the change in marginal rates between the same pairs of years with a time length of three years. Their empirical strategy distinguishes the income and substitution effect of tax changes.

To identify these effects separately, they need variations in the average tax rate[9] that are orthogonal to variations in the marginal tax rate. This is supplied by the fact that the same change in the marginal tax rate implies a different change in the average tax rate for individuals with different incomes within the same tax bracket. In case of a single tax episode, however, that variation can be highly correlated with initial income controls, which are crucial to account for mean reversion and, as the authors argue, changes in the overall income distribution. Using a long panel dataset covering many tax reforms, they overcome all these difficulties and find that the overall elasticity of taxable income is approximately 0.4, which is primarily due to a very elastic response of taxable income for taxpayers who have incomes above $100,000 per year and for itemizer taxpayers. They also find an insignificant income effect.

Using a methodology similar to Auten and Carrol (1999) and an exceptionally large dataset (nearly 500,000 prime age taxpayers) covering the 1988 Canadian tax reform, Sillamaa and Veall (2001) find that the responsiveness of income to changes in taxes is substantially smaller in Canada (0.25) than in the Auten and Carrol (1999) study for the US. They also report much higher responses for seniors and high income individuals.

Aarbu and Thoresen (2001) find even lower elasticity measures for Norway analyzing the 1992 Norwegian tax reform. They employ a panel dataset of more than 2000

[9] Gruber and Saez (2002) work with virtual income instead of the average tax rate. Virtual income is the intercept of the budget line using the current tangent (one minus the marginal tax rate) as its slope. Non-labor income differs from virtual income as long as the marginal tax rate is not constant. The Appendix shows that virtual income and the average tax rate lead to the same specification.

individuals and find that estimates for the elasticity of taxable income range between -0.6 and 0.21. Focusing on regressions which contain a measure for mean reversion in income, their baseline estimates are between 0 and 0.21.

In contrast, Ljunge and Ragan (2005) obtain comparable compensated elasticities to Gruber and Saez (2002), of around 0.35, for the Swedish tax reform in 1991 ("the tax reform of the century"), using a six-year panel of 109,000 individuals. However, they also find a sizable and significant income effect, implying a much lower uncompensated elasticity.

Saez *et al* (2010) provide a comprehensive overview of the ETI literature and conclude that most US estimates range from 0.12 to 0.4. They emphasize that there is no compelling evidence that the behavioural response comes from real economic factors, it is rather an adjustment in tax optimization and tax evasion. They point out that labour supply elasticity, especially in the case of prime age males, is substantially lower than the elasticity of taxable income. However they also argue that the source of adjustment is irrelevant if we only consider the welfare effects. Another important finding of their comparative study is that the elasticity of taxable income is not a universal parameter, but differ largely by the tax rules, especially the deduction rules and the methodology of the analysis.

Instead of the elasticity of total reported income Blomquist and Selin (2010) analyzed the elasticity of hourly wage rates and taxable labour income to the net-of-tax rate and found somewhat lower elasticities for men and somewhat higher for women. They found a statistically significant response in wage rates both among married men and women, although females were found to be a lot more elastic. Their estimates of the hourly wage rate elasticity are 0.14–0.16 for males and 0.41–0.57 for females and the taxable labour income elasticity estimates are somewhat higher: 0.19–0.21 for men and 0.96–1.44 for women.

Although the ETI captures more margins of adjustment in one measures, including labour supply response, tax optimization and tax avoidance, it can only be measured for those who had reported income both before and after the reform. Therefore, labour supply adjustment on the so-called extensive margin (participation response) cannot be measured by the ETI. The welfare effects on this margin can be substantial however.

For example using simulations based on four US tax reforms Eissa *et al* (2004) showed that welfare gains along the extensive margin can be more substantial than labour supply response along the intensive margin. However as we emphasized before, that welfare loss along the intensive margin stem from not only the labour supply elasticity, but other components (such as tax optimization and tax evasion) of the elasticity of taxable income.

However Chetty (2008) analyzed the welfare loss measured by the ETI and found that because of tax optimization of the taxpayers the efficiency cost of taxing high income individuals is not necessarily large despite the high elasticity of their taxable income.

1.3 The Empirical Framework

Methodology

We estimate the effect of the change in the marginal tax rate on the taxpayers' reported taxable income following a slightly modified version of Gruber and Saez (2002). Taxpayers derive utility from consumption *c* and disutility from income generation efforts ('labour') *y*, and face a budget set which is locally linear: $c = y(1-\tau)+R$. Here τ is the marginal tax rate (one minus the local slope of the budget line) and R is the intercept of the local budget line (virtual income). Utility maximization yields an income supply function $y(\tau,R)$ – see point A_1 in Figure 1.2. Notice that a tax change in general affects both the marginal tax rate and the intercept of the budget line (or alternatively, the average tax rate, ATR) – see point A_2 in Figure 1.2.

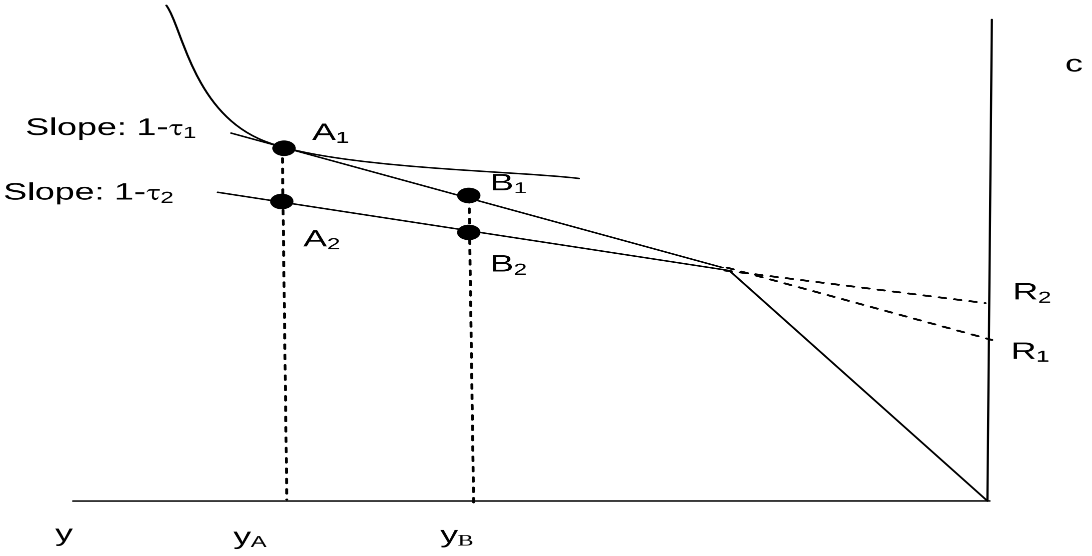
Consequently, the response of income to a tax change ($d\tau$,dR) can be written as:

$$dy = -\frac{\partial y}{\partial(1-\tau)}d\tau + \frac{\partial y}{\partial R}dR.$$

Introducing the uncompensated tax price elasticity parameter $\beta^u = (1-\tau)/y\left(\partial y/\partial(1-\tau)\right)$, the income effect parameter $\phi = (1-\tau)\partial y/\partial R$ and the compensated tax price elasticity $\beta = \beta^u - \phi$ (from the Slutsky equation), we obtain

$$\frac{dy}{y} = -\beta\frac{d\tau}{1-\tau} + \phi\frac{dR - yd\tau}{y(1-\tau)}.$$

Figure 1.2 The nonlinear budget set



For non-infinitesimal tax changes, it is more appropriate to discretize this equation in a log-log specification. Replacing *dy/y* by *Δlogy*, *dτ/(1-τ)* by *Δlog(1-MTR)* and *(dR-ydτ)/(y(1-τ))* by *Δlog(1-ATR),* [10] we get

$$\Delta \log y_i = \beta\Delta\log(1-MTR_i) + \phi\Delta\log(1-ATR_i). \quad (2)$$

Looking back to Figure 2, one can see now the key intuition beneath the empirical separation of the substitution effect (*β)* and the income effect (*ϕ)*. Without a behavioural response, taxpayer A moves from point A_1 to A_2, while B moves from B_1 to B_2. This implies the same change in the marginal tax rate for both, but a different change in their

[10] This term is the approximation of virtual income, similarly to the specification of Gruber and Saez (2002). See the Appendix for more details.

average tax rate, as the increased marginal tax rate applies to a different fraction of their income.

In addition to the terms in equation (2), income may change from year to year due to nontax factors as well. As Auten and Carroll (1999) and Gruber and Saez (2002) point out, one needs to control for additional covariates x_i that do not vary over time but may have a time-varying effect on income (such as wealth or entrepreneurial skills), and initial income y_0 (to control for mean reversion in income and changes in the overall income distribution). This gives our full specification:

$$\Delta \log(y_i) = \gamma \log(y_{0i}) + x_i'\Delta\alpha + \beta\Delta\log(1 - MTR_i) + \phi\Delta\log(1 - ATR_i) + u_i. \qquad (3)$$

Notice that this also coincides (apart from the presence of the average tax rate) with the first difference of equation (1).

The endogeneity of actual tax rates is a major problem in estimating equation (3). The Appendix contains a formal discussion of the identification procedure; here we only outline its main ingredients. On the one hand, the MTR can change both because of the change in legislation (exogenous variation) and because of an unexplained shift of taxable income (endogenous variation). This latter is characteristic of progressive tax systems: a negative income shock can cause – holding other factors fixed – a decrease in the MTR.

This means that $\mathrm{cov}(\Delta\log(1 - MTR_i), u_i) \neq 0$, hence all parameter estimates are inconsistent. To overcome this problem, the usual procedure[11] is to instrument the log change in the true tax price by the log difference of the *synthetic* tax price in 2005 and the actual tax price in 2004. We calculate this synthetic MTR (SMTR) by applying the 2005 rules to inflated 2004 income and tax allowances. The synthetic MTR is the marginal tax rate that would have been applicable in 2005 had the taxpayer's real income not changed.

There is an identical endogeneity problem with the average tax rate as well, which can be treated by instrumenting the second period 1-ATR by the synthetic 1-ATR. We calculate this synthetic ATR (SATR) similarly to SMTR.

[11] For example, Auten and Carroll (1999), Gruber and Saez (2002) follow this approach.

To use the synthetic tax rates as instruments, they need to be exogenous in equation (3) and correlated with the appropriate realized tax rate once the other explanatory variables have been netted out. If the error term u_i is uncorrelated with all the right hand side variables, then the exogeneity of the instruments is satisfied by construction because they are calculated using the 2004 income inflated to 2005. We check the second condition using first stage diagnostic tests (partial F statistics). We also report a test for the exogeneity of realized tax rates (the C-statistics) and the Kleibergen-Paap rk statistics for the rank condition.[12]

It is important to take a closer look at the role of initial income. Some taxpayers who have unusually high or low incomes in 2004 may experience large offsetting changes. This mean-reversion effect can bias the tax price elasticity estimates: a negative correlation between the income innovation u_i and initial income y_{0i} of equation 3 makes the error term correlated with initial and synthetic tax rates, too.

The exclusion of low income taxpayers from the sample can limit this bias, but in order to further control for the mean reversion effect, we include *initial income* in the model as Moffitt and Wilhelm (2000) suggest and also allow for an income-dependent intercept and initial income coefficient (following Gruber and Saez, 2002). This should lead to an error term u_i that is uncorrelated with initial income. This way we also treat the problem of changes in the income distribution: a widening of the income distribution, for example, would induce a positive correlation between u and y_{0ii}.

Using only two periods of tax data, it is in general difficult to disentangle the impact of the marginal tax rate, the average tax rate and initial income (Gruber and Saez, 2002). The Hungarian tax code, however, has the feature that most tax deductions are deducted from the tax itself (as opposed to the tax base), and there is an income-dependent phase-out of deduction eligibility. This phase-out leads to a cross-sectional variation in marginal (and also average) tax rates which are independent of income. Consequently, there is sufficient variation in the change in marginal and average tax rates even for similar initial income levels.

[12] This exogeneity test estimates the equation assuming that all right hand side variables are exogenous, using the instruments as additional orthogonality conditions, and then tests the exogeneity of the realized tax rates with the C-statistics. The Kleibergen-Paap rk statistics test for the full rank of the instruments (rank condition), in a heteroskedasticity-robust way. See Baum *et al*, 2007 for details.

Marginal tax rate (MTR)

The variable of interest is the difference of the logarithm of the tax price[13] for a taxpayer in 2005 and 2004. The tax reform episode reduced the number of tax brackets from three to two, increased the employee tax credit, raised the annual maximum of pension contributions and introduced a gradual, income-dependent phase-out of certain tax allowances (also raising marginal tax rates for some). These led to various changes in marginal and average tax rates.[14] The Appendix contains a detailed description of the episode.

In general, it is hard to describe these tax changes as a function of taxable income itself. For example, if a tax deduction is phased out gradually above certain income levels, that leads to an increase in the marginal tax rate, depending on both income and deduction status. Moreover, all deductions and the employee tax credit are limited by broad income and not taxable income.[15]

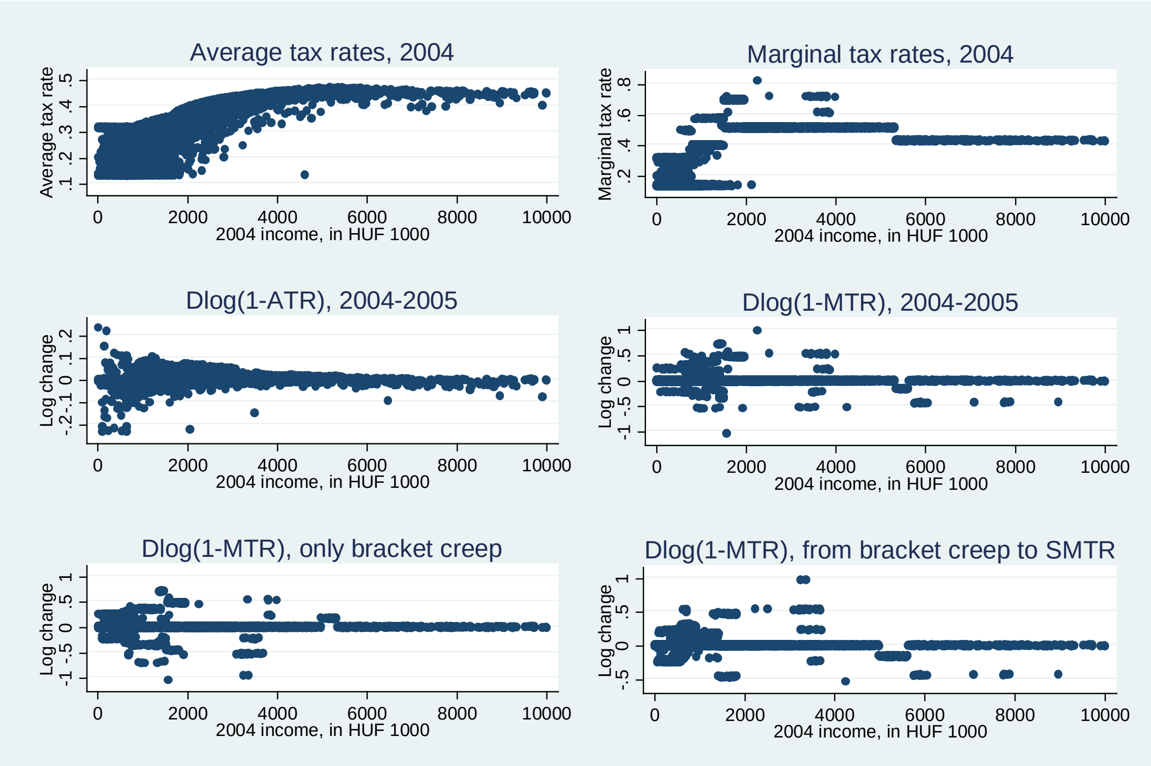
The distribution of average and marginal tax rates in 2004 (which include social security contributions as well) and the full impact of all changes (including the "bracket creep" of not adjusting tax brackets to inflation) is summarized in Figure 1.3. We also added the breakdown of the change in marginal tax rates into the bracket creep and then the tax reform itself. For better visibility, we drop individuals above an annual income of 10,000,000[16] and use a 5% random sample.

The top left panel indicates that the average tax rate broadly increases with taxable income, although it starts decreasing at very high income levels (due to the annual

[13] The expression 'tax price' refers to the fact that for unchanged wages, a change in the tax rate coincides with the change in the relative price of leisure.
[14] Elements of the social benefit system also have incentive effects and affect the marginal *effective* tax rate. Scharle (2005) argues that the marginal effective tax rate can be exceptionally high on low income levels, despite the fact that the tax system is designed to be progressive.
It is important to note that in our analysis we only take into account the effects of the tax schedule, tax credit and social security contribution modifications and not the changes in the social benefit system. However we limit our sample to individuals above the minimum wage, therefore most taxpayers who are eligible for any social benefit are left out anyway.
[15] Broad income consists of wage income, non-wage labor income (the sum of these two is our taxable income measure), and other, mostly capital incomes (taxed separately).
[16] The exchange rate is around 250 HUF per euro. An annual income of 10,000,000 corresponds to the top 0.5 percentile of the income distribution.

maximum of pension contributions). Various tax deductions, however, lead to large individual differences. The top right panel plots marginal tax rates and we see that the highest marginal rates are faced by two groups of taxpayers: those who just lose their eligibility for the employee tax credit (income range 1,000,000-2,000,000) and those who lose their eligibility for various tax deductions.[17]

Figure 1.3 Tax rates in 2004, and the 2004-2005 change in the log of synthetic tax prices in our sample



The middle two panels describe the change in the log of one minus the average and marginal tax rates (a *decrease* thus means a *rise* in tax obligations). The bottom two panels depict the change in the log of one minus the marginal tax rate due to inflation (left panel), and then the additional effect of the tax changes (right panel). There is a general decline in the average tax rate for low and medium income taxpayers, though not universally (exceptions are largely due to the bracket creep). The most important variation in the marginal tax rate corresponds to the 636,000-4,000,000 income range (30 to 95 percentile of the income distribution). This is partly due to the employee tax

[17] One such example is the tax deduction for certain computer purchases ('SULINET' program). There is full deduction below an income level of 3,400,000, no deduction above 4,000,000, and a gradual phase-out in between. This leads to an extra 10% marginal tax rates for those with some deductions in the income range 3,400,000-4,000,000.

credit – the legislative change points towards a decrease, but the bracket creep again leads to an increase for some. Another major source is the unchanged income limit of various tax deductions, leading to both increases and decreases. For high income taxpayers, the 6,000,000 overall tax deduction income limit, the increase in the annual pension contribution limit, and the introduction of an income limit to the family tax allowance have a positive effect on the marginal and average tax rates. Overall, there is a substantial and non-obvious variation in average and marginal tax rates.

Data

The source of data for our analysis is a Hungarian Tax and Financial Control Office (APEH) panel of individual tax returns for the years 2004 and 2005. This dataset was prepared for the Hungarian Ministry of Finance, and it contains data from the personal income tax forms 0453 and 0553 (unaudited). The random sampling was done by the tax authority choosing 250,000 anonymous individuals for the year 2004, and matching their tax returns for the year 2005. It is natural that some individuals fall out of the sample between years, thus the panel for the second year contains 8.9% less observations. It is still an exceptionally large panel including more than 227,000 individuals, about 5% of all taxpayers.

We limit our sample by leaving out individuals with extreme rates of income changes (over 500 or below 1/500 – 16 observations). We also drop observations with nonzero foreign income (1336 observations), as it would be hard to compute their true marginal and average tax rates. Besides, those individuals are likely to differ from the rest of the population. We further drop a small number of additional observations (a total of 202) where certain data cells violate the tax code in a way that affects the tax obligation of the taxpayer. Regional indicators are missing from 583 observations. Then we limit the sample to taxpayers who filed in both years, which leads to a sample of 215,315. From this population, we limit our attention to those who had taxable income above the compulsory annual minimum wage in 2004 (636,000, top 70%), a sample of 150,141. Finally, we exclude observations where reported and calculated employee tax credit numbers differ significantly (5423 observations, of which 3465 is above the minimum wage) in either tax year.[18] We certainly do a robustness check whether this last deletion has an effect on our estimates (and it does not). Our full income sample has 209,892 observations; of which 146,676 are above the 2004 minimum wage.

Following the literature, and Auten and Carroll (1999) in particular, we include a set of individual characteristics in the regression that are likely to be correlated with income changes. *Taxpayer's wealth* is likely to be correlated with the ability to alter portfolios and labour arrangements as taxes change, thus we include a dummy for declaring any capital income in 2004 or 2005. *Entrepreneurial status* may reflect the ability of income shifting between different tax categories and the propensity of risk taking, therefore a dummy is included for income from any kind of self-employment income in 2004 or 2005. The *life cycle and family status of the individual* can have an effect on income changes, thus we include the age of the taxpayer in 2004, its square and a dummy for family based on claiming the family allowance.[19] We apply *urban dummies* to control for the difference in income growth in urban and rural areas (Aarbu and Thoresen 2001): we use a dummy for the capital (*Budapest*), another for the 19 county capitals; and also a regional dummy to control for regional differences. There might be different opportunities for income growth based on *gender* differences. Although *occupation* may have a significant effect (Auten and Carroll, 1999), the dataset does not allow us to control for that.

One also needs to control for the mean-reversion of income, and potential changes in the income distribution. We include *initial income* in the model as Moffitt and Wilhelm (2000) suggest, and also allow an income-dependent intercept and initial income coefficient (following Gruber and Saez, 2002).

The synthetic change in the marginal (average) tax rate is the difference in the logarithm of one minus the synthetic and the actual 2004 marginal (average) tax rate. It is calculated as follows. The 2004 income, deductions and most allowances[20] are inflated to 2005 using the official statistics office annual average inflation for 2004 (6.8%). The

[18] In these cases, the difference is between 2.1 and 12.25. This difference is negligible for the *average* tax rate, but it might be influential for the *marginal* tax rate of some. See footnote 22 for details.
[19] There is no reliable information on family status in Hungarian tax reports. People claiming the family tax allowance certainly have children, but others who are not claiming it may also have children.
[20] Some allowances correspond to delayed claims, which means that eligibility comes from a period prior to 2005, but the deduction itself has not been utilized for some reason. We assume that there were no behavioral responses in such cases, thus the inflated allowance was set equal to the realized allowance.

synthetic tax rates are then equal to the appropriate tax rates of the inflated income using the 2005 tax rules. The detailed program codes are available from the authors upon request.

The dependent variable in the model is the difference in the logarithm of income in the years 2005 and 2004. Income is defined as the total income that is covered by the personal income tax schedule.

Although most papers use a longer panel for the analyses in order to measure the long-term effects of the tax reforms we only had access to a one-year panel therefore had to do the estimation over a short period. However, Kiss (2010) used the same method to analyse the ETI on Hungarian, data but on a different tax reform episode and with a three year panel and found elasticities slightly lower than our results.

Table 1.1 presents the descriptive statistics of the variables in our total working sample and in the subsample of individuals with income above the 2004 minimum wage.

Table 1.1. Means and standard deviations of variables

Variable	Total working sample		Above the min. wage	
	Mean	Std. Dev.	Mean	Std. Dev.
Δlog taxable income	0.10	0.57	0.03	0.39
Δlog (1 - marginal tax rate)	0.02	0.23	0.04	0.26
Δlog (1 – exogenous marginal tax rate)	0.03	0.13	0.03	0.15
log 2004 gross income	6.88	0.96	7.33	0.61
Δlog (1 - average tax rate)	0.01	0.07	0.01	0.07
Δlog (1 – exogenous average tax rate)	0.00	0.02	0.01	0.02
Wealth dummy	0.29	0.45	0.36	0.48
Age in 2004	39.86	11.82	40.71	11.10
Age in 2004 squared	1728.38	989.79	1780.54	930.85
Entrepreneurship dummy	0.17	0.37	0.16	0.36
Family dummy	0.28	0.45	0.34	0.47
Gender dummy	0.53	0.50	0.53	0.50
Budapest dummy	0.18	0.39	0.19	0.39
Regional capital dummy	0.41	0.49	0.42	0.49
Observations	209,892		146,676	

1.4 Estimation results

Table 1.2 presents our basic results for those who earned at least the annual minimum wage in 2004 (the upper 70% of the income distribution). Model 1 includes only one regressor, the tax price. Models 2-4 gradually add further controls: first initial income, then the income effect (the change in the average tax rate), and the full set of individual characteristics (the coefficients of the regional dummies are not reported). Finally, Model 5 allows the initial income coefficient and the constant to differ across income deciles (coefficients not reported). In all cases, the exogeneity of the realized tax rates is strongly rejected, while all first stage diagnostic statistics and rank tests are perfect for the instruments.

The estimates for the tax price are significant in all specifications and vary between 0.0494-0.0743, depending on the controls included. This range is lower than most tax elasticity estimates for other countries (for example Auten and Carroll, 1999: 0.6; Gruber and Saez, 2002: 0.4 for the US; Sillamaa and Veall, 2001: 0.14 for Canada; or Aarbu and Thoresen, 2001: 0.21, for Norway; Ljunge and Ragan, 2005: 0.35 for Sweden).

Initial income is highly significant and its inclusion decreases the key elasticity by one third, while the further inclusion of the income effect and additional controls has a limited impact on the tax price elasticity. Though the income effect appears to have the wrong sign in Models 3 and 4,[21] it becomes insignificant once we allow for our most flexible control for changes in the income distribution (Model 5).

Most of the control variables behave the way we expected. For example, wealth has a positive effect on the income change, family, as a proxy for having children, decreases the possibility to adjust income to tax rate changes.

The results change substantially if we concentrate on a middle income sample (2004 income above 2,000,000, top 20%).[22] As Table 1.3 shows, the coefficient for our key regressor is now around 0.3. Initial income is still significant, and it decreases the tax

[21] If log (1 – ATR) increases, that corresponds to a decrease in the average tax burden, implying an increase in net disposable income. If leisure is a normal good, its consumption should go up, hence the generation of income ('labor supply') should go down ($\phi < 0$).

[22] This is the range where employee tax credit is already completely phased out under the 2005 tax code; thus the variation in synthetic tax prices is not due to changes in the employee tax credit scheme.

price elasticity estimate by 20%. The income effect has the right sign, it is quite significant and it decreases the tax price elasticity further. Additional covariates (particularly the flexible controls for initial income) then reverse this decline.

Given that Model 5 has the richest set of covariates, that the income-dependent coefficients do influence certain parameters (particularly the income effect) and the finding of Gruber and Saez (2002) that mean-reversion and the change in the income distribution are more complicated than a pure control for the log of initial income, we treat Model 5 as our benchmark. Under that choice, we get a compensated elasticity of 0.337 and an uncompensated elasticity of 0.07 in the top 20% sample; and an elasticity of 0.065 in the top 70% sample, both compensated and uncompensated.

Table 1.2. Main results, 2004 income in the top 70%

Δ*log taxable income*	Model 1	Model 2	Model 3	Model 4	Model 5
Δ*log (1 - marginal tax rate)*	**0.0743****	**0.0528****	**0.0501****	**0.0494****	**0.0648****
	(0.011)	(0.011)	(0.011)	(0.011)	(0.016)
Δ*log (1 - average tax rate)*			0.145*	0.340**	-0.0673
			(0.064)	(0.067)	(0.065)
Log 2004 gross income		-0.0231**	-0.0252**	-0.0311**	
		(0.0022)	(0.0025)	(0.0028)	
Wealth				0.0294**	0.0265**
				(0.0024)	(0.0023)
Age				0.0143**	0.0135**
				(0.00094)	(0.00091)
Age squared				-0.000208**	-0.000197**
				(0.000012)	(0.000011)
Entrepreneurship				0.0196**	0.0139**
				(0.0034)	(0.0034)
Family				-0.0039	-0.00653**
				(0.0022)	(0.0021)
Gender				0.00746**	0.00712**
				(0.0022)	(0.0021)
Budapest				0.00226	0.00361
				(0.0051)	(0.0048)
Regional capital				0.00012	-0.000853
				(0.0028)	(0.0027)
Constant	0.0288**	0.199**	0.213**		
	(0.0011)	(0.016)	(0.018)		
p-value of the Kleibergen-Paap rk statistics (full rank of the instruments)	0	0	0	0	0
p-value of the C statistics (exogenity of marginal and average tax rates)	0	0	0	0	0
First stage partial F					
For the marginal tax rate	10978.05	10840.36	5665.87	5709.65	2928.02
For the average tax rate			3549.76	3318.36	2577.54
Observations	146,676	146,676	146,676	146,676	146,676

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1% level*
Model 5 includes separate initial income and constant terms for the ten income deciles of the sample.

Table 1.3. Main results, 2004 income in the top 20%

Δlog taxable income	Model 1	Model 2	Model 3	Model 4	Model 5
Δlog (1 - marginal tax rate)	**0.402****	**0.325****	**0.268****	**0.290****	**0.337****
	(0.052)	(0.051)	(0.047)	(0.050)	(0.059)
Δlog (1 - average tax rate)			-0.654**	-0.384**	-0.267*
			(0.11)	(0.12)	(0.12)
Log 2004 gross income		-0.0763**	-0.0849**	-0.0788**	
		(0.0064)	(0.0065)	(0.0069)	
Wealth				0.0168**	0.0169**
				(0.0041)	(0.0043)
Age				0.0209**	0.0216**
				(0.0022)	(0.0022)
Age squared				-0.000281**	-0.000289**
				(0.000027)	(0.000027)
Entrepreneurship				0.0196**	0.0203**
				(0.0053)	(0.0054)
Family				-0.0120**	-0.0113*
				(0.0044)	(0.0045)
Gender				0.0016	0.00167
				(0.0044)	(0.0045)
Budapest				-0.0014	-0.00144
				(0.0089)	(0.0091)
Regional capital				0.000727	0.000391
				(0.0056)	(0.0057)
Constant	0.0171**	0.634**	0.721**		
	(0.0022)	(0.051)	(0.053)		
p-value of the Kleibergen-Paap rk statistics (full rank of the instruments)	0	0	0	0	0
p-value of the C statistics (exogenity of marginal and average tax rates)	0	0	0	0	0
First stage partial F					
For the marginal tax rate	722.23	711.97	360.72	361.98	317.52
For the average tax rate			867.33	762.01	745.33
Observations	41,819	41,819	41,819	41,819	41,819

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1% level*
Model 5 includes separate initial income and constant terms for the ten income deciles of the sample.

Robustness

First we explore whether the age composition of our sample matters.[23] Table 1.4 compares results for three age groups, adding a restricted sample (18-60) and prime age (23-55) for both income samples we used so far. All regressions contain the full set of controls (Model 5), with income deciles corresponding to the sample at hand. For the sample in the top 70% of the income distribution, the tax price elasticity tends to decrease as we restrict the age composition; for the sample in the top 20%, the tax price elasticity increases, and the income effect coefficient becomes smaller. These changes, however, are quite modest in size.

Table 1.4. 2SLS regression results for different age groups

	Income in the top 70 %			Income in the top 20 %		
Δlog taxable income	All ages	18-60	23-55	All ages	18-60	23-55
Δlog (1 - marginal tax rate)	**0.0648****	**0.0592****	**0.0576****	**0.337****	**0.353****	**0.357****
	(0.016)	(0.016)	(0.014)	(0.059)	(0.060)	(0.060)
Δlog (1 - average tax rate)	-0.0673	-0.0524	-0.0306	-0.267*	-0.234	-0.155
	(0.065)	(0.064)	(0.063)	(0.12)	(0.12)	(0.12)
First stage partial F						
For the marginal tax rate	2928.02	2857.76	2982.12	317.52	308.22	298.13
For the average tax rate	2577.54	2521.08	2353.07	745.33	736.46	696.73
Observations	146,676	143,185	129,961	41,819	40,451	36,238

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1%*
The p-values for the Kleibergen-Paap rk statistics and the C-statistics are zero in all columns.

Next, we run our benchmark regression on various income groups separately. The subgroups are mostly defined in line with the tax code: the top 70-20 % (636,000-2,000,000) is roughly the range where the employee tax credit still applies; the top 20-5% (2,000,000-4,000,000) is a range where most deductions are still active or are just being phased out; while 6,000,000 (top 2%) is the cutoff for the new deduction phase-out introduced in 2005.

[23] Gruber and Saez (2002) suggest to weight observations by their income when deriving overall elasticities used for predicting revenue effects. Therefore as one of our robustness checks we run the regressions with weighting the observations. We found that the coefficients of the MTR do not change substantially as a result, only the coefficients of the ATR. The explanation is that although the beta is very high for the 9^{th} income decile, it falls back to low values for the 10^{th} decile, therefore when weighting by income, the low value of the 10^{th} decile receives a high weight (see Figure 1.4).

Table 1.5. 2SLS regression results for different income groups

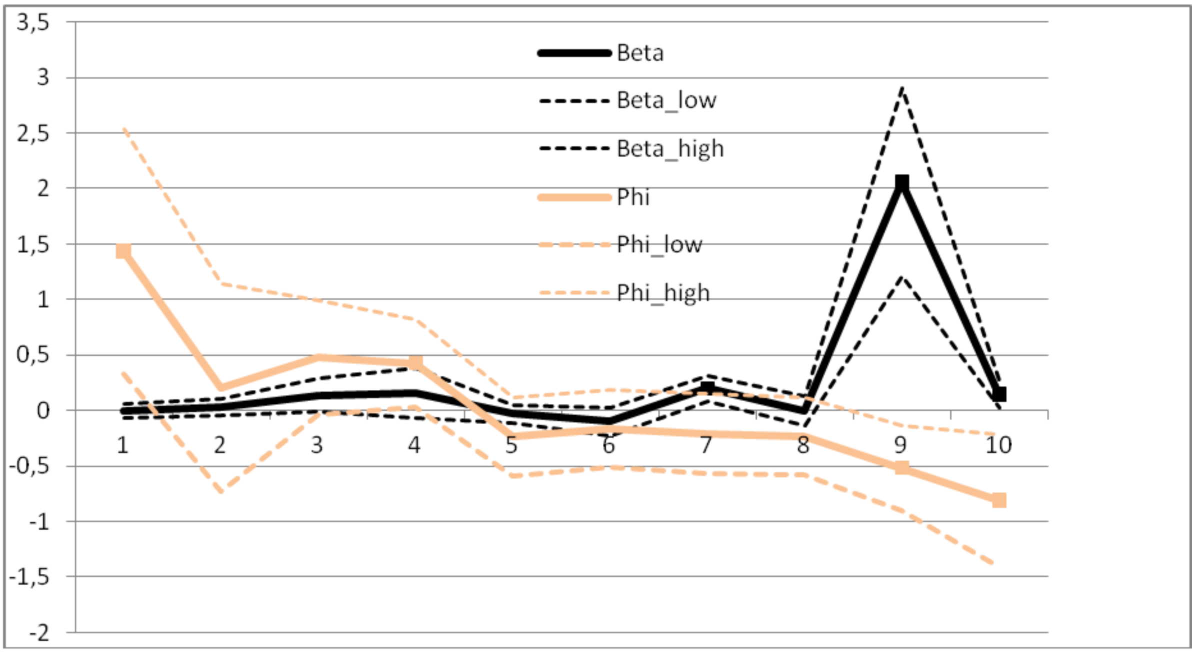
Δlog taxable income	p30-100	p30-80	p80-100	p80-95	p80-98	p95-100
Δlog (1 - marginal tax rate)	**0.0648****	**0.0292**	**0.337****	**0.451****	**0.379****	**-0.0517**
	(0.016)	(0.015)	(0.059)	(0.060)	(0.060)	(0.31)
Δlog (1 - average tax rate)	-0.0673	0.0443	-0.267*	-0.0502	-0.0402	-0.918*
	(0.065)	(0.077)	(0.12)	(0.13)	(0.13)	(0.46)
First stage partial F						
For the marginal tax rate	2928.02	3032.96	317.52	288.83	313.83	25.34
For the average tax rate	2577.54	1818.28	745.33	664.52	675.83	101.88
Observations	146,676	104,857	41,819	31,494	37,609	10,325

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1%*
The p-values for the Kleibergen-Paap rk statistics and the C-statistics are zero in all columns.

The numbers in Table 1.5 suggest that the 0.0648 overall tax price elasticity is a mix of an even lower elasticity (0.0292) in the 70-20% of the income distribution and a much higher elasticity in the top 20%. This higher elasticity comes mostly from the income range 20-5%. In the top 5%, the estimate becomes very noisy: it gets much smaller and its standard error increases. Our interpretation is that the exogenous variation in tax rates in this income range is insufficient for estimating the tax price elasticity (as indicated by the little variation in the synthetic marginal tax rate in Figure 3).[24] The income effect, on the other hand, comes mostly from high earners. This apparent backward bending labour supply may in fact reflect their bargaining power, allowing them to bargain about their *after-tax* wage. At longer time horizons, we are likely to see this income effect decreasing as bargaining should matter less. Later on, we also show that the strong income effect comes from taxpayers with cost deductions, pointing to a role of income shifting between different tax bases.

[24] Another factor contributing to the insignificant tax price elasticity for the high income group is that a large part of the change in their MTR reflects an increase in pension contributions, which are much better linked to direct future benefits to the same taxpayer than overall taxes.

Figure 1.4 The income and substitution effect by income deciles



Beta is the coefficient of the marginal; phi of the average tax rate. The dashed lines are the 95% confidence bands. Marker points indicate significance at the 5% level.

We further explore the income dependence of the marginal and the average tax rate coefficient. Our sample allows for a specification where these coefficients are also interacted with the income decile dummies,[25] though it is imprecisely estimated, and identification is clearly much weaker. Figure 4 presents the evolution of the income and the substitution effect parameter and its 95% confidence band. One can see that the coefficient of the substitution effect (beta) is quite precisely estimated, though it is insignificant for income deciles 1-6 and 8. The income effect (phi) is much less precisely estimated. It is nevertheless positive, although mostly insignificant in the first four deciles, suggesting a participation effect (as opposed to an income effect). It switches to strongly negative in the top two deciles. Apart from the significantly positive income effect in the lowest decile, the figure reinforces our dual finding of practically no behavioural response in the lower part of the income distribution, and a moderately strong substitution and income effect in the top 20%.

[25] Note that income deciles refer to the working sample, which is the top 70% of the entire income distribution. Consequently, one decile of our working sample is 7% of the entire population.

Finally, we check whether the elimination of those taxpayers who had potential problems with their reported employee tax credit numbers matter for the income and substitution effect parameters.[26] As Table 1.6 suggests, the estimates change very little.

Table 1.6. The inclusion of taxpayers with problems in their reported employee tax credit

Δlog taxable income	Top 70%		70-20%		Top 20%	
	without tax credit problems	with tax credit problems	without tax credit problems	with tax credit problems	without tax credit problems	with tax credit problems
Δlog (1 - marginal tax rate)	**0.0648****	**0.0562****	**0.0292**	**0.0335***	**0.337****	**0.336****
	(0.016)	(0.014)	(0.015)	(0.015)	(0.059)	(0.060)
Δlog (1 - average tax rate)	-0.0673	-0.0157	0.0443	0.104	-0.267*	-0.244
	(0.065)	(0.066)	(0.077)	(0.078)	(0.12)	(0.13)
First stage partial F						
For the marginal tax rate	2928.02	3558.43	3032.96	3261.54	317.52	317.34
For the average tax rate	2577.54	2616.30	1818.28	1879.84	745.33	726.78
Observations	146,676	150,141	104,857	108,247	41,819	41,894

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1%*
The p-values for the Kleibergen-Paap rk and the C-statistics are zero in all columns.

Summing up, we find lower elasticities for our larger sample than other empirical studies. Concentrating on a medium-high income sample leads to an elasticity of around 0.3, already in the high range of the international evidence. As Gruber and Saez (2002) indicate, high tax price elasticities for the U.S. are likely to be driven by itemizing, which is a cost reduction status that can be chosen by all taxpayers. Employees are also entitled to some cost deductions in Hungary, but their coverage and impact is very limited.[27] This is likely to reduce tax price elasticity, as a major margin of adjustment is

[26] Employee tax credit is calculated based on *wage income* capped by the monthly minimum wage times the number of eligible months, and then it is phased out according to *broad income*. The 'number of eligible months' variable is missing from our original dataset. We recovered this variable by allowing its value to go from 0 to 12 and selecting the one with which we get back the reported tax credit (with a rounding error of 2.1, which allows for multiple rounding errors before summing up). For around 5500 taxpayers, none of the values 0-12 were able to replicate their reported tax credit. We attribute this to the fact that tax credit rules are quite complicated and our data contains *unaudited* tax files. The difference never exceeds 12.25, which means that this problem is negligible for the average tax rate. The phase-out of the employee tax credit, however, creates complicated patterns for the marginal tax rate, which might be sensitive to such miscalculations.

[27] In our sample, roughly 10% of all taxpayers report some cost deductions. These deductions usually refer to labor income derived from secondary income sources, where either a flat rate or an itemized deduction applies. The average deduction, however, is 163, compared to the average income of 3041 in this group.

missing. Combining this observation with the fact that we had only a one year difference between our pre- and post-reform observations, our elasticity results are rather high.

Limiting the potential channels of adjustment

Here, we explore the importance of two adjustment mechanisms: first, we check the heterogeneity of our results with respect to cost deduction status. Table 1.7 shows that those who do not have cost deductions show a higher substitution effect, but a zero income effects. This suggests that the population-wide substitution effect in the top 20% is largely unrelated to cost deductions, while the income effect might come from deductions. Given the fact that deductions are, on average, 1% of taxable income in all of our subsamples, the income effect coefficient of the deduction group may reflect their higher overall flexibility in declaring income, and not deductions themselves.

Table 1.7. Heterogeneity by cost deduction status

Δlog taxable income		Top 70%		Top 20%		70-20%	
		No hete-rogeneity	Hetero-geneity	No hete-rogeneity	Hetero-geneity	No hete-rogeneity	Hetero-geneity
Δlog (1 - marginal tax rate)	**Total**	**0.0648****		**0.337****		**0.0292**	
		(0.0166)		(0.0674)		(0.0158)	
	No deduction		**0.0608****		**0.420****		**0.0269**
			(0.0174)		(0.0885)		(0.0166)
	Deduction		**0.0777***		**0.2041***		**0.0405**
			(.0329)		(0.0929)		(0.0348)
	Difference		0.0169		-0.216		0.0136
			(0.0335)		(0.119)		(0.0363)
Δlog (1 - average tax rate)	Total	-0.0673		-0.267*		0.0443	
		(0.0693)		(0.146)		(0.0786)	
	No deduction		0.0857		0.0518		0.127
			(0.0751)		(0.171)		(0.0832)
	Deduction		-0.7173**		-0.9409**		-0.4426*
			(0.1434)		(0.2388)		(0.1937)
	Difference		-0.803**		-0.993**		-0.570**
			(0.154)		(0.272)		(0.205)
Observations		146,676	146,676	41,819	41,819	104,857	104,857

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1%*
All specifications contain the cost deduction dummy as an extra control.
The specification interacts realized and synthetic tax price variables with deduction status dummies.
The p-values for the Kleibergen-Paap rk, the C- and the first stage partial F statistics are all zero.

Second, we look at heterogeneity with respect to being pure wage earners (Table 1.8). Wage earners exhibit a higher (top 70%, top 70-20%) or an equal (top 20%) substitution effect. The income effect is estimated very imprecisely, but again, there is no marked difference between pure wage earners and those who have additional sources of income. Overall, this finding suggests that shifting between capital and labour income has a limited role in determining tax price elasticities. Given that pure wage earners have limited room for income underreporting, it also weakens the case for tax avoidance as a key determinant. This is in contrast to the finding of Gorodnichenko *et al* (2009) for Russia.

Table 1.8. Heterogeneity by "wage earner" status

Δlog taxable income		Top 70%		Top 20%		70-20%	
		No heterogeneity	Heterogeneity	No heterogeneity	Heterogeneity	No heterogeneity	Heterogeneity
Δlog (1 - marginal tax rate)	**Total**	**0.0648****		**0.337****		**0.0292**	
		(0.0166)		(0.0674)		(0.0158)	
	Wage earner		**0.0761****		**0.3337****		**.04209***
			(0.0179)		(0.0816)		(0.0174)
	Has nonwage income		**0.0272**		**0.344****		**-0.0155**
			(0.0292)		(0.0997)		(0.0302)
	Difference		0.0489		-0.0098		0.0576*
			(0.0307)		(0.120)		(0.0329)
Δlog (1 - average tax rate)	Total	-0.0673		-0.267		0.0443	
		(0.0693)		(0.146)		(0.0786)	
	Wage earner		-0.0579		-0.2175		0.0688
			(0.0804)		(0.1755)		(0.0915)
	Has nonwage income		-0.0680		-0.331		0.0484
			(0.109)		(0.215)		(0.130)
	Difference		0.0101		0.113		0.0204
			(0.126)		(0.256)		(0.152)
Observations		146,676	146,676	41,819	41,819	104,857	104,857

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1%*
All specifications contain the wage earner status dummy as an extra control.
The specification interacts realized and synthetic tax price variables with wage earner dummies.
The p-values for the Kleibergen-Paap rk, the C- and the first stage partial F statistics are all zero.

1.5 Flat tax predictions

We now quantify the implications of a hypothetical flat income tax proposal of a tax rate of 30,3% above the 2005 minimum wage (684,000) and a 13,5% social security contribution rate. These rates are applied to all components of taxable income. This means that tax deductions are eliminated; and all incomes that used to be part of the tax base but were previously untaxed (like scholarships) are now taxed the same way as any other personal income item.

The single tax rate is chosen in a way that the proposal is revenue neutral in case of no behavioural response.[28] Eliminating the tax exempt status of the minimum wage would imply a combined rate of 32%. This is close to CEE flat tax rates, but those flat tax schemes also involve a tax-exempt income range. Consequently, our 13.5+30.3% rate is high compared to other flat tax rates in the CEE region.[29] It is also somewhat higher than the current flat rate proposal in Hungary (a combined rate of approximately 33%, no zero rate).

Let us stress that this reform does not change the overall tax rate below the minimum wage. Our reasons are twofold: on the one hand, we do not have reliable estimates for taxpayer behaviour below the minimum wage; on the other, an increase in the marginal and the average tax rate for this income group is likely to involve substantial social tensions.[30]

We apply this tax scheme to 2005 income data under three scenarios. Scenario 1 assumes no behavioural effect at all. Scenario 2 assumes no income effects and the appropriate substitution effect (an elasticity of 0.0291 in the top 70-20 % and 0.336 in the top 20%). Scenario 3 works with the same substitution effect and adds the income effect (a parameter of -0.271) in the top 20%.[31] Although such a large tax change may induce larger behavioural responses, the literature does not point to a particularly important nonlinearity.

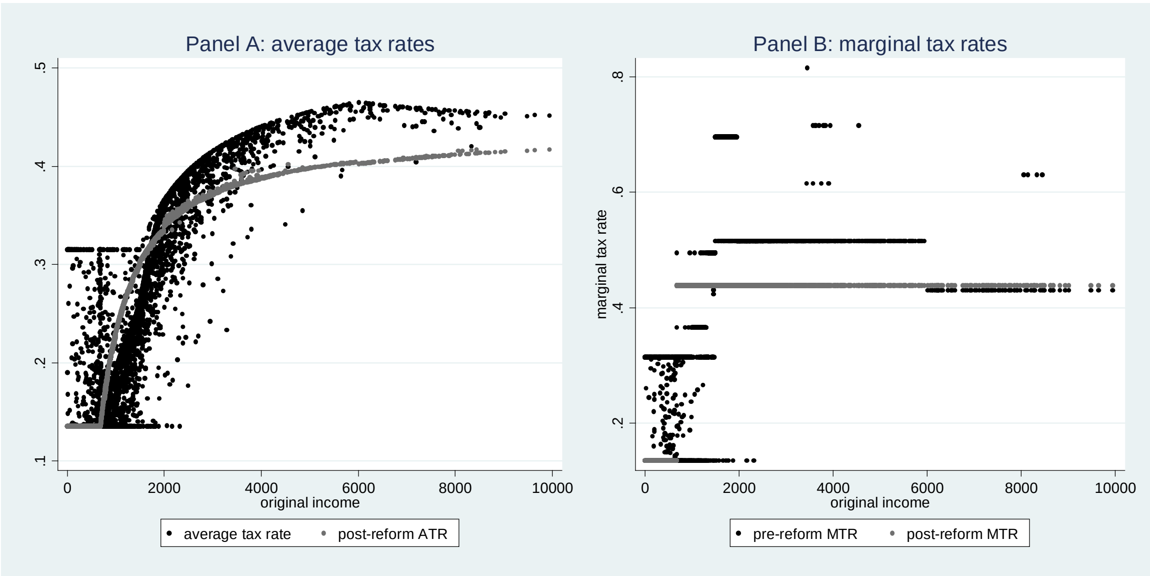
As this tax scheme still makes the marginal and average tax rate endogenous, we predict income changes the following way. First we calculate the 'no behavioural response' case by inserting original 2005 incomes into the new tax scheme. Then we calculate the change in income implied by the realized marginal and average tax rates corresponding to scenario one. This new income leads to different realized tax rates, with which we

[28] A 41.3% combined rate would be revenue neutral under our baseline behavioral response scenario.
[29] Ivanova *et al* (2005) gives an international comparison: flat tax personal income tax rates range from 12% to 19%. Based on more recent and more comprehensive comparisons (Keen *et al*, 2006 and www.worldwide-tax.com), this range is between 10% and 25%. Ivanova *et al* (2005) also report that there was an additional social security contribution rate and a tax-exempt 'zero bracket' in Russia, while Moore (2005) indicates the same for Slovakia.
[30] Actual flat tax schemes are often similar. For example, the flat tax scheme in Slovakia involves a single rate above some tax-exempt threshold, and social security contributions are kept separately.
[31] According to our detailed estimates, the substitution and income effects are much less precisely known for the top of the income distribution. A flat tax, however, has a very similar effect ont he marginal and the average tax rate of top earners. It means that as long as the uncompensated elasticity is small, the reaction of top earners is not pivotal for our predictions. Setting both the substitution and the income effect to zero in the top 2% (see Table 1.9) slightly *increases* our predicted revenue and income gains.

update our income estimate. This iterative process leads to a solution where our predicted post-reform incomes are consistent with the appropriate realized tax rates.[32]

Figure 1.5 depicts the change in the average and marginal tax rates (the former is calculated under Scenario 3) as a function of pre-reform 2005 income (in a 2% random sample for better visibility). It is immediately visible that there is a substantial increase in the average tax rate between the minimum wage and 2,000,000; and most of the fall in the marginal tax rate concentrates in the range 2,000,000-6,000,000. We will return to the former property in the incidence analysis; the latter, however, is quite desirable, since taxable income is quite sensitive to the tax price in that income range.

Figure 1.5 Average and marginal tax rates: before and after the flat income tax scheme



[32] In practice, this procedure is much simpler. Without an income effect, there is only one necessary adjustment: those who start above 684,000 but would go below as a response to higher marginal tax rates bunch at exactly 684,000. Anyone who remains above the minimum wage will be subject to a marginal tax rate of 43.8%.
For the income effect, we first use the 'no behavioral response' ATR (calculated in Scenario 1). This leads to some income change, which then implies a slightly different realized ATR. In the next step, we modify our predicted income change by the log difference of these two (one minus) ATRs, multiplied by the income effect coefficient. Then we calculate the corresponding ATR again and repeat the previous step till convergence. After the second step, the change becomes negligible.

There is also a decline in marginal tax rates below the minimum wage. This is due to the fact that our hypothetical tax scheme determines tax obligations based solely on taxable income, while the original 2005 tax scheme often used *broad income* to determine the tax payment on *taxable income*. As a matter of fact, most taxpayers earning below the 2005 minimum wage would experience no change in their marginal tax rate (34,436 out of 49,647).

Table 1.9 summarizes the main implications of our flat income tax. According to the design of our hypothetical reform, without a behavioural response there is no change in budget revenues and taxable income. Adding the substitution effect leads to a 2.77% increase in revenues, together with a 1.88% increase in after-tax income. These numbers become somewhat smaller as we add the income effect: a 2.06% increase in revenues and a 1.39% increase in after-tax income. If one gives up the revenue gain, the 30.3% tax rate can be reduced to 27.9%. That would imply a 2.1% increase in pre-tax income and a 3.9% increase in after-tax income.[33] These effects are substantial – total pretax income is approximately one third of total GDP in Hungary, which is the base of the 32% employer contributions, and the approximately 32% income tax and employee contribution -- but we do not see such a “miracle” as flat tax proponents would like.[34]

[33] Under the 41.3% combined tax rate scenario, the inclusion of the substitution and the income effect leads to zero revenue gain, and an increase of 2.1% of pretax income and a 4.04% increase in aftertax income.

[34] Apart from additional effects through the extensive margin, the increase in total pretax income is an upper bound on the shift of labor supply. In case of a constant returns to scale technology, this also limits the general equilibrium impact on total production (GDP). If the rate of return on capital is unchanged, then labor demand is flat and the shift in labor supply equals the increase in output. If the rental rate has to increase to absorb the extra supply of labor, then output increases by less than the shift in labor supply.

Table 1.9. Implications of a flat income tax scheme

	Behavioural effects considered		
	None	only subst.	subst. and income
Percentage change in total			
Budget revenue (employee part only)	0.04	3.31	2.45
Budget revenue (employee and employer)	0.02	2.77	2.06
pretax income	0	2.30	1.71
after-tax income	-0.02	1.88	1.39
Pretax income, % change in			
p90/p10	0	5.08	4.18
p90/p50	0	5.64	4.74
p10/p50	0	0.56	0.56
p75/p25	0	2.16	2.16
p75/p50	0	2.17	2.17
p25/p50	0	0.00	0.00
Gini (pre reform: 0.46023)	0.46023	0.46038	0.4655
After-tax income, % change in			
p90/p10	0.07	4.62	3.81
p90/p50	11.48	17.03	16.10
p10/p50	11.23	11.78	11.78
p75/p25	-2.40	-0.54	-0.54
p75/p50	5.90	7.73	7.73
p25/p50	8.55	8.25	8.25
Gini (pre reform: 0.38529)	0.39582	0.403536	0.40116

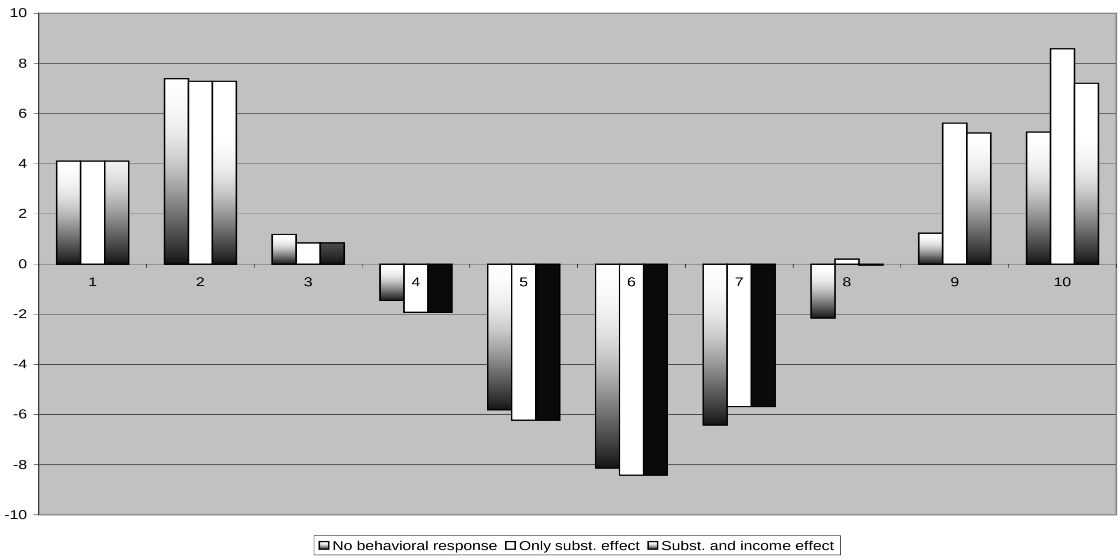
For a full description of the three scenarios, see the main text. Variables like p90/p10 refer to the ratio of the 90 and 10 percentile of the income distribution.

There are, however, notable changes in the income distribution (due to the nature of our data, we are talking about the distribution of taxpayer individual and not household income). In pretax income, the most substantial change is in the 90-10 percentile (p90-p10) and the p90-p50 ratio, an increase of 4-5.5%. In after-tax income, there are similar changes in the p90-p10 ratio, but all ratios involving the median are much higher. This is in line with our observation that there is a substantial increase in the average tax rate between the minimum wage and 2,000,000 (see Figure 1.5). The Gini coefficient of pretax income increases from 0.46023 to 0.4655; while for after-tax income, it increases from 0.38529 to 0.40116.[35] This increase is partly driven by the change in tax rates, and

[35] These changes in the Gini coefficient are roughly similar to typical annual changes in the Gini coefficients of per household member income, individual income and individual labor income. Most percentile ratios, on the other hand (like p90/p10) change much more during our hypothetical reform than

partly by the behavioural response: without the latter, the after-tax Gini would be 0.39582.

Figure 1.6 The percentage change in after-tax income by 2005 after-tax income deciles



To illustrate the detailed incidence of the tax reform[36] and the impact of behavioural responses, Figure 1.6 plots the percentage change in the average after-tax income for pre-reform after-tax income deciles, for Scenarios 1, 2 and 3. There is a substantial increase in the average income level in the first two deciles and some increase in the third decile, which are unaffected by the presence of behavioural responses. There is a small decline in decile 4, and a very sizable fall in deciles 5-7. In deciles 4-6, the behavioural response works against taxpayers as they experience a small increase in their marginal tax rates as well. In decile 7, the behavioural response alleviates the impact of higher average tax rates; in decile 8, it turns an income loss into an income gain. Finally, deciles 9 and 10 experience a sizable increase in their income. The behavioural response is most notable in decile 9, increasing the gain from 1.23% to 5.25%.

in a typical year (Kapitány and Molnár, 2005). Note that our calculations cannot take into account individuals without taxable income and redistribution within households. Consequently, these Gini numbers cannot be directly compared to typical measures of income inequality across households. Still, as Benedek and Lelkes (2006) suggests, the distribution of household income and individual income are quite similar.

[36] Benedek and Lelkes (2006) discuss the redistributional aspects of a flat tax reform at depth.

In summary, these three cases illustrate the importance of the elasticity of taxable income to changes in the marginal tax rate. Even the internationally small elasticity estimate (0.0648) has a remarkable effect on the government's budget, while the 0.337 elasticity is very influential for tax revenue developments. Based on our flat tax results, there is room for a parallel improvement of budget revenues and taxable income. Such a reform, however, involves important changes in income inequality, and its burden falls mostly on lower-middle income taxpayers.

Let us also stress the importance of the income effect. Table 1.9 and Figure 1.6 show that its presence has very important quantitative effects on income and revenue predictions. In particular, a reduction in the average tax rate of top earners leads to a substantial decrease in their income gain brought about by lower marginal tax rates (see income decile 10 on Figure 1.6).

A comment is in order regarding the current Hungarian flat tax policy debate. A special feature of Hungarian personal income taxation is the system of employee tax credits, which makes low (wage) incomes untaxed, at the expense of higher marginal tax rates in a phase-out range. Our finding of a low substitution effect below the top 20% of the income distribution and a substantial substitution effect above it implies that the location of the phase-out range is quite important. If it falls heavily in the top 20% bracket, the high marginal tax rates can deter income generation due to the substitution effect. According to the 2010 tax system, the phase-out range goes well into the top 20% bracket. Consequently, a flat tax proposal that would eliminate such an employee tax credit scheme (or at least lower the phase-out range) can generate more substantial gains than our predictions would suggest. According to preliminary calculations of Scharle *et al* (2010), the sheer reduction of the phase-out range below the top 20% range can generate budget revenues of around 1% of GDP.

1.6 Conclusions

In evaluating tax policies and forecasting the effects of future tax changes, it is essential to distinguish the influence of changing tax rates and changing law enforcement. In case of extensive tax reforms it is usually not possible. Hungary introduced a medium-scale reform in 2004/2005 without any changes in tax audit rules and practices. We used this occasion to analyze the behavioural response of taxable income to marginal and average tax rates.

Our empirical analysis suggests an overall tax price elasticity of about 0.06 in Hungary. Though this number is significantly lower than elasticities found in other countries, even this low elasticity can have some effect on the government's budget. Moreover, the upper 20% of the population exhibits a much higher elasticity, exceeding 0.3, and even as high as 0.45 for some income groups. This is already at the high end of the international evidence. We demonstrated that such elasticities have important impacts on the income generation process and budget revenues.

These results are mixed news for flat tax proponents: the low overall elasticity indicates that cutting marginal tax rates might not lead to such an economic stimulus as many would expect. For the upper 20% of the population, however, a decrease in marginal tax rates may indeed lead to a substantial increase in income generation, which would also exacerbate the adverse redistributional aspects of such a reform.

Our detailed flat income tax simulation confirmed these general points. In particular, we calculated the impact of a reform that keeps the existing 13.5% combined income tax and social security contribution rate below the annual minimum wage, and its single rate above the minimum wage is selected in such a way that there is no effect on budget revenues in case of no behavioural respons. This revenue neutral flat tax rate (30.3% income tax plus 13.5% social security) is high compared to other flat tax rates in the CEE region.

We predict a roughly 2% improvement of budget revenues and a 1.4% increase in taxable income, which is significant but rather modest. On the other hand, there are important changes in the income distribution, and the overall burden falls mostly on lower-middle income taxpayers (income deciles 5-7).

Besides the flat tax predictions, our results have a number of additional, potentially important, policy implications. One is that the conclusions of Gruber and Saez (2002) for the US also apply to Hungary – both in terms of the desirability of low marginal taxes on a broad income basis, and in terms of the potentially low distortion caused by the high marginal tax rates of phasing out employee tax credits.

The first statement is supported by our highly positive marginal tax price elasticity estimate. As compared to the US, where much of the elasticity is likely to be due to itemized deductions, we find that deductions do not contribute to the sensitivity of taxable income to marginal tax rates. Combined with the finding that wage earners exhibit similar estimates of the substitution effect, it suggests that the elasticity we find may be much closer to a true "generalized" labour supply elasticity than the US findings.

The second claim is based on the finding that the same elasticity is much lower in the income range 636,000-2,000,000 where employee tax credits are phased out (in 2004 and 2005). On the other hand, the marginal tax rates implied by phasing out other tax allowances are likely to cause substantial losses, as those extra 10-20% marginal rates apply to taxpayers with substantial tax price elasticity and high preexisting marginal tax rates. This also applies to the 2010 phase-out range of employee tax credits.

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Appendix

A. Changes in the Hungarian tax system, 2004-2005

The four key elements of the 2004-2005 tax reform were the following (Income Tax Act 1995; OECD, 2004 and 2005).

Reduction of the number of tax brackets from three to two. Taxpayers with taxable income between 800,000 and 1,500,000 experienced an 8 percentage point decrease in their marginal tax rate. The tax schedule in Table A1.a changed to the schedule in Table A1.b.

Table A1.a Tax schedule in 2004

		Number of tax filers
0 – 800 000	18 %	1 815 111
800 001 – 1 500 000	26 %	1 138 156
1 500 001 -	38 %	1 196 610

Source: http://www.apeh.hu/adotablak and Tax and Financial Control Office

Table A1.b Tax schedule in 2005

		Number of tax filers
0 – 1 500 000	18 %	2 806 935
1 500 001 -	38 %	1 342 948

Source: http://www.apeh.hu/adotablak and Tax and Financial Control Office

The maximum amount of the supplementary employee tax credit was increased from 540 per month to 1260 per month. The phase out interval for the supplementary tax credit was changed from 720,000-756,000 to 1,000,000-1,302,000, which also means the changing of the phase out rate from 18% to 5%.[37]

[37] In Hungary the employee (earned income) tax credit has two parts, the main 'tax credit' and the 'supplementary tax credit'. Both are applicable after earned wage income, therefore entrepreneurs are excluded from these allowances. The two together guaranteed the tax exempt status of the minimum wage until 2006. Both have a gradual phase out, although the two intervals differ.

An income limit was introduced both for the family tax allowance and for the sum of other tax allowances. Parents are eligible for the total amount of the family tax allowance if their broad income is below 8,000,000, above this limit the allowance is phased out by a rate of 20%.[38] Broad income consists of wage income, non-wage labor income (the sum of these two is our taxable income measure), and other, mostly capital incomes (taxed separately). For the sum of other tax allowances the maximum amount of the allowance is 100,000 and the eligibility broad income limit is 6,000,000, above which it is gradually withdrew (also at a rate of 20%).

The maximum of annual pension contribution was increased from 451,095 to 510,051. This implies that the maximum income for pension contribution was changed from 5,307,000 to 6,000,600.

There were no changes in the rate of the social security contributions, namely in the pension, sickness and the unemployment scheme, their level remained 8.5, 4 and 1 percent respectively.

B. The identification scheme

Following Gruber and Saez (2002), we write the change in income as a sum of the substitution and the income effect:

$$\frac{\mathrm{d}\,y}{y} = -\beta\frac{d\tau}{1-\tau} + \phi\frac{dR - yd\tau}{y(1-\tau)} + u_1. \qquad (4)$$

Here the first regressor is the realized change in *ln(1-mtr)*, while the second is the realized c hange in *ln(1-atr)*. For this latter step, one needs an extra assumption: $y(1-\tau) \approx y - y\tau + R$. This is also adopted by Gruber and Saez (2002). This is then how the approximation works:

$$d\log\underbrace{\left(\frac{y - T(y)}{y}\right)}_{1-ATR} = d\log\left(\frac{R + y - y\tau}{y}\right) = \frac{dR + dy - dy\tau - yd\tau}{R + y - y\tau} - \frac{dy}{y}$$

$$\approx \frac{dR + dy - dy\tau - yd\tau}{y(1-\tau)} - \frac{dy}{y} = \frac{dR - yd\tau}{y(1-\tau)}.$$

[38] Family tax allowances, just like other elements of the income tax system, work on an individual basis, i.e. parents can decide which of them requests the tax allowance, and they also have the option to split the amount.

Notice that Gruber and Saez (2002) do no deduct the *dy/y* term. That distorts the parameters – their estimates need to be divided by *1-ϕ*, which is essentially one for them, finding no income effects. For us it does matter as our ϕ is often nonzero.

Equation (4) cannot be estimated via OLS because the realized tax rate changed for two reasons: tax reform (exogenous variation) and income dependence of the tax scheme (endogenous variation). The proposed solution is to instrument each tax rate variable by its "synthetic" version, which is the change in the appropriate tax rate implied by the change in legislation, applied to *unchanged real income*.

Formally, this is how identification works. Assume that

$\tau = \tau(y,\ \lambda)$ and $R = R(y,\ \lambda)$,

where λ is a parameter indexing the tax reform. Using a first order approximation:

$$\frac{d\tau}{1-\tau} = \tau_1 \frac{dy}{y} + \tau_2 d\lambda$$

$$\frac{dR - yd\tau}{y(1-\tau)} = R_1 \frac{dy}{y} + R_2 d\lambda.$$

Here in principle the second term is nothing but the change in the synthetic tax rate: the change in *ln(1-mtr)* implied by reform λ, for an unchanged income level. As any practical reform is a discrete change, the first order approximation is surely not precise – meaning that there is a separate error term corresponding to this equation, moreover, the coefficient of the synthetic tax rate change can differ from one.[39] Thus we write the equations for the realized tax rate changes as follows:

$$\frac{d\tau}{1-\tau} = \tau_1 \frac{dy}{y} + \tau_2 ms + u_2$$

$$\frac{dR - yd\tau}{y(1-\tau)} = R_1 \frac{dy}{y} + R_2 as + u_3.$$

Here the variable *ms* is the shorthand for the change in the synthetic (unchanged real income) log one minus marginal tax rate, and *as* is the same for the average tax rate.

Based on this, it is straightforward to see that the original regression (4) is misspecified – both of the right hand side terms contain the error term u_1 in general (unless there is no endogeneity problem in the sense that the tax rate – be it the marginal or the average

[39] Running exploratory regressions confirms this: regressing the realized MTR change on all controls plus the change in income and the synthetic MTR change, with income change instrumented by the synthetic change in ATR yields a synthetic MTR coefficient around 0.3. The same argument applies to the ATR equation: here we get a coefficient of 0.9, still differing from one at the 5% level.

– does not change with income levels).

Equation (4) can still be estimated by single equation IV. We run (4) by using *ms* and *as* as instruments – they are uncorrelated with the error terms and (by the reduced form) are correlated with the realized tax rate changes. This identifies β and ϕ.

Chapter 2

Entrepreneurial Tax Changes in Hungary: Tax price Elasticity of the Self-employed

2.1 Introduction

In the first chapter of this thesis I showed that employees in Hungary react to tax changes substantially. In this chapter I investigate the elasticity of reported income of the self-employed to tax rate changes and decompose it to labour supply response and other factors, more importantly tax evasion. Taxable income can change for several reasons besides changes in labour supply. As a response to tax changes, individuals might increase their work effort and tax-deductible activities, renegotiate their compensation package including non-cash elements and can also change their income underreporting behaviour.[1] Usually, these components are very difficult to separate (Gorodnichenko *et al*, 2009 is one of the few exceptions that separates the labour supply and tax evasion responses). Entrepreneurs are self-employed, therefore the role of in-kind benefits is probably very low, and hence the two major elements defining the taxable income response are the labour supply and the tax evasion effects.

In the last few decades an extensive body of literature has emerged on the elasticity of taxable income to changes in the marginal tax rate. Most studies find a significant positive effect of decreasing tax rates on reported income. Some of these studies also suggest that only part of this response comes from increased labour supply, while taxpayers also adapt to changes by altering the form of compensation and tax evasion. The substitution of unreported income by reported income as a response to tax rate changes might increase with the income underreporting possibilities, e.g. in case of

[1] For the self-employed there are possible other margins of adjustment too, e.g. timing of income flows or attributing parts of the self-employment income to other family members, but these effects cannot be estimated based on the individual tax report data.

small enterprises or in economies with extensive black economies. Several authors[2] found that tax evasion was more widespread among entrepreneurs than employees. In spite of this finding, only a few studies estimate the tax responsiveness of the self-employed[3].

In this chapter, I argue that overall elasticity of the self-employed is 7-12%, and elasticity reduces to about half when controlled for tax evasion. Therefore, the true labour supply elasticity of the self-employed is around 5%. For the estimation I use a Hungarian tax reform episode. Hungary introduced a new type of tax, called “Simplified Entrepreneurial Tax” (EVA) as of January 2003, under which there is a substantially lower tax rate and simplified tax administration. The tax base is different from the general case, it is based on the gross income of the enterprise instead of the usual net-of-VAT revenue. This also means that EVA taxpayers do not report costs of operation.

The overall elasticity is lower than comparable European estimates for employees, but almost twice as large as the overall elasticity of employees in Hungary. An explanation for low elasticity is that most of the self-employed minimise their tax payment by tax evasion and tax avoidance under all conditions; therefore, they are not very responsive to tax rate changes. However, estimated labour supply elasticity is fairly modest, so self-employed individuals to some extent do react to tax rate changes in their real labour efforts.

The aim of this chapter is to analyse elasticity of reported income of self-employed to tax changes in Hungary and to isolate the true labour supply elasticity of entrepreneurs. To guide this empirical analysis, I develop a simple model of the behaviour of the self-employed that takes into account both labour supply and tax evasion. The basis of the model is the usual deterrence model, where the expected utility is determined by the probability and penalty of tax evasion. First, I present a simple form of the model showing how labour supply response can be separated from tax evasion effects. Then I add the special tax rules applying to the self-employed. I test this model empirically on individual tax returns data and demonstrate that at least part of the income response to tax rate changes comes from tax-avoidance and not from increased income-generating efforts.

[2] For example the stream of literature applying the consumption-based estimation of tax evasion following Pissarides and Weber (1989).

[3] See Kopczuk (2010) on Polish data for example.

The chapter is organised as follows. Section 2 reviews the relevant empirical literature; section 3 describes the methodology of the analysis, including the description of the dataset; section 4 presents main results of the analysis; and section 5 concludes.

2.2 Related literature

The first stream of empirical studies on labour income taxation dealt with labour supply elasticity estimations (Heckman, 1993 gives a summary of these studies). In these studies labour supply participation is found to be more elastic to tax rate changes than labour supply on the intensive margin, measured by the hours worked, and also secondary earners (usually women) are found to be more elastic on both margins than primary earners[4]. A more recent stream of literature focuses on the elasticity of taxable income rather than labour supply. The two streams of literature have different foci.

Labour supply is a real economic measure that has considerable influence on the output of the economy. Therefore, it is a major policy concern is most countries, especially in Europe, where ageing of the population results in high inactivity. Taxable income, however, is a very important measure from a budgetary point of view and captures changes in the form of compensation and tax compliance as well. Most of these papers concentrate on the elasticity of taxable income with respect to the change in the tax price (net-of-tax income per marginal pretax dollar, i.e., one minus the marginal tax rate). Usually the effect of tax changes on work efforts, and tax evasion are not separated, but only changes in declared taxable income are considered. The estimated elasticity varies substantially by the period and country examined and the regression specification.

Estimates on elasticity range from very low (even negative e.g. Aarbu and Thoresen, 2001) up to some very high (close to 1, e.g. Feldstein, 1995) figures. Typically, US taxpayers are somewhat more elastic than Europeans (Gruber and Saez, 2002 and Saez *et al*, 2010 give a summary of the earlier results), and taxpayers with higher income tend to react to a greater extent. However, as Gruber and Saez (2002) emphasise, tax elasticity literature focuses on taxable income which contains labour supply responses, adjustments in the form of compensation, unmeasured effort and tax compliance. These

[4] see for example Evers *et al* (2006).

factors might even be more elastic to taxation than labour supply. In their work of summarising labour supply literature, Blundell and MaCurdy (1999) state that male labour supply elasticity to after-tax wages is low. However, they find that labour supply responsiveness of secondary earners (generally women) can be much higher.

Starting from Feldstein (1995), applied empirical strategy to estimate the effect of tax price on taxpayers' income is very similar (in logs):

$$y_{it} = c_i + \gamma_t + \alpha_t x_i + \beta \log(1 - MTR_{it}) + u_{it} \qquad (1)$$

where y_{it} is taxable income, MTR_{it} is the marginal tax rate, c_i is the fixed effect for individual i and γ_t is a time-specific effect. The variables in x_i are individual characteristics that do not vary over time, but may have a time-varying effect on y_{it}. Finally, β is the elasticity of taxable income.

In the early studies income and substitution effects are not distinguished. Gruber and Saez (2002) is the first study to distinguish these two effects of the tax changes. In their study they include both the marginal tax rate and the virtual income or average tax rate as explanatory variables for changes in the taxable income and also include controls for the income mean reversion and changes in the income distribution. The overall estimated elasticity of taxable income in Gruber and Saez (2002) is around 0.4 mostly coming from the high elasticity of the high income taxpayers. However the income effect is found to be insignificant.

Allingham and Sandmo (1972) make a seminal contribution to the tax evasion literature with the deterrence model. In their model taxpayer is modelled as a gambler who chooses reported income in order to maximize expected utility. Undeclared taxable income has a payoff t, the rate of income tax with probability (1-p) and a penalty □with probability p. The expected payoff is (1-p)t-p□. If it is positive, the taxpayer will evade. Yitzhaki (1974) emphasised that it is important to distinguish if the penalty is imposed on the income or the tax understatement.

All the early models of tax evasion considered only income understatement and exogenous detection probability. First, Cremer and Gahvari (1994) set up a model of tax evasion with a concealment technology where tax-evaders can influence their probability of being caught. When audited, the probability of detection depends on the amount spent on concealment. They show that tax evasion in this form changes the progressivity of the tax system.

Although it is very difficult to obtain reliable data on tax evasion, there is, however, a substantial empirical literature on the topic. Most of the studies use the TCMP data, which contains the result of successful tax audits in the United States. Slemrod and Yitzhaki (2000) summarise tax evasion based on this dataset as follows. Based on the audit coverage of around 1%, the estimated evasion is about 17% of the true tax liability. Evasion greatly differs between social groups; for example, voluntary reporting was 99.5% for wages and salaries whereas only 41.4% for self-employed.

Gorodnichenko *et al* (2009) in their recent empirical study separated tax evasion and labour supply effect of a tax reform using Russian data. They follow the technique of Pissarides and Weber's (1989) to evaluate the 2001 Russian flat tax reform that brought about a substantial tax cut: they use the difference between reported consumption and income in the household budget survey to estimate tax evasion. Their major finding is that tax evasion response to the tax cut was large, whereas the productivity response was fairly modest as opposed to previous estimations. Therefore, the estimated welfare gains of the reform are about 30% lower than other estimation approaches suggest. This highlights the fact that separating the tax evasion and productivity responses to tax cuts might be necessary to evaluate tax reforms correctly.

The first chapter of this thesis (also as Bakos, Benczur and Benedek, 2009) estimated tax price elasticity using Hungarian data following the method of Gruber and Saez (2002) and found an elasticity of 6-30%. This estimation only covered the employed population and excluded the self-employed.

From Elek *et al* (2009), we know that the self-employed on average declare a lower income than the employed. Based on the dataset of the Central Administration of the Hungarian Pension Insurance, Elek *et al* (2009) conclude that most entrepreneurs declare a wage income around the minimum wage. Kreko and P. Kiss (2007) showed that entrepreneurs tend to declare labour income as capital income in order to decrease their tax obligations. Based on the comparison of administrative and survey datasets in the third chapter of this thesis (also as Benedek and Lelkes, 2009) I argue that income underreporting is higher among the self-employed than employees in Hungary.

The above listed findings emphasise the fact that tax evasion responses have substantial revenue effect, probably even more so for the self-employed than for employees. To understand the nature of this relationship, it is necessary to evaluate the tax evading behaviour of small enterprises.

2.3 Empirical analysis

In this chapter of the thesis, I analyse the responsiveness of the self-employed to tax changes in Hungary. To better understand the tax reporting behaviour, I use a deterrence model, based on Allingham and Sandmo (1972), similar to the one applied by Tonin (2009).

The self-employed choose their labour supply, true net cost of production and share of hidden income. Their net income is defined by corporate tax, dividend tax, personal income tax and social security contribution. Since taxes on wage income (PIT + ssc) are greater than taxes on corporate income at all levels, they keep the level of wages at the legal minimum, thus the PIT does not influence their optimal level of output. When underreporting income, they save the corporate and dividend tax payment on unreported income but face a probability of being caught and fined. As a result, their behaviour will be a function of the effective tax rate and the optimal level of underreporting. The optimal underreporting will be captured by an interaction of the effective tax rate and evasion related individual characteristics in the empirical model.

To better understand the tax evasion model, I first derive tax price elasticity based on a simple model to demonstrate how tax evasion can be controlled for in this setup. The model is then extended by adding the special tax rules of the self-employed. I derive output supply as a function of taxes and further controls, then take first differences to see how reported income reacts to tax rate changes. Finally, I estimate the equation using actual data of the Hungarian self-employed population.

A simple model of tax evasion

Taxpayers chose their reported income in order to maximise their expected utility. Taxes have to be paid on every unit of reported income, while unreported income is untaxed. At this stage, I do not specify the tax scheme. Taxpayers face some probability *p* of tax audit and if they are caught underreporting a fine of ψ has to be paid on the evaded tax. Taxpayers decide on their total labour supply (*L*) and on what share to hide from the tax authority (*h*=HL/L, the share of hidden and total labour supply). The probability of being caught underreporting is a function of the share of hidden income *p=p(w*HL/(w*L))=p(HL/L)=p(h).*[5] The expected utility of each outcome is the payoff minus the disutility of labour weighted by the probability of their occurrence.

The expected payoff in case of not being caught is the sum of the aftertax reported income and the total unreported income (not taxed) plus the non-labour income of the individual: $\mathrm{w}\left(\left(\mathrm{L}-\mathrm{HL}\right)\left(1-\tau\right)+\mathrm{HL}\right)+\mathrm{R}$, where *w* is the wage rate, τ is the tax rate and R is non-labour income. The disutility of work is in the usual CRRA form and proportional to $\frac{\mathrm{L}^{\phi+1}-1}{1+\phi}$, the implicit utility of leisure. L is the hours worked in the given period; ϕ is the elasticity of labour supply. Thus, the expected utility if not being caught is :

$$\mathrm{w}\left(\left(\mathrm{L}-\mathrm{HL}\right)\left(1-\tau\right)+\mathrm{HL}\right)+\mathrm{R}-\omega\frac{\mathrm{L}^{\phi+1}-1}{\phi+1} \quad . \tag{1}$$

The other outcome is that the entrepreneur is caught underreporting. In this case he or she has to pay a penalty proportional to the evaded tax (ψ). Thus the expected utility if being caught is :

[5] This formulation states that the share of hidden income is independent of the tax rate, similar to Tonin (2009). In this setup the saving and cost of tax evasion are both proportional to the tax rate and net out. If income underreporting had an extra fix cost then the saving on underreporting would still be proportional to the tax rate but the cost of concealment would be the sum of a proportional and a fixed term therefore higher tax rate would imply higher saving thus higher share of underreporting.

$$w\left(\left(L-HL\right)\left(1-\tau\right)+HL\right)+R-\omega\frac{L^{\phi+1}-1}{\phi+1}-\psi\left(w\cdot HL\right)\tau. \tag{2}$$

Total expected utility is the weighted sum of the two outcomes ((1) and (2)):

$$\begin{aligned}EU=&\left(1-p\right)\left[w\left(\left(L-HL\right)\left(1-\tau\right)+HL\right)+R-\omega\frac{L^{\phi+1}-1}{\phi+1}\right]\\&+p\left[w\left(\left(L-HL\right)\left(1-\tau\right)+HL\right)+R-\omega\frac{L^{\phi+1}-1}{\phi+1}-\psi\left(w\cdot HL\right)\tau\right]\end{aligned} \tag{3}$$

After simplifications:

$$EU=wL\left(1-h\right)\left(1-\tau\right)+whL+R-\omega\frac{L^{\phi+1}-1}{\phi+1}-p\cdot\psi\cdot\tau\cdot w\cdot h\cdot L \tag{4}$$

$$EU=w\cdot L\left[\left(1-h\right)\left(1-\tau\right)+h\left(1-p\cdot\psi\cdot\tau\right)\right]+R-\omega\frac{L^{\phi+1}-1}{\phi+1} \tag{5}$$

$$EU=w\cdot L\left[1-\tau\left(1-h\left(1-p\cdot\psi\right)\right)\right]+R-\omega\frac{L^{\phi+1}-1}{\phi+1} \tag{6}$$

The two decision variables of the taxpayer are labour supply and the share of hidden income.

Doing maximisation and taking FOCs:

$$\partial/\partial L: w\left(1-\tau\left(1-h\left(1-\psi p\left(h\right)\right)\right)\right)=\omega L^{\phi} \tag{7}$$

$$\partial/\partial h: 1-\psi p\left(h\right)=h\cdot\psi\cdot p'\left(h\right) \tag{8}$$

For simplicity in notation, I introduce the shorthand $Q=1-h\left(1-\psi p\left(h\right)\right)$.

Let us specify the probability of being caught as $p\left(h\right)=p_0+Bh^{\beta}$, so that it is the sum of some autonomous p_0 probability of being caught that taxpayers face regardless of their type and actions and a function of h and their characteristics (B).

From (7) :

$$\left[\frac{w(1-\tau Q)}{\omega}\right]^{\frac{1}{\phi}} = L \tag{9}$$

And from (8) :

$$\left[\frac{1-\psi p_0}{\psi B(\beta+1)}\right]^{\frac{1}{\beta}} = h \tag{10}$$

Only reported income is observed:

$$\begin{aligned} Z^{rep} &= w(L-HL) = w\cdot L(1-h) = w\left(\frac{w(1-Q\tau)}{\omega}\right)^{\frac{1}{\phi}}\left(1-\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta}\right) = \\ &= \left(\frac{w^{\phi+1}}{\omega}\right)^{\frac{1}{\phi}}(1-Q\tau)^{\frac{1}{\phi}}\left(1-\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta}\right) \end{aligned} \tag{11}$$

To see how reported income changes as a response to tax rate changes, I take logs and first differences :

$$\Delta \log Z^{rep} = \Delta \log wL + \Delta \log(1-h) \tag{12}$$

The first term in (12) :

$$\begin{aligned} \log wL &= \frac{1}{\phi}\left((\phi+1)\log w + \log\omega\right) + \frac{1}{\phi}\log(1-Q\tau) \\ \Delta \log wL &= \frac{1}{\phi}\Delta\log(1-Q\tau) \end{aligned} \tag{13}$$

$$\Delta \log wL = \frac{1}{\phi}\Delta\log\left((1+\tau)\frac{1-Q\tau}{1-\tau}\right) = \frac{1}{\phi}\Delta\log(1+\tau) + \frac{1}{\phi}\Delta\log\left(\frac{1-Q\tau}{1-\tau}\right) \tag{14}$$

Remember that

$$Q = 1-h(1-\psi p(h)) = 1-\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta}\left(1-\psi p_0 - \frac{1-\psi p_0}{\psi(1+\beta)}\right) = 1-\frac{f(p_0)}{B^{1/\beta}} \tag{15}$$

where $\mathrm{f}\left(\mathrm{p}_0\right)=\dfrac{\left(1+\psi\left(1+\beta\right)\right)\left(1-\psi \mathrm{p}_0\right)^{\frac{\beta+1}{\beta}}}{\left(\psi\left(1+\beta\right)\right)^{\frac{1+\beta}{\beta}}}$,

so

$$\frac{1-Q\tau}{1-\tau}=\frac{1-\tau+\tau f\left(p_0\right)/B^{\beta}}{1-\tau}=1+\frac{\tau}{1-\tau}\frac{f\left(p_0\right)}{B^{1/\beta}} \tag{16}$$

$$\Delta\log\left(\frac{1-Q\tau}{1-\tau}\right)=\Delta\log\left(1+\frac{\tau}{1-\tau}\frac{f\left(p_0\right)}{B^{1/\beta}}\right)\approx\Delta\left(\frac{\tau}{1-\tau}\frac{f\left(p_0\right)}{B^{1/\beta}}\right). \tag{17}$$

Assuming that all individual characteristics captured by B are constant in time, this is just an interaction of "being caught" related individual characteristics and the change in $\tau/\left(1-\tau\right)$, which is approximately the change in τ itself.

The second term in (12) can be rewritten:

$$\Delta\log\left(1-h\right)=\Delta\log\left(1-\left(\frac{1-\psi p_0}{\psi B\left(1+\beta\right)}\right)^{1/\beta}\right)=\Delta\log\left(1-\frac{g\left(p_0\right)}{B^{1/\beta}}\right)\approx\Delta\left(\frac{g\left(p_0\right)}{B^{1/\beta}}\right) \tag{18}$$

Where $g\left(p_0\right)=\left(\dfrac{1-\psi p_0}{\psi\left(1+\beta\right)}\right)^{1/\beta}$.

Thus for the reported income we get:

$$\Delta\log wL^{rep}=\frac{1}{\phi}\Delta\log\left(1-\tau\right)+\varphi\Delta\left(\left(\frac{\tau}{1-\tau}\right)\frac{f\left(p_0\right)}{B^{1/\beta}}\right)+\upsilon\Delta\log\left(1-\frac{g\left(p_0\right)}{B^{1/\beta}}\right) \tag{19}$$

Equation (19) says that the percentage change in reported income is a function of the percentage change in 1 minus the tax rate, an interaction of avoidance-related characteristics and the change in the tax rate itself and the change in the avoidance-related characteristics.

Notice that if one does not include the interaction terms, then the error term will in general contain the tax rate, so the percentage change in 1 minus the tax rate will be correlated with the error term.

The key parameter of interest is $\frac{1}{\phi}$, the true labour supply elasticity.

Finally (19) can be transformed into an estimable equation:

$$\Delta \log wL_i^{rep,g} = a_i + \frac{1}{\phi}\Delta \log\left(1 - MTR_i\right) + \varphi\Delta\left(\frac{MTR_i}{1 - MTR_i} * b_i\right) \tag{20}$$

A tax evasion model of the self-employed

The case of the self-employed is more complicated than the simple model. Entrepreneurs face multiple taxes, and optimise labour supply and other factors of production too. In order to be able to model the entrepreneurial behaviour I extend the above model. I keep the deterrence setup, but in order to guide the empirical estimation of tax price elasticity, I include all taxes that self-employed face in Hungary. First, I derive the elasticity of the self-employed without tax evasion and then add underreporting to the model. I need a production function approach instead of having the profit and wage functions of the economic agents (as in Tonin, 2009 for example) because self-employed make both production and labour supply decisions. If it was a firm-employee setup, the profit and labour supply optimisations could be done separately, and the production function would not have to appear in the tax evasion model of the individual.

First, I derive the output supply as a function of taxes and other controls, then I take first differences to obtain the change in reported income as a function of these controls, and finally I transform the results into an estimable equation. The final model differs from the basic microeconomic optimizations used in the tax price elasticity literature in two elements: i) besides the effect of tax changes on reported income, I also take into account the effect of tax evasion on income generation; ii) instead of analysing the elasticity of individuals I focus on the self-employed. Self-employed individuals act as firms and maximize the income of the enterprise; therefore, instead of the individual optimization, I use a production function approach.

In the model, firms use labour and other inputs in their production function, they face costs of operation and pay taxes. Similarly to the simple model, the setup is a deterrence model so that they can decide to underreport their income, but there is some probability of being caught underreporting. In such cases they have to pay a fine. Production, share of hidden income, true costs, tax rates, the probability of being caught and the penalty function define the after tax income of the entrepreneurs. Entrepreneurs can also report fictitious costs FC in their tax file.

In their optimisation, firms maximise the expected utility from the entrepreneurial activity by choosing their work effort (L), cost of operation (C) and share of hidden income (h). The entrepreneur has a labour supply of *L*, true net cost of *C* (which is the sum of intermediate inputs and capital costs) and his or her net production is *F(L,C)*. Out of their production *F*, a part *HF* (hidden F) is sold below the counter without giving a receipt and charging (and paying) VAT, i.e. without any trace of the transaction. The rest of the production is sold above the counter, and is therefore observed and reported to the tax authority. It generates a gross revenue of $(1+\tau)(F-HF)$ (this is observed and reported), where τ is the VAT rate. The true gross sales of the enterprise is $(1+\tau)F-\tau HF$. Total costs paid are $(1+\tau)C$.

Entrepreneurs can also report fictitious costs FC in their tax file. We assume that entrepreneurs can make these costs look perfectly legal, which means that only certain types of personal expenditure items can be declared as fictitious costs. Thus, it is not outright cheating and only implies costs coming from the altered consumption basket. This is to say that entrepreneurs do not take any criminal steps to decrease their tax obligations (such as buying fictitious invoices on the black market), but only report some of their personal costs as the cost of operation (e.g. computers, office equipment, etc.). These expenses can be defended towards the tax authority in case of tax audits. However, the self-employed need to change their consumption basket to some extent to increase their costs level as certain products can be reported in the tax files while others cannot. Changing their consumption from the utility maximising basket to the tax optimising basket has some personal costs, but this does not include any monetary costs because, as mentioned above, I assume that entrepreneurs do not engage in any illegal transactions to decrease their tax obligations. For small enterprises, this is a realistic assumption. So, the reported fictitious costs FC has an increasing, concave/convex cost function x(FC). This is the cost for excessive cost reporting, by altering their personal consumption basket. I assume that this cost is simply a function of the size of fictitious costs: x(FC).

Entrepreneurs pay four types of taxes.

- Value added tax (VAT): τ(F-HF-C-FC) – entrepreneurs need to send τ of all legal sales and can reclaim the VAT from all (legal and fictitious) costs;

- Personal income tax (PIT) and social security contributions (SSC): $\tau_{inc}\, w$ - tax base for both PIT and SSC is w, wage income;

- Corporate tax: τ_{corp} (F-HF-C-FC-w) - the tax base is the net income of the enterprise, with net costs and wage income deducted;

- Dividend tax: τ_{div} ((F-HF-C-FC-w) (1-τ_{corp})) - the tax base is the aftertax profit of the enterprise.

The total aftertax labour income is (1-τ_{inc})w. Similarly to the simple model, the disutility of work is proportional to $\frac{L^{\phi+1}-1}{1+\phi}$.

The total aftertax capital income, conditional on not being caught is

$$(1+\tau)F-\tau HF-(1+\tau)C-\tau(F-HF-C-FC)-\tau_{corp}(F-HF-C-FC-w)-w-$$
$$-\tau_{div}\left(F-HF-C-FC-w\right)\left(1-\tau_{corp}\right)-\omega\frac{L^{\phi+1}-1}{\phi+1} \qquad (21)$$

Entrepreneurs optimise their tax payments. Based on the Hungarian regulation $\tau_{corp}+\tau_{div}\left(1-\tau_{corp}\right)<\tau_{inc}$, therefore rational taxpayers keep the wage income as little as possible. There is a legal constraint set by the minimum wage, and no other rules apply to the wage level of the self-employed, so essentially $w=\overline{w}$, and it is no longer a choice variable.[6]

After rearranging, the total aftertax income, not being caught is

$$\begin{aligned}&\left(\mathrm{F}-\mathrm{C}\right)\left(1-\left(\tau_{\mathrm{corp}}+\tau_{\mathrm{div}}\left(1-\tau_{\mathrm{corp}}\right)\right)\right)-\omega\frac{\mathrm{L}^{\phi+1}-1}{\phi+1}+\overline{\mathrm{w}}\left(\tau_{\mathrm{corp}}-\tau_{\mathrm{inc}}+\tau_{\mathrm{div}}\left(1-\tau_{\mathrm{corp}}\right)\right)+\tau\mathrm{FC}+\\&+\left(\mathrm{HF}+\mathrm{FC}\right)\left(\tau_{\mathrm{corp}}+\tau_{\mathrm{div}}\left(1-\tau_{\mathrm{corp}}\right)\right)-\mathrm{x}\left(\mathrm{FC}\right)\end{aligned} \tag{23}$$

Solution to the model without tax evasion

First I derive a solution to the model without tax evasion. If the self-employed did not engage in underreporting, then their total aftertax income would be equal to a simpler form of (23) since hidden production (HF) and fictitious costs (FC) would be equal to zero:

$$\left(\mathrm{F}-\mathrm{C}\right)\left(1-\left(\tau_{\mathrm{corp}}+\tau_{\mathrm{div}}\left(1-\tau_{\mathrm{corp}}\right)\right)\right)-\omega\frac{\mathrm{L}^{\phi+1}-1}{\phi+1}+\overline{\mathrm{w}}\left(\tau_{\mathrm{corp}}-\tau_{\mathrm{inc}}+\tau_{\mathrm{div}}\left(1-\tau_{\mathrm{corp}}\right)\right) \tag{23}$$

I define the effective tax rate as $\tau_{\mathrm{c}}=(\tau_{\mathrm{corp}}+\tau_{\mathrm{div}}(1-\tau_{\mathrm{corp}}))$.

I assume that F(L,C) is in a Cobb-Douglas form:

$$F\left(L,C\right)=AL^{\alpha}\left(C/\pi_{c}\right)^{1-\alpha}=\left(A\pi_{c}^{\ \alpha-1}\right)L^{\alpha}C^{1-\alpha}.$$

The production function contains real production and costs, but in the data we only observe nominal F and C. In case of F, the price index will be absorbed by the TFP term *(A);* for C, the price level (π) can be merged into the catchall TFP term because of the Cobb-Douglas assumption. In the estimation, the price effect will merge into the overall time trend, industry dummies, etc. For the sake of simplicity, I rename the TFP term

[6] For some observations, w > minimum wage for rational reasons, but even in these cases w is not a choice variable. These rational reasons can be twofold: i) to accumulate social security benefits for pension reasons (then w=total income) or ii) having unused PIT deductions (then w= the amount that offsets PIT allowances)

$\left(A\pi_c^{\alpha-1}\right)$ as simply A, so the production function becomes the usual form[7] $F(L,C)=AL^{\alpha}C^{1-\alpha}$.

Therefore (23) becomes :

$$AL^{\alpha}C^{1-\alpha}\left(1-\tau_c\right)-C\left(1-\tau_c\right)-\omega\frac{L^{\phi+1}-1}{\phi+1}+\overline{w}\left(\tau_c-\tau_{inc}\right) \tag{24}$$

Note that if we set α=1 and disregard costs (C=0) then (24) is very similar to the simple model case (eq. 6).

Taking the FOCs of (24):

$$\partial/\partial L: A\alpha L^{\alpha-1}C^{1-\alpha}\left(1-\tau_c\right)=\omega L^{\phi} \tag{25}$$

$$\partial/\partial C: A\left(1-\alpha\right)L^{\alpha}C^{-\alpha}\left(1-\tau_c\right)=1-\tau_c \tag{26}$$

Again, for L the FOC is very similar to the simple model (eq. 7)

From the FOCs

$$L/C=\left(\frac{1-\tau_c}{1-\tau_c}\frac{1}{A\left(1-\alpha\right)}\right)^{1/\alpha}=\left(\frac{1}{A\left(1-\alpha\right)}\right)^{1/\alpha} \tag{27}$$

$$L=\left(\frac{A\alpha\left(1-\tau_c\right)}{\omega}\right)^{1/\phi}\left(L/C\right)^{\frac{\alpha-1}{\phi}} \tag{28}$$

Using the results in the production function:

$$F=AL^{\alpha}C^{1-\alpha}=AL\left(L/C\right)^{\alpha-1}=A\left(\frac{A\alpha\left(1-\tau_c\right)}{\omega}\right)^{1/\phi}\left(L/C\right)^{(\alpha-1)(1+1/\phi)} \tag{29}$$

$$=A\left(\frac{A\alpha\left(1-\tau_c\right)}{\omega}\right)^{1/\phi}\left(\frac{1}{A\left(1-\alpha\right)}\right)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}} \tag{30}$$

[7] This simplification is only possible under the Cobb-Douglas assumption. Under any other functional form (e.g. CES) the production function would remain more complicated.

I rewrite (30) in a simpler form :

$$F = A^{1+\frac{1}{\phi}+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}} c\left(1-\tau_c\right)^{\frac{1}{\phi}} = A^{\frac{1+\phi}{\alpha\phi}} c\left(1-\tau_c\right)^{\frac{1}{\phi}} \quad (33)$$

where $c = \left(\frac{\alpha}{\omega}\right)^{\frac{1}{\phi}} \left(1-\alpha\right)^{\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}$.

So reported income (equal to the true income in this case) is a function of the net-of-tax rate (1-MTR) and some other factors that are function of the individual characteristics.

Solution to the model with tax evasion

I derived the simple model of income elasticity with tax evasion (eq. 11) and the model of self-employed without tax evasion (eq. 33). Next, I am going to combine these two to obtain the model of self-employed with tax evasion.[8]

If self-employed underreport their revenues they face a probability of being caught: p(HF/F). This is determined by the share of hidden income h=HF/F. In case of being caught, a penalty has to be paid, which is proportional to the evaded tax: $\psi HF\tau_c$.

Total expected utility of the entrepreneurial activity is the sum of the net income under the no-evasion and evasion scenarios weighted by their probability (the weighted sum of eq. 23 and the expected fine):

$$(F-C)(1-\tau_c)-\omega\frac{L^{\phi+1}-1}{\phi+1}+\overline{w}(\tau_c-\tau_{inc})+HF\tau_c+(\tau+\tau_c)FC-x(FC)-p\psi HF\tau_c \quad (34)$$

Because of the Cobb-Douglas assumption (34) becomes:

$$AL^{\alpha}C^{1-\alpha}\left(1-\tau_c\left(1-h\left(1-\psi p\left(h\right)\right)\right)\right)-C\left(1-\tau_c\right)-\omega\frac{L^{\phi+1}-1}{\phi+1}+\left(\tau+\tau_c\right)FC-x\left(FC\right) \quad (35)$$

[8] I am only going to present the main steps of the derivation in the main text, for a detailed description of all steps see Appendix B.

It is immediately obvious that (in this particular setting), the FC decision is completely independent from the L-C-h decision.[9] I assume that x(FC) is a separate optimisation problem, and the optimal level of FC is chosen independently.

Taking the FOCs of (35):

$$\partial/\partial L : A\alpha L^{\alpha-1}C^{1-\alpha}\left(1-\tau_c\left(1-h\left(1-\psi p\left(h\right)\right)\right)\right)=\omega L^{\phi} \qquad (36)$$

$$\partial/\partial C : A\left(1-\alpha\right)L^{\alpha}C^{-\alpha}\left(1-\tau_c\left(1-h\left(1-\psi p\left(h\right)\right)\right)\right)=1-\tau_c \qquad (37)$$

$$\partial/\partial h : 1-\psi p\left(h\right)=h\psi p'\left(h\right) \qquad (38)$$

Again, for *L* and *h* the FOCs are very similar to the simple model (eq. 7 and 8).

Similarly to the case of the simple model, the probability of being caught is the sum of some autonomous p_0 probability of being caught, and a function of *h* and individual characteristics (*B*): $p\left(h\right)=p_0+Bh^{\beta}$.

For simplicity in notation, I again introduce the same shorthand $Q=1-h\left(1-\psi p\left(h\right)\right)$.

From the FOCs :

$$L/C=\left(\frac{1-\tau_c}{1-Q\tau_c}\frac{1}{A\left(1-\alpha\right)}\right)^{1/\alpha} \qquad (39)$$

$$L=\left(\frac{A\alpha\left(1-Q\tau_c\right)}{\omega}\right)^{1/\phi}\left(L/C\right)^{\frac{\alpha-1}{\phi}} \qquad (40)$$

$$h=\left(\frac{1-\psi p_0}{\psi B\left(1+\beta\right)}\right)^{1/\beta} \qquad (41)$$

Using the results in the production function:

[9] Other possible specifications of x(.) would contain the relation of F and FC such as x(FC,F), but for simplicity I keep x(FC) in this setup.

$$F = A\left(\frac{A\alpha\left(1-Q\tau_c\right)}{\omega}\right)^{1/\phi}\left(\frac{1-\tau_c}{1-Q\tau_c}\frac{1}{A\left(1-\alpha\right)}\right)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}} = A^{\frac{1+\phi}{\alpha\phi}}c\left(1-\tau_c\right)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}}\left(1-Q\tau_c\right)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}}$$

(42)

where $c = \left(\frac{\alpha}{\omega}\right)^{\frac{1}{\phi}}\left(1-\alpha\right)^{\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}$

Again, only reported income is observed not true income:

$$F^{reported} = F\left(1-h\right) = A^{\frac{1+\phi}{\alpha\phi}}c\left(1-\tau_c\right)^{\frac{1}{\phi}}\left(\frac{1-Q\tau_c}{1-\tau_c}\right)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}}\left(1-\left(\frac{1-\psi p_0}{\psi B\left(1+\beta\right)}\right)^{1/\beta}\right) \qquad (43)$$

Observe that this is similar to both the simple tax evasion and the no-tax evasion self-employed cases. The differences appear in the exponent of the $\left(1-\tau_c\right)$ and $\left(1-Q\tau_c\right)$ terms. The reason is that in the tax evasion production function model self-employed save on their tax payments, both because of their true cost of production (which decreases the tax base) and the undeclared revenues.

In order to analyse the tax price elasticity of the self-employed, a tax reform episode is necessary. A recent change in the regulation, the introduction of a new tax type, is such an episode. However, it not only changed the tax rate but also introduced a special tax regulation, so we have to check if the above setup is still sufficient for the analysis. In the next part, I will demonstrate that the new tax type, the EVA scenario, is a special case of the general model; therefore the above setup is sufficient for the analysis.

Under the EVA scenario, production, sales and hidden production take the same form, only tax regulations are different. The tax base for the EVA enterprises is the gross revenue (as opposed to income net of VAT), and costs are not deductible from the tax base; therefore these enterprises do not report costs.[10] Since costs are not reported, the respective VAT cannot be reclaimed, thus total costs paid become (1+ τ)C. No VAT, PIT, corporate and dividend taxes are due, only the EVA-tax based on gross declared revenues: τ_{eva}(F-HF)(1+τ). They still have to pay ssc based on the wage income part: τ_{ss}w. So the total tax payment becomes: (F-HF)(1+τ) τ_{eva}+ τ_{ss}w. However, the

[10] Since they do not report costs, fictitious costs don't make sense in this case, thus we do not have the x(FC) part of the cost function here.

regulation allows these entrepreneurs to pay ssc based on the minimum wage and τ_{eva} < τ_{ss} so rational taxpayers will again choose $w = \overline{w}$.

Since costs are not reported, reporting fictitious costs does not make sense in this case, so *x(FC)* is not present here.

Using our assumption of a Cobb-Douglas production function the full aftertax expected profit becomes the following:

$$\mathrm{AL}^{\alpha}\mathrm{C}^{1-\alpha}\left(1+\tau\right)\left(1-\tau_{eva}\right)+\mathrm{AL}^{\alpha}\mathrm{C}^{1-\alpha}\left(1-\psi p\right)h\left(1+\tau\right)\tau_{eva}-\omega\frac{\mathrm{L}^{\phi+1}-1}{\phi+1}-\left(1+\tau\right)\mathrm{C} \tag{44}$$

The FOCs somewhat differ from the general case because of the different taxes due:

$$\partial/\partial\mathrm{L}:\mathrm{A}\alpha\mathrm{L}^{\alpha-1}\mathrm{C}^{1-\alpha}\left(1-\tau_{eva}\left(1-h\left(1-\psi p\left(h\right)\right)\right)\right)=\frac{\omega\mathrm{L}^{\phi}}{\left(1+\tau\right)} \tag{45}$$

$$\partial/\partial\mathrm{C}:\mathrm{A}\left(1-\alpha\right)\mathrm{L}^{\alpha}\mathrm{C}^{-\alpha}\left(1-\tau_{eva}\left(1-h\left(1-\psi p\left(h\right)\right)\right)\right)=1 \tag{46}$$

$$\partial/\partial h:1-\psi p\left(h\right)=h\psi p'\left(h\right) \tag{47}$$

Again, the penalty function is $p\left(h\right)=p_0+Bh^{\beta}$ and we have the shorthand $Q=1-h\left(1-\psi p\left(h\right)\right)$:

$$L/C=\left(\frac{1}{1-Q\tau_{eva}}\frac{1}{A\left(1-\alpha\right)}\right)^{1/\alpha} \tag{48}$$

$$L=\left(\frac{A\alpha\left(1-Q\tau_{eva}\right)\left(1+\tau\right)}{\omega}\right)^{1/\phi}\left(L/C\right)^{\frac{\alpha-1}{\phi}} \tag{49}$$

$$h=\left(\frac{1-\psi p_0}{\psi B\left(1+\beta\right)}\right)^{1/\beta} \tag{50}$$

So the production function becomes the following :

$$F = A^{1+\frac{1}{\phi}+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}} c\left(1-\tau_e\right)^{\frac{1}{\phi}} \left(1-\tau_{eva}\right)^{\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}} \left(\frac{1-Q\tau_{eva}}{1-\tau_{eva}}\right)^{1/\phi+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}, \qquad (51)$$

where c is a constant containing α and ω.

In this case the effective tax rate is defined as $1-\tau_e = (1+\tau)(1-\tau_{eva})$.

Reported income becomes :

$$F^{reported} = F\left(1-h\right) = A^{\frac{1+\phi}{\alpha\phi}} c\left(1-\tau_e\right)^{\frac{1}{\phi}} \left(1-\tau_{eva}\right)^{\frac{(1-\alpha)(1+\phi)}{\alpha\phi}} \left(\frac{1-Q\tau_{eva}}{1-\tau_{eva}}\right)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}} \left(1-h\right) \qquad (52)$$

Equations (43) and (52) can be combined into a single expression for reported income as $\tau_{eva} = 0$ for all non-eva taxpayers:

$$F^{reported} = F\left(1-h\right) = A^{\frac{1+\phi}{\alpha\phi}} c\left(1-\tau_a\right)^{\frac{1}{\phi}} \left(1-\tau_b\right)^{\frac{(1-\alpha)(1+\phi)}{\alpha\phi}} \left(\frac{1-Q\tau_b}{1-\tau_b}\right)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}} \left(1-\left(\frac{1-\psi p_0}{\psi B\left(1+\beta\right)}\right)^{1/\beta}\right), \qquad (53)$$

where *(a=c, e)* and *(b=c, eva)* respectively if one is taxed under the normal or the EVA scheme.

Under the normal tax scheme, there are three cases where the effective marginal tax rate may differ from τ_c: i) if a taxpayers takes all his or her income as wage income for accumulating pension entitlements, which can be the case for some taxpayers close to retirement age. For these taxpayers, I assume that an extra unit of income would be taken out as wage income; ii) if a taxpayer declared wage income below the minimum wage, then an extra unit of earned income must be declared as wage income; or iii) if a taxpayer has unused PIT allowances and an extra unit of income could be offset by the unused PIT allowance. In the first two cases (i and ii); the effective marginal tax rate is τ_{inc}, so *a=b=inc*, whereas for iii) the effective tax rate is the ssc rate, so *a=b=ssc.*

To obtain the change in reported income as a function of other variables I take logs and first differences again:

$$\Delta \log F^{rep} = \Delta \log F + \Delta \log(1-h) \tag{54}$$

The first term in (54) becomes :

$$\Delta \log F = \frac{1+\phi}{\alpha\phi}\Delta a + \frac{1}{\phi}\Delta \log(1-\tau_a) + \frac{1-\alpha+\phi-\alpha\phi}{\alpha\phi}\Delta \log(1-\tau_b) + \frac{1+\phi-\alpha\phi}{\alpha\phi}\Delta \log\left(\frac{1-Q\tau_b}{1-\tau_b}\right) \tag{55}$$

Just like in the case of the simple model :

$$Q = 1-h\big(1-\psi p(h)\big) = 1-\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta}\left(1-\psi p_0 - \frac{1-\psi p_0}{\psi(1+\beta)}\right) = 1-\frac{f(p_0)}{B^{1/\beta}} \tag{56}$$

where $f(p_0) = \dfrac{\big(1+\psi(1+\beta)\big)(1-\psi p_0)^{\frac{\beta+1}{\beta}}}{\big(\psi(1+\beta)\big)^{\frac{1+\beta}{\beta}}}$,

therefore $$\frac{1-Q\tau_b}{1-\tau_b} = \frac{1-\tau_b+\tau_b f(p_0)/B^{\beta}}{1-\tau_b} = 1+\frac{\tau_b}{1-\tau_b}\frac{f(p_0)}{B^{1/\beta}} \tag{57}$$

$$\Delta \log\left(\frac{1-Q\tau_b}{1-\tau_b}\right) = \Delta \log\left(1+\frac{\tau_b}{1-\tau_b}\frac{f(p_0)}{B^{1/\beta}}\right) \approx \Delta\left(\frac{\tau_b}{1-\tau_b}\frac{f(p_0)}{B^{1/\beta}}\right). \tag{58}$$

Similarly to the simple model, I assume that all individual characteristics captured by B are constant in time; therefore this term is an interaction of "being caught" related individual characteristics and the change in $\tau_b/(1-\tau_b)$, which is approximately the change in τ_b itself.

The second term in (54) capturing tax evasion is exactly the same as (18):

$$\Delta \log(1-h) = \Delta \log\left(1-\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta}\right) = \Delta \log\left(1-\frac{g(p_0)}{B^{1/\beta}}\right) \approx \Delta\left(\frac{g(p_0)}{B^{1/\beta}}\right), \tag{59}$$

where $g\left(p_0\right)=\left(\frac{1-\psi p_0}{\psi\left(1+\beta\right)}\right)^{1/\beta}$.

By putting together (55), (58) and (59) we obtain reported income in a form similar to the simple model:

$$\Delta\log F^{rep}=\gamma\Delta a+\frac{1}{\phi}\Delta\log\left(1-\tau_a\right)+\vartheta\Delta\log\left(1-\tau_b\right)+\varphi\Delta\left(\left(\frac{\tau_b}{1-\tau_b}\right)\frac{f\left(p_0\right)}{B^{1/\beta}}\right)+\upsilon\Delta\log\left(1-\frac{g\left(p_0\right)}{B^{1/\beta}}\right) \tag{60}$$

where *(a=c, e)* and *(b=c, eva),* respectively, if one is taxed under the normal or the EVA scheme.

Therefore the percentage change in reported income is a function of productivity related individual characteristics (the change in *a*), the percentage change in 1 minus the tax rate, an interaction of avoidance-related characteristics and the change in the tax rate itself, and the change in the avoidance-related characteristics.

The key parameter of interest is $\frac{1}{\phi}$, the true labour supply elasticity. It is important to emphasise that by controlling all other factors, the true labour supply elasticity $\left(\frac{1}{\phi}\right)$ could be isolated in (60) and can be estimated. Tax shifting between capital and labour is incorporated in the model, fringe benefits are rather limited in case of the self-employed so it is essentially tax evasion that we control for when isolating labour supply.

Several assumptions have been made throughout the modelling that need to be assessed in order to be able to evaluate the empirical results in the next section. First, the functional form of profit maximisation seems crucial. As already mentioned before, the profit and labour supply functions need to appear together in the maximisation problem because of the special feature that self-employed act both as employees and employers, so they optimise on profits and labour supply in parallel. The production function determines what function of the effective tax rate (τ) needs to interact with individual controls when accounting for tax evasion. The Cobb-Douglas formulation of the production function is the most common in the literature, as obtaining an estimable equation is the least complicated in this case (for example the user cost of capital literature uses this specification in most cases). In case of other functional forms, such as the CES, the solution of the FOCs that can be linearized with several simplifications only. Therefore, I use the Cobb-Douglas production function to arrive at an understandable estimable equation. The simple model showed, however, that without the production function approach, the controls for tax evasion in the regression specification are the same.

In this model, all self-employed are modelled as firms. There is anecdotal evidence that some self-employed are in fact employees without a contract (falsely self-employed) and it is not straightforward whether this setup describes their behaviour as well. However, the simple model at the first stage gave a very similar solution to the model; therefore, if we disregard the profit maximisation behaviour of the entrepreneurs and only consider the labour supply margin, the estimable equation will still be very similar, thus the estimable equation can be used to describe the behaviour of the falsely self-employed too.

Another crucial assumption is that the fictitious cost of the self-employed can be defended and made to look perfectly legal. This is to say that entrepreneurs do not engage in illegal activities in order to minimise their tax payment. All other forms of fictitious costs are captured by the x(FC) function. If false receipts are obtained from family members the x(FC) function contains the costs. Should we assume that they do indeed buy invoices to account for expense, the penalty function would need to contain other forms of penalty besides fines, such as the probability of being caught by the police or being sentenced to imprisonment. These forms of penalty are hard to monetize, and most deterrence models do not consider these either.

Since the wage income part is not a choice variable in the current model the only progressive element of the self-employed taxation is the dividend tax. It has two tax rates (20% and 35%) and the limit of the higher tax bracket depends on the individual declared wage income. All other taxes due are linear (corporate income tax, VAT, EVA). Therefore the dividend tax is the only element which is endogeneous with the reported income. I am going to come back to this feature when discussing the estimation results.

In the next subsection I present the estimation strategy based on the discussed model.

Estimation strategy

The changes in the reported revenues is regressed on changes in the tax rate and some control variables (eq. 60) in order to capture the income response of small enterprises to tax changes.

$$\Delta \log F^{rep} = \gamma\Delta a + \frac{1}{\phi}\Delta \log\left(1-\tau_a\right) + \vartheta\Delta \log\left(1-\tau_b\right) + \varphi\Delta\left(\left(\frac{\tau_b}{1-\tau_b}\right)\frac{f\left(p_0\right)}{B^{1/\beta}}\right) + \upsilon\Delta \log\left(1-\frac{g\left(p_0\right)}{B^{1/\beta}}\right) \tag{60}$$

where *(a=c, e)* and *(b=c, eva).*

However to carry out the actual estimation, some modifications are introduced to the estimable equation: the log of the initial income and the interaction of the EVA dummy and the VAT rate are included, and an EVA dummy is used instead of the EVA tax rate (explanation follows below). In some specifications, we also instrument the MTR for endogeneity reasons.

The estimable equation becomes

$$\Delta \log F_i^{rep} = a_i + \frac{1}{\phi}\Delta \log\left(1-MTR_i\right) + \beta \log F_{i_0} + \vartheta(D_{eva_i}) + \delta\left(D_{eva_i} * \log\left(VAT_i\right)\right) + \varphi\Delta\left(\frac{MTR_i}{1-MTR_i} * b_i\right) \tag{61}$$

We have two types of transition: from non-eva to non-eva and from non-eva to eva. In the first case the eva dummy (D_{eva}) is zero both pre and post reform, thus (eq. 61) is equivalent to the following:

$$\Delta \log F_i^{rep} = a_i + \frac{1}{\phi}\Delta \log\left(1-MTR_i\right) + \beta \log F_{i_0} + \varphi\Delta\left(\frac{MTR_i}{1-MTR_i} * b_i\right) \tag{62}$$

Under the second type of transition the pre-reform value of the EVA dummy (D_{eva}) is zero and the post-reform value is one. Also the pre-reform MTR values are straight forward to calculate but the post-reform MTRs are bit more complicated. Recall that for the second term in (eq. 61) the value of (1-MTR) is the effective EVA tax rate that also contained the VAT rate and was defined the following way: $1-\tau_e=(1+\tau)(1-\tau_{eva})$. However for the last term in (61) the MTR is simply the EVA tax rate. Thus under the second type of transition (eq. 61) becomes the following:

$$\Delta \log F_i^{rep}=a_i+\frac{1}{\phi}\Big[\log\Big(\big(1+VAT_i^1\big)\big(1-EVA_i^1\big)\Big)-\log\big(1-MTR_i^0\big)\Big]+\beta\log F_i^0 \\ +\vartheta(D_{eva_i})+\delta\big(D_{eva_i}*\log\big(1+VAT_i\big)\big)+\varphi\left(\left(\frac{EVA_i^1}{1-EVA_i^1}-\frac{MTR_i^0}{1-MTR_i^0}\right)*b_i\right), \qquad (63)$$

where *EVA* stands for the EVA tax rate and superscripts 0 and 1 are the pre- and post reform values.

The dependant variable is the reported revenue net of VAT. However, under the EVA scenario, only the gross reported revenue is observed; therefore, the net revenue must be calculated. Since we do not observe the actual VAT rate, we calculate a synthetic VAT rate for the EVA enterprises by applying the post reform VAT rules on the pre-reform VAT tax bases. The net reported income for the EVA entrepreneurs is the reported gross revenue divided by this synthetic (1+VAT) rate. [11]

The key explanatory variable in our estimation is the difference of the logarithm of the tax price[12] for a taxpayer in 2004 and 2001, i.e. the change in (1 - marginal tax rate) defined either by the corporate and dividend tax rates or by the EVA tax rate (Appendix A presents details of the tax regulation). However, as pointed out before, in some cases the MTR is set to the PIT+SSC or the SSC rate.

The marginal tax rate can change for two reasons. The change in the tax regulation is exogenous, but there might also be an endogenous variation that takes place due to the shift in the income level and is therefore endogenous in case of a progressive tax system. If we do not treat this problem, the tax price and the error term will be

[11] In case of an eva-eva change this would be problematic as the VAT rate is not observed even before the reform. However in this analysis we do not have such cases.
[12] The expression 'tax price' refers to the fact that for unchanged wages, a change in the tax rate coincides with the change in the relative price of leisure.

correlated ($\mathrm{cov}(\Delta \log(1-MTR_i), u_i) \neq 0$) and our estimates will be inconsistent. The usual way to overcome this problem is to instrument the true marginal tax rate by a synthetic tax rate.[13] This synthetic rate is calculated by applying the post-reform tax rules to the inflated pre-reform income and deductions.[14] This way, the synthetic MTR is the tax rate that would have been applicable after the reform had the real income of the taxpayer not changed. Of course the instrument can only be used if they are sufficiently correlated with the actual tax rates.

In the regression analysis, I also include the level of income in the initial period to control both for income mean-reversion and for changes in the income distribution, as Moffitt and Wilhelm (2000) suggest.

A set of individual characteristics is also included in the regression that are likely to be correlated with the income changes, such as gender, age, age square, regional information (7 regions, Budapest dummy and city dummy) and field of activity (measured by the two-digit TEAOR code).

The EVA tax rate enters the regression too. As the EVA tax rate is uniformly 15% for all entrepreneurs, this is equivalent to having an EVA dummy in the regression.

Although entrepreneurs file the VAT report, this does not mean that they bear the actual total cost of VAT. Entrepreneurs (firms in general) might pass on total or only part of the VAT to consumers. Firms producing for the same market face the same elasticity of demand, therefore by region and industry the passthrough should be similar. However, the passthrough might differ along the type of transition (nonEVA-nonEVA vs. nonEVA-EVA) as non-EVA and EVA enterprises face different VAT rules (EVA enterprises cannot claim back the VAT, but they have a lower tax rate). Therefore, I add the log of VAT interacted with the type of transition to the regression.

In the regression, controls are used for the effect of tax evasion in order to isolate the effect of the tax price only. The change in the tax evasion is represented by the last two terms in (60) (terms that contain the B term): $\Delta \log\left(\frac{1-Q\tau_c}{1-\tau_c}\right)$ and $\Delta \log\left(1-\frac{g(p_0)}{B^{1/\beta}}\right)$.

[13] For example, Auten and Carroll (1999), Gruber and Saez (2002) follow this approach.

[14] For indexation we use the the official annual average inflation figures of the statistics office.

The latter is approximately $\Delta\left(\frac{g(p_0)}{B^{1/\beta}}\right)$. By assuming an appropriate functional form, this can be written as $c+\sum d_i X_i$, where X_i is the set of all evasion-relevant (fixed) characteristics of an entrepreneur. However, using a fairly short period (2001-2004) for estimation, we assume that the individual characteristics captured by *B* do not change; therefore, in this particular setting the last term in (58) drops out.

For the former expression, we saw that $\Delta\log\left(\frac{1-Q\tau_b}{1-\tau_b}\right)\approx\Delta\left(\frac{\tau_b}{1-\tau_b}\frac{f(p_0)}{B^{1/\beta}}\right)$. Since we assume that the tax evasion function of the individuals does not change over the given period, only the interaction of the individual characteristics and the change in the tax rate $\left(\frac{\tau_b^{t+1}}{1-\tau_b^{t+1}}-\frac{\tau_b^{t}}{1-\tau_b^{t}}\right)$, where (*b*= *c, eva*), remains in the regression. [15]

2.4 Dataset

The source of data for the analysis is a Hungarian Tax and Financial Control Office (APEH) panel of tax returns of self-employed for the years 2000-2006, prepared for the Hungarian Ministry of Finance. A 10% representative sample of the self-employed was taken for 2006, and lines of the tax reports for the years 2000-2006 were added for the individuals in the sample. For the analysis we use data for 2001 and 2004. The dataset contains unaudited data from the personal income tax, EVA and VAT tax forms. The personal income tax report covers the revenues and costs of the enterprises. The dataset also contains individual data on age, gender, activity and region.

The EVA was introduced in 2003, but it was not announced until 2002, so the 2001 figures should be free of any expectation effects. I take 2004 as the end of the period, as in that year the corporate tax changed from 18% to 16% which gives variation in the tax rate of the non-EVA population. Although the dataset is available from 2001 to 2006, a longer panel would contain more autonomous economic effects that influence tax

[15] Should we assume a change in the tax evasion behaviour too, depending on the type of taxation for the end-period, the interaction of individual characteristics and the initial tax rate $\frac{\tau_b^{t}}{1-\tau_b^{t}}$, and the characteristics themselves, interacted with the type of transition would need to enter the regression too.

payment of the enterprises, but are unrelated to the tax rate changes. Most studies analysing the ETI are based on a 3-year panels.

The data contains 28.233 entrepreneurs. I leave out those observations that were taxed with the fix cost deduction rate (a way of taxation only available for a special group) and only keep the self-employed with positive net revenues both in 2001 and 2004. This gives 17.390 observations. I limit the sample by omitting individuals who also had wage income in these years (4964 observations), as I assume that they have different behaviour. I also drop observations where certain cells violate the tax rules (1 observation). I leave out entrepreneurs where the level of the wage income does not comply with the rationality assumption: where the wage part is above the minimum wage, but neither for pension savings nor for PIT tax allowance reasons (1189 observations). After these restrictions remains the working sample that contains 11.236 observations.

Table 2.1 presents the descriptive statistics of the variables in the sample of entrepreneurs with positive net revenues and our working sample.

Table 2.1. Means and standard deviations of variables

Variable	SEs with positive net revenues in both years		Working sample	
	Mean	Std. Dev.	Mean	Std. Dev.
Δlog income	0.1226	0.9807	0.0748	0.8342
Δlog (1 - marginal tax rate)	0.1812	0.3652	0.1709	0.3660
Δlog (1 - synth. marginal tax rate)	0.0748	0.3723	0.0267	0.3898
Δlog (1 + VAT)	0.0092	0.0552	0.0101	0.0578
Eva dummy	0.2026	0.4020	0.1416	0.3487
Δlog (tax rate/1 – tax rate)	-0.0452	0.3806	-0.0282	0.3268
Gender dummy	0.3843	0.4864	0.3888	0.4875
Age in 2004	45.7	10.67	45.8	10.9
Age in 2004 squared	2201.1	1005.1	2215.9	1039.3
Region	3.54	2.21	3.63	2.21
Field of activity	10.18	6.38	9.22	6.23
Budapest dummy	0.1750	0.3800	0.1583	0.3651
Regional capital dummy	0.3023	0.4593	0.2728	0.4454
No. observations	17.390		11.236	

2.5 Results

I use four specifications to estimate the tax price elasticity of the self-employed. In the basic model, the change in the gross revenues is only regressed on the change in the tax price (1 - the marginal tax rate). In Model 2, the initial income and the EVA dummy are also included. In Model, 3 the estimation is extended by the individual characteristics. In Model 4 controls, for tax evasion controls are introduced by including the interaction of evasion-related individual characteristics with the change in the tax rate.

The log change of the tax price has a significant positive effect in all specifications. If only the tax price is used as control, the elasticity is around 12%. This is low, compared to US estimates, but modest in European comparison. It is almost double as large as the estimate for the total employee population in Chapter 1 of the thesis (see also Bakos *et al*, 2009).

Introducing further controls the elasticity becomes lower in the OLS specification to 7,2% in Model 3. When controlling for tax evasion too, the elasticity drops to 5,1% (Model 4). By controlling for tax evasion in Model 4, the labour supply elasticity of the self-employed is isolated.

To check whether the variables controlling for tax evasion have a joint significant effect and whether the estimates in Model 3 and 4 differ, I perform a joint Wald-test on the parameters. The test result, (F(27, 11157) = 7.34; Prob > F = 0.0000), supports the assumption that including tax-evasion related explanatory variables in the model significantly improves the fit; therefore, the elasticity estimations in Model 3 and 4 are different. If we test the parameters separately, gender (at a 10% level), age and age square (at a 5% level) and activity (at a 1% level) display significant individual effects too.

Table 2.2. Results of the OLS regressions

	Model 1	Model 2	Model 3	Model 4
Δlog(tax price)	0.120***	0.0671***	0.0718***	0.0506**
	(0.0213)	(0.0258)	(0.0256)	(0.0255)
Eva dummy		0.0354	0.190***	0.234***
		(0.0271)	(0.0345)	(0.0346)
Log(init. inc.)		-0.200***	-0.229***	-0.224***
		(0.00540)	(0.00592)	(0.00590)
Eva * VAT			-1.328***	-1.295***
			(0.187)	(0.186)
Gender			-0.0557***	-0.0588***
			(0.0168)	(0.0167)
Age			-0.00728	-0.00588
			(0.00464)	(0.00464)
Age square			-4.88e-05	-6.21e-05
			(4.89e-05)	(4.89e-05)
Budapest dummy			-0.0219	-0.0186
			(0.0370)	(0.0368)
City dummy			-0.0224	-0.0184
			(0.0242)	(0.0241)
Region			Included	Included
Activity			Included	Included
Tax evasion controls				Included
Constant	0.0443***	1.653***	2.301***	2.230***
	(0.00861)	(0.0444)	(0.120)	(0.120)
Observations	11236	11236	11223	11223
R-squared	0.003	0.112	0.148	0.164

*Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

As mentioned before, the key explanatory variable might be endogenous. The usual way to overcome endogeneity is to do an IV instead of an OLS regression. Table 2.3 presents the results. In this specification, the basic elasticity (Model 1) is somewhat lower: 9,5%. Although Model 2 shows a negative elasticity, the full specification - Model 3 - gives a similar result as the OLS, namely 3,9%. Controlling for tax evasion again lowers substantially the elasticity. Thus, the results of the IV regression are somewhat lower than those of the OLS, but the main findings are similar. However the IV regression exhibits significance problems.

Doing the Wald-test proves that controlling for tax evasion causes a significant difference again (F(30,11157) = 7.34, Prob > F = 0.0000). Although the progressivity of the income tax may cause endogeneity, we cannot reject the hypothesis, based on the Durbin-Wu-Hausman test[16], that the OLS results are consistent.

Table 2.3. Results of the IV regressions

	Model 1	Model 2	Model 3	Model 4
Δlog(tax price)	0.0950***	-0.0958**	0.0390	0.00872
	(0.0275)	(0.0439)	(0.0433)	(0.0435)
Eva dummy		0.142***	0.209***	0.259***
		(0.0358)	(0.0398)	(0.0402)
Log(init. inc.)		-0.200***	-0.229***	-0.224***
		(0.00541)	(0.00592)	(0.00590)
Eva * VAT			-1.303***	-1.264***
			(0.189)	(0.188)
Gender			-0.0558***	-0.0589***
			(0.0168)	(0.0167)
Age			-0.00769*	-0.00642
			(0.00466)	(0.00466)
Age square			-4.47e-05	-5.67e-05
			(4.91e-05)	(4.92e-05)
Budapest dummy			-0.0219	-0.0178
			(0.0242)	(0.0241)
City dummy	0.0950***	-0.0958**	0.0390	0.00872
	(0.0275)	(0.0439)	(0.0433)	(0.0435)
Region			Included	Included
Activity			Included	Included
Tax evasion controls				Included
Constant	0.0443***	1.653***	2.301***	2.230***
	(0.00861)	(0.0444)	(0.120)	(0.120)
Observations	11236	11236	11223	11223
R-squared	0.003	0.112	0.148	0.164
Durbin-Wu-Hausman chi-sq test	*2.02445*	*21.16051*	*0.88100*	*1.41835*
P-value	*0.15478*	*0.00000*	*0.34793*	*0.23367*

*Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

As a robustness check, I have also run the regression on the total working population (17.390 observations) to check whether results are sensitive to the selection of the working sample. The overall elasticity in Model 1 is somewhat higher (19%), but in

[16] The H0 is that the explanatory variable is exogenous, therefore the OLS gives consistent estimates and the IV is not necessary. If the p-value is small we reject the null hypothesis, and have an endogeneity problem. We give the test values and the p-values of the test for the 4 specifications.

Model 3 and 4, results are very similar to the smaller subsample. Detailed results can be found in Appendix C.

Results of the IV estimation in Models 1, 3 and 4 were in line with the OLS results, but there are significance problems in the last two models.[17] Therefore, I chose a subgroup for estimation, where instrumentation is not necessary. Since the endogeneity problem is caused by the progressivity of the dividend tax, I only keep observations for which the dividend tax rate is in the lower bracket (20%) and are “far enough” from reaching the higher bracket. For this group, the MTR is exogenous; therefore, the OLS gives consistent results.

The estimates in this case are very similar to the previous OLS results. The elasticity in Model 1 is 12%, whereas the elasticity in the model with all the individual controls (Model 3) is 7%. When controlling for tax evasion (Model 4), the elasticity drops to 4,4%. Again, the Wald-test on the evasion-related parameters shows that the elasticity estimates in Models 3 and 4 are significantly different. The result of the test, ($F(30,10297) = 4.82$; $Prob > F = 0.0000$), shows that controlling for tax evasion significantly changes the elasticity. This mostly comes from the activity information; the other factors, such as gender, age, age square and regional information, do not have a significant joint effect on elasticity.

[17] In Model 2 the sign of the elasticity differs from the other estimates, but this is not unusual in these types of empirical studies, see for example the results of Gruber and Saez (2002) whose estimates depend on the specification too.

Table 2.4. Results of the OLS2 regressions on the smaller subgroup

	Model 1	Model 2	Model 3	Model 4
Δlog(tax price)	0.125***	0.0637**	0.0695***	0.0441*
	(0.0218)	(0.0266)	(0.0264)	(0.0265)
Eva dummy		0.0517*	0.209***	0.243***
		(0.0275)	(0.0350)	(0.0351)
Log(init. inc.)		-0.204***	-0.232***	-0.226***
		(0.00570)	(0.00625)	(0.00626)
Eva * VAT			-1.317***	-1.301***
			(0.187)	(0.187)
Gender			-0.0466***	-0.0496***
			(0.0175)	(0.0178)
Age			-0.0101**	-0.00896*
			(0.00484)	(0.00499)
Age square			-1.42e-05	-2.72e-05
			(5.11e-05)	(5.30e-05)
Budapest dummy			-0.0219	-0.0186
			(0.0370)	(0.0368)
City dummy			-0.0224	-0.0184
			(0.0242)	(0.0241)
Region			Included	Included
Activity			Included	Included
Tax evasion controls				Included
Constant	0.0335***	1.675***	2.330***	2.281***
	(0.00903)	(0.0467)	(0.126)	(0.129)
Observations	10375	10375	10363	10363
R-squared	0.003	0.114	0.150	0.162

*Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

To make sure that the OLS is consistent, I run the Durbin-Wu-Hausman test for endogeneity, using the synthetic MTR for the IV. For Models 1, 3 and 4, we cannot reject the hypothesis that the OLS gives consistent results. Again, the results of the IV are similar to the OLS in their magnitude and in the effect of controls on the estimates, but Models 3 and 4 exhibit significance problems.

Table 2.5. Results of the IV regressions on the smaller subgroup

	Model 1	Model 2	Model 3	Model 4
Δlog(tax price)	0.109***	-0.0817*	0.0463	0.0172
	(0.0279)	(0.0449)	(0.0444)	(0.0451)
Eva dummy		0.147***	0.222***	0.259***
		(0.0362)	(0.0403)	(0.0408)
Log(init. inc.)		-0.204***	-0.232***	-0.226***
		(0.00570)	(0.00625)	(0.00626)
Eva * VAT			-1.300***	-1.280***
			(0.189)	(0.189)
Gender			-0.0467***	-0.0497***
			(0.0175)	(0.0178)
Age			-0.0104**	-0.00934*
			(0.00486)	(0.00502)
Age square			-1.13e-05	-2.34e-05
			(5.13e-05)	(5.33e-05)
Budapest dummy			-0.0199	-0.0196
			(0.0386)	(0.0385)
City dummy			-0.0195	-0.0123
			(0.0252)	(0.0251)
Region			Included	Included
Activity			Included	Included
Tax evasion controls				Included
Constant	0.0364***	1.686***	2.340***	2.292***
	(0.00958)	(0.0468)	(0.127)	(0.130)
Observations	10375	10375	10363	10363
R-squared	0.003	0.112	0.150	0.161
Durbin-Wu-Hausman chi-sq test	*0.82735*	*16.26620*	*0.42645*	*0.54926*
P-value	*0.36304*	*0.00006*	*0.51374*	*0.45862*

*Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

2.6 Conclusions

In this chapter I investigated the tax price elasticity of the self-employed. The tax reform episode used for the analysis was the introduction of a new taxation policy, the simplified entrepreneurial tax in Hungary in 2003. This regulation ensures a general low marginal tax rate for the enterprises, but does not take into account the real costs of operation. The enterprises opting for the new regulation are typically the ones with mid or high income level and operate in fields of activity involving low costs.

To facilitate the empirical estimation, I developed a simple model of the self-employed. In this model, entrepreneurs act like firms; they maximise their profit by using labour input and costs of production and they pay taxes. They hide a share of their income and face some probability of being caught. If they are caught, they have to pay a fine. By solving this model, the labour supply response to tax rate changes could be separated from other responses.

I used tax returns data of the self-employed from 2001 and 2004 to estimate the effect of tax rate changes on the reported income of entrepreneurs. Results show that the marginal tax rate has a significant effect on declared income: the elasticity of the taxable income of the self-employed to the tax price is around 11,5-12%. When introducing further controls, the elasticity figure falls to 7-8%. If tax evasion is also included as a control variable the elasticity of declared income to changes in the tax price falls to about 4,3-5,5%. Given that in the Hungarian tax system other margins of adjustment are limited, this figure is the real labour supply elasticity of the self-employed.

The elasticity estimates are low compared to US findings, but are in the range of comparable European figures. Hungarian studies found about 5-7% elasticity over the whole income distribution bracket for employees, and 20%-33% elasticity for high income employees (see Chapter 1 of the thesis, published as Bakos *et al*, 2008 and Kiss, 2010). The elasticity estimates for the self-employed are, therefore, about twice the overall elasticity of employees. This low tax price elasticity is explained by the fact that self-employed minimise to a minimum level under all conditions their tax payment by tax evasion and tax avoidance; therefore, they are not very responsive to tax rate changes. However, the estimated labour supply elasticity is fairly modest, so the self-employed do react to tax rate changes in their real labour efforts. Labour supply elasticity is about 4-5%.

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Appendix

A. Tax regulation in Hungary for the self-employed

The tax reform episode that I analyzed was the introduction of the so-called simplified entrepreneurial tax (EVA in Hungarian) in January 2003. As a result, the self-employed[18] may choose between two forms of taxation[19].

The first, general type of taxation is based on the income of the enterprise. Enterprises pay a profit tax of 18%, altered to 16% as of January 2004, based on the annual income of the enterprise. The annual income is declared revenues minus declared costs of the enterprise, reduced by so-called withdrawal. The withdrawal is to replace the wage income for entrepreneurs after which the personal income tax and the social security contributions are due. If the enterprise has sufficient income, the withdrawal cannot be lower than the minimum wage. The personal income tax obligation can be offset by tax allowances. Entrepreneurs also face a dividend tax based on aftertax income. For the part of the dividend below the 30% of the withdrawal, a 20% dividend tax is due; on the part above the 30%, a 35% tax is due. These enterprises also file a VAT tax report. The marginal tax rate in this case is defined by corporate and dividend tax rates.

The other type of taxation, introduced in Hungary in January 2003, is called the simplified entrepreneurial tax (EVA). It replaces all the above taxes, except the social security contribution, i.e. the VAT, the profit tax, the personal income tax on withdrawal and the entrepreneurial dividend tax (other small taxes, such as local taxes and educational and cultural contributions are due). The tax base of the EVA is the gross revenue of the enterprise; in other words, it does not take into account the costs of production. The EVA tax rate is 15% of the total tax base. As no VAT or personal income tax is due on top of that, VAT cannot be reclaimed, and tax allowances cannot be taken into account. Under the EVA, entrepreneurs pay the same social security contribution rate as other enterprises or employees, and the legal minimum base of the

[18] In Hungary small enterprises can choose from 3 entrepreneurial forms: self-employment, company with unlimited liability (Bt) or limited liability company (Kft). In this paper we only analyse enterprises that operate as self-employed.
[19] A third method of taxation based on a fixed cost-deduction rate of 40% of the income. This way of taxation was available for enterprises with annual income below 6 million HUF, who was engaged in activities exempt from VAT.

contribution is the minimum wage, just as under other forms of taxation.[20] Enterprises that had been operating for two years without exceeding a 15 million HUF revenue limit (including VAT) before 2003 could have opted for this type of tax starting as of January 2003. The limit for entitlement was raised to 25 million HUF as of January 2004.

Table A1 summarizes the main features of those two forms of taxation:

Table A1 Tax regulation for entrepreneurs in 2003

2 possible forms of taxation for self-employed	**„Normal" self-employed taxation**	**EVA**
Profit or income tax base	Revenue of enterprise - declared costs (net of VAT) decreased by withdrawal	Gross Revenue of enterprise (including VAT)
Profit or income tax rate	18%	15%
Other taxes	- PIT and ssc (40.5%/41.5%) on withdrawal (minimum the min.wage) - Dividend tax of 20% or 35%	SSC (40.5%/41.5%) on min.wage
VAT	Yes	No
Rules for choosing this type	No	Yes, 15m HUF annual gross revenue in the last 2 years

[20] They can pay ssc based on a higher income but in this case they have to notify the authority about the chosen base.

B. Solution of the tax evasion model including all steps of the deduction

$F(L,C) = AL^{\alpha}(C/\pi_c)^{1-\alpha} = \left(A\pi_c{}^{\alpha-1}\right)L^{\alpha}C^{1-\alpha}$.

Therefore the total after income of the entrepreneur is the following:

$$AL^{\alpha}C^{1-\alpha}\left(1-\tau_c\left(1-h\left(1-\psi p(h)\right)\right)\right)-C(1-\tau_c)-\omega\frac{L^{\phi+1}-1}{\phi+1}+(\tau+\tau_c)FC-x(FC) \tag{A1}$$

The FOCs of (A1):

$$\partial/\partial L: A\alpha L^{\alpha-1}C^{1-\alpha}\left(1-\tau_c\left(1-h\left(1-\psi p(h)\right)\right)\right)=\omega L^{\phi} \tag{A2}$$

$$\partial/\partial C: A(1-\alpha)L^{\alpha}C^{-\alpha}\left(1-\tau_c\left(1-h\left(1-\psi p(h)\right)\right)\right)=1-\tau_c \tag{A3}$$

$$\partial/\partial h: 1-\psi p(h)=h\psi p'(h) \tag{A4}$$

We use $p(h)=p_0+Bh^{\beta}$ and $Q=1-h\left(1-\psi p(h)\right)$.

From the FOCs we get the following:

$$L/C=\left(\frac{1-\tau_c}{1-Q\tau_c}\frac{1}{A(1-\alpha)}\right)^{1/\alpha} \tag{A5}$$

$$L=\left(\frac{A\alpha(1-Q\tau_c)}{\omega}\right)^{1/\phi}(L/C)^{\frac{\alpha-1}{\phi}} \tag{A6}$$

$$h=\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta} \tag{A7}$$

Using the results in the production function:

$$F=AL^{\alpha}C^{1-\alpha}=AL(L/C)^{\alpha-1}=A\left(\frac{A\alpha(1-Q\tau_c)}{\omega}\right)^{1/\phi}(L/C)^{(\alpha-1)(1+1/\phi)}$$

$$=A\left(\frac{A\alpha(1-Q\tau_c)}{\omega}\right)^{1/\phi}\left(\frac{1-\tau_c}{1-Q\tau_c}\frac{1}{A(1-\alpha)}\right)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}}$$

$$=A^{1+\frac{1}{\phi}+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}c(1-\tau_c)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}}(1-Q\tau_c)^{1/\phi+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}=A^{\frac{1+\phi}{\alpha\phi}}c(1-\tau_c)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}}(1-Q\tau_c)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}} \tag{A8}$$

where $c=\left(\frac{\alpha}{\omega}\right)^{\frac{1}{\phi}}(1-\alpha)^{\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}$

Therefore reported income becomes the following:

$$F^{reported}=F(1-h)=A^{\frac{1+\phi}{\alpha\phi}}c(1-\tau_c)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}}(1-Q\tau_c)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}}\left(1-\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta}\right)$$

$$=A^{\frac{1+\phi}{\alpha\phi}}c(1-\tau_c)^{\frac{1}{\phi}}\left(\frac{1-Q\tau_c}{1-\tau_c}\right)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}}\left(1-\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta}\right) \tag{A9}$$

Under the EVA case the full aftertax expected profit is:

$$F(1+\tau)(1-\tau_{eva})-\tau_{ss}\overline{w}-\omega\frac{L^{\phi+1}-1}{\phi+1}+(1-\psi p)HF(1+\tau)\tau_{eva}-(1+\tau)C$$

$$=AL^{\alpha}C^{1-\alpha}(1+\tau)(1-\tau_{eva})+AL^{\alpha}C^{1-\alpha}(1-\psi p)h(1+\tau)\tau_{eva}-\omega\frac{L^{\phi+1}-1}{\phi+1}-(1+\tau)C \tag{A10}$$

The FOCs are the following:

$$\partial/\partial L: A\alpha L^{\alpha-1}C^{1-\alpha}\left(1-\tau_{eva}\left(1-h\left(1-\psi p(h)\right)\right)\right)=\frac{\omega L^{\phi}}{(1+\tau)} \tag{A11}$$

$$\partial/\partial C: A(1-\alpha)L^{\alpha}C^{-\alpha}\left(1-\tau_{eva}\left(1-h\left(1-\psi p(h)\right)\right)\right)=1 \tag{A12}$$

$$\partial/\partial h: 1-\psi p(h)=h\psi p'(h) \tag{A13}$$

Rewriting the FOCs:

$$L/C=\left(\frac{1}{1-Q\tau_{eva}}\frac{1}{A(1-\alpha)}\right)^{1/\alpha} \tag{A14}$$

$$L=\left(\frac{A\alpha(1-Q\tau_{eva})(1+\tau)}{\omega}\right)^{1/\phi}(L/C)^{\frac{\alpha-1}{\phi}} \tag{A15}$$

$$h=\left(\frac{1-\psi p_0}{\psi B(1+\beta)}\right)^{1/\beta} \tag{A16}$$

So the production function becomes the following:

$$F = AL^{\alpha}C^{1-\alpha} = AL\left(L/C\right)^{\alpha-1} = A\left(\frac{A\alpha\left(1-Q\tau_{eva}\right)\left(1+\tau\right)}{\omega}\right)^{1/\phi}\left(L/C\right)^{(\alpha-1)(1+1/\phi)}$$

$$= A\left(\frac{A\alpha\left(1-Q\tau_{eva}\right)\left(1+\tau\right)}{\omega}\right)^{1/\phi}\left(\frac{1}{1-Q\tau_{eva}}\frac{1}{A(1-\alpha)}\right)^{\frac{\alpha-1}{\alpha}\frac{1+\phi}{\phi}} = A^{1+\frac{1}{\phi}+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}c\left(1+\tau\right)^{\frac{1}{\phi}}\left(1-Q\tau_{eva}\right)^{1/\phi+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}$$

$$F = A^{1+\frac{1}{\phi}+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}c\left(1+\tau\right)^{\frac{1}{\phi}}\left(1-\tau_{eva}\right)^{1/\phi+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}\left(\frac{1-Q\tau_{eva}}{1-\tau_{eva}}\right)^{1/\phi+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}} =$$

$$= A^{1+\frac{1}{\phi}+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}c\left(1-\tau_{e}\right)^{\frac{1}{\phi}}\left(1-\tau_{eva}\right)^{\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}}\left(\frac{1-Q\tau_{eva}}{1-\tau_{eva}}\right)^{1/\phi+\frac{1-\alpha}{\alpha}\frac{1+\phi}{\phi}} \tag{A17}$$

where c is a constant containing α and ω.

Reported income is:

$$F^{reported} = F\left(1-h\right) = A^{\frac{1+\phi}{\alpha\phi}}c\left(1-\tau_{e}\right)^{\frac{1}{\phi}}\left(1-\tau_{eva}\right)^{\frac{(1-\alpha)(1+\phi)}{\alpha\phi}}\left(\frac{1-Q\tau_{eva}}{1-\tau_{eva}}\right)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}}\left(1-h\right) \tag{A18}$$

Combining the non-eva and the EVA cases:

$$F^{reported} = F\left(1-h\right) = A^{\frac{1+\phi}{\alpha\phi}}c\left(1-\tau_{a}\right)^{\frac{1}{\phi}}\left(1-\tau_{b}\right)^{\frac{(1-\alpha)(1+\phi)}{\alpha\phi}}\left(\frac{1-Q\tau_{b}}{1-\tau_{b}}\right)^{\frac{1+\phi-\alpha\phi}{\alpha\phi}}\left(1-\left(\frac{1-\psi p_{0}}{\psi B(1+\beta)}\right)^{1/\beta}\right) \tag{A19}$$

where (a=c, e) and (b=c, eva) respectively if one is taxed under the normal or the EVA scheme.

C. Regression results on the total working population

	OLS				IV			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Δlog(tax price)	0.189***	0.0675***	0.0801***	0.0393	0.254***	-0.0582	0.0607	0.0158
	(0.0202)	(0.0242)	(0.0241)	(0.0242)	(0.0260)	(0.0413)	(0.0417)	(0.0424)
Eva dummy		0.125***	0.306***	0.394***		0.197***	0.316***	0.406***
		(0.0220)	(0.0266)	(0.0275)		(0.0292)	(0.0315)	(0.0330)
Log(init. inc.)		-0.244***	-0.267***	-0.259***		-0.244***	-0.267***	-0.259***
		(0.00472)	(0.00505)	(0.00506)		(0.00473)	(0.00505)	(0.00506)
Eva * VAT			-1.292***	-1.273***			-1.276***	-1.254***
			(0.145)	(0.145)			(0.147)	(0.148)
Gender			-0.0601***	-0.0613***			-0.0602***	-0.0613***
			(0.0154)	(0.0154)			(0.0154)	(0.0154)
Age			-0.0131***	-0.0123***			-0.0134***	-0.0127***
			(0.00440)	(0.00442)			(0.00442)	(0.00445)
Age square			1.35e-05	7.49e-06			1.61e-05	1.10e-05
			(4.67e-05)	(4.71e-05)			(4.69e-05)	(4.74e-05)
Budapest dummy			0.0375	0.0410			0.0375	0.0411
			(0.0335)	(0.0333)			(0.0335)	(0.0333)
City dummy			-0.0434**	-0.0393*			-0.0432**	-0.0392*
			(0.0217)	(0.0216)			(0.0217)	(0.0216)
Region			Included	Included			Included	Included
Activity			Included	Included			Included	Included
Tax evasion controls				Included				Included
Constant	0.0792***	1.990***	2.676***	2.592***	0.0674***	1.994***	2.684***	2.602***
	(0.00823)	(0.0381)	(0.114)	(0.114)	(0.00875)	(0.0381)	(0.114)	(0.114)
Observations	17390	17390	17368	17368	17390	17390	17368	17368
R-squared	0.005	0.142	0.176	0.188	0.004	0.141	0.176	0.188

*Notes: standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Chapter 3

The distributional implications of income underreporting in Hungary

Joint with Orsolya Lelkes[+]

3.1 Introduction

Tax evasion hinders the evaluation of tax policies. The ability (and inclination) of specific social groups to evade tax varies widely, and this leads to a considerable variation in the actual tax burden of individuals with similar levels of income. Tax evasion skews income redistribution and results in a social outcome that may be unintended and non-transparent to policymakers and may be perceived by taxpayers as unfair. In particular, where assessment of eligibility for benefits relies on scrutiny of a person's tax return, tax evasion renders targeting inefficient, since there is benefit 'leakage' to ineligible recipients. For these reasons, ignoring tax evasion can be seriously misleading in terms of the distributive and fiscal effect of social benefits and the tax system. In view of this, we aim to explore a procedure to correct income data for tax evasion.

In order to come up with a fair income-redistribution system, policymakers need to know not only the income of individuals, but also how they actually comply with tax regulations.[1] Currently, very little is known about this. The general approach of policymakers to tax evasion concerns lost budget revenues. We argue, however, that a more important problem is that it affects redistribution, and often in an unclear and unintended fashion. Therefore, policies aiming to reduce income tax evasion may not achieve the intended outcome. In this chapter, we try to shed some light on those unintended implications.

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[1] On the features of the Hungarian tax policy, see Appendix B.

The aim of this chapter is to provide estimates of the size and distribution of income tax evasion in Hungary and to explore its implications. The chapter takes advantage of access to a random sample of income tax returns for incomes earned in 2005, containing information on 227,688 individuals - some 5% of all taxpayers - and a survey dataset of 2005 household income. We follow a novel approach in our exercise. Our approach is similar to Christie *et al* (2005), but by using microdata in the analysis, we can relieve the assumption that tax evasion is uniform across all income groups and explore differences between population groups. We match the administrative tax records with the Household budget survey income and construct a reported income distribution in the survey. By comparing the reported income to true income in the survey, we can analyse the distributional effects of income underreporting. This chapter provides results concerning the extent and distribution of income tax evasion.

We find that the average rate of underreporting is 18%, although this ranges from around 64% among the self-employed to 4% among employees. Similarly to Bloomquist (2003) and Johns and Slemrod (2008), we find that tax evasion is U-shaped; it is the highest among low and high income groups, whereas the most compliant are middle income taxpayers. Tax evasion reduces personal income tax payment by about 20%, increases income inequality and reduces the progressivity of the tax system.

The chapter is structured as follows. Section 2 briefly reviews the literature on tax evasion and its measurement. Section 3 presents the data; Section 4, the methodology; Section 5, the main findings; and Section 6, the distributional implications. Finally, Section 7 presents our conclusions.

3.2 Literature

Theoretical models demonstrate that, apart from other aspects, an evaluation of tax evasion is essential from the perspective of redistribution, since evasion modifies the redistributive effect of tax progressivity (Freire-Serén and Panadés, 2008). As Persson and Wissén (1984) emphasize, tax evasion can render counterproductive those policies that aim to reduce income inequality.

Measuring tax evasion might appear straightforward: just compare tax returns and tax audit data (if we manage to account for the fact that audits tend not to be random). Tax audit data can provide detailed information on non-compliance, which can be further enriched if linked to census data (Beron *et al,* 1992). However, as Slemrod (2007) states, measuring tax evasion is not at all straightforward even if we have data on successful audits. Tax audits cannot necessarily detect all unreported income, but even if they do, it is very difficult to distinguish whether underreporting was willful or inadvertent. Sometimes, it is just as difficult to decide if it was legal or illegal. However, in most countries (including Hungary), researchers do not even have access to such audit data.

Alternative methods for estimating tax evasion are based on income surveys, on consumption data, or on discrepancies in economic statistics. The two former approaches require access to tax records – something that may not be possible in many countries. Studies that compare incomes as reported in administrative tax records and in income surveys assume that tax evaders have no incentive to conceal their true income when responding to an income survey (e.g. Fiorio and D'Amuri (2005) for Italy and Matsaganis and Flevotomou (2008) for Greece). Consumption-based studies argue for the use of data on the share of, for example, expenditure on food, on the assumption that the self-employed and employees have the same preferences regarding food (Pissarides and Weber, 1989; Lyssiotou *et al.*, 2004). As an alternative, discrepancies in economic statistics can also provide information on tax evasion. This approach could include a comparison of actual tax revenue and the national accounts (which include estimates of the informal economy and partly also of the illegal economy), or it could be based on macro studies related to the informal economy (e.g. Schneider and Enste, 2000; Schneider and Klinglmair, 2004)[2].

The share of the 'underground economy'[3] is quite high in Hungary compared to other European countries, and was estimated at 25% in 1999–2000 (Schneider and Klinglmair, 2004). This situates the country in a group of high evaders, alongside other

[2] On the problems of measuring the underground economy in transition countries, see Hanousek and Palda (2004).
[3] The 'economic underground' (our focus in this paper) consists of activities that are productive in an economic sense and quite legal, but that are deliberately concealed from the public authorities in order to avoid the payment of taxes or social security contributions. It includes underreporting of production (understating revenue or overstating costs) and also deliberate non-registration (of whole enterprises or parts of a registered enterprise). For a discussion of the concepts and their definitions, see the 1993 System of National Accounts and the OECD Handbook for the Measurement of the Non-Observed Economy.

former communist countries, as well as such Mediterranean countries as Greece and Italy.

The calculations of Christie *et al* (2005) provide a recent assessment of comparative evidence concerning the extent of tax evasion. The fundamental assumption in their study was that tax evasion is uniform across all income groups -- they had no access to individual tax records. This chapter casts doubt on this assumption by exploring differences between population groups. Christie *et al* (2005) found that PIT compliance was 70% (see Table 3.1) in Hungary in 2002.

Table 3.1. Income tax evasion in European countries

Country	PIT compliance, %	PIT theoretical effective rate, %	Year
Austria	75	19.0	2003
Belgium	70	25.4	2002
Czech Republic	77	12.1	2003
Estonia	56	21.6	2003
France	60	16.5	1999
Germany	75	17.7	2002
Hungary	**70**	**21.1**	**2002**
Italy	62	22.7	2002
Latvia	45	18.9	2002
Netherlands	73	13.3	1998
Poland	66	18.6	1998
Portugal	68	12.1	2002
Slovakia	56	11.2	2002
UK	78	16.9	2002*

*Note: *UK fiscal year: 6 April 2002 – 5 April 2003.*
Source: Christie et al. (2005)

There are a number of empirical studies that focus on income underreporting in Hungary. Semjén *et al* (2008), using attitudinal survey questions, find that about 15% of all respondents received a share of their income as cash in hand, while 14% received part of their wage income as enterprise income. Altogether, 26% of respondents evaded some part of their income tax in 2006 and 2007. Elek *et al* (2009) put the share of unregistered employment at 16–17% of the labour force, basing this estimate on a comparison of administrative (pension insurance registry data) and survey data for 2001–04. Elek *et al* (2009) find that, in 2003, some 50–60% of those who reported a minimum wage in fact underreported their income, and received on average about a third of their actual income as ‘envelope wages’.

3.3 Data

Our estimation of income underreporting is based on two datasets: a random sample of unaudited administrative tax records and the nationally representative Household Budget Survey (HBS) of the Hungarian Central Statistical Office. Both contain data on 2005 incomes.

The sample of administrative tax records (also referred to as ‘APEH’, reflecting the name of the tax authority) includes 227,688 individuals, or about 5.4% of all taxpayers in the country.[4] The data refer to annual incomes from 2005. The sample size falls to 217,530 in the sample used for analysis. We top-coded the dataset by excluding those taxpayers who had income (any type of income) above the highest value in the survey data.[5] We also excluded taxpayers with zero taxable income.[6] The tax records include certain socio-demographic characteristics of individuals, including age, sex, post code and, for a smaller sub-sample, the number of dependants and occupation.

The HBS dataset includes 24,549 individuals in 9,058 households. The number of individuals falls to 9,270 if we select only taxpayers and use only the working-age population. Income data are collected from household members aged 16 and over; demographic information is available for all members. The income reference period is the calendar year 2005.[7]

[4] There were 4.4 million taxpayers in 2005, or 44% of the total population. Of those, 4.2 million were taxed under the progressive tax system (APEH 2006). This latter is our reference population.
[5] So as to eliminate outliers from the tax audit data, we excluded taxpayers with a total income tax base of over 26.88 million Hungarian forints (HUF), wage income of over 19.67 million HUF, self-employment income of over 24 million HUF and other taxable income of over 7.21 million HUF. The number of these excluded observations is not substantial, altogether making up about 0.2% of the sample.
[6] We use a broad definition of taxable income, including income subject to the progressive tax scheme and separately taxed self-employment income (tax base of the Simplified Business Tax is not included). Note that other separately taxed income, such as capital income, is not included in the analysis.
[7] According to the National Statistical Office, high-income households are underrepresented and low-income households are overrepresented in the HBS, and therefore average income is somewhat underestimated by the HBS (KSH 2004: 29).

Crucially, the results of the analysis depend on the extent to which the two datasets are comparable in terms of both the target population and income. Our first step, therefore, was to assess actual comparability.

The main differences between the survey data and the administrative data are as follows: (i) HBS is based on voluntary participation, whereas it is a legal requirement for anybody with taxable income to file a tax return; (ii) there may be under-sampling of high-income households in the HBS due to non-response, which would lead to underestimating of top incomes and of the extent of inequality; (iii) incomes in the HBS are self-reported; thus, there may be recall errors (respondents not remembering correctly).

These features are common to all surveys, but the extent of these biases is hard to assess. A study of Kézdi (1998) using the Income Survey of 1997 assessed the validity of survey income by comparing self-reported earnings to incomes reported by the employees considered to be true income. He found that the average of the self-reported measures was 20% lower than that of the true income, and the difference was the highest for high income groups, and the variance was also smaller by almost 30%. The inequality of incomes measured by the Gini coefficient was also smaller within the self-reported incomes, mostly explained by the lower self-reporting rate of higher income individuals. As a result, the kurtosis of the distribution was higher for self-reported measures, and distribution was skewed to the left. However, Kézdi (1998) notes that differences within groups were not systematic. A comparative study of the self-reported HBS and the administrative tax returns data has not yet been conducted.

Molnár (2005) had access to the pre-imputed information of the HBS and compared them to the imputed and published dataset. He found that data was imputed for about 6-6,5% of households, which is problematic, as most households where incomes were imputed belonged to the first or tenth deciles after imputation.

Although these studies make the user ambiguous about the HBS, this is the only reliable source of Hungarian households' self-reported income with sufficient sample size and detailed information about demographic characteristics. Therefore we decided to base our analysis thereon.

To assess the aggregate reliability of the incomes in the HBS, we checked it against the official statistics of the National Statistical Office. The total gross employment income of households in the HBS is 9.280 billion HUF for 2005, whereas the official statistics for the gross employment income of households is 10.096 billion HUF (total minus the income of those living in non-profit institutions), which shows a gap of about 8%. Throughout the paper we assume that the income reported in the survey equals true income and base our results on this assumption. However we shall return to the implications of the possible failure of this assumption when discussing our results.

The HBS and the APEH data are similar in certain crucial respects: (i) both include personal incomes with reference to the calendar year 2005, and incomes given are annual incomes (rather than, say, monthly); (ii) information on gross income is available in both; (iii) both datasets include basic demographic information on respondents, including sex, age, region of residence and employment status (employee or self-employed). These features mean that the two datasets are, in fact, comparable.

We created a comparable reference population in the two datasets by (1) ensuring that the tax record sample was representative and (2) reconciling the taxpayer population identified in the two datasets.

First of all, we reweighted the tax record sample on the basis of aggregate data on the entire population of taxpayers.[8] The weights were calculated on the basis of region and employment status.[9]

Second, the reweighted tax sample had to be reconciled with the HBS by restricting the latter sample to taxpayers. We thus reduced the HBS sample to those who had positive taxable income and stated that they had filed a tax return. This provides a good approximation of Hungarian taxpayers, because in 2005 most social incomes – including pensions, universal family benefits and other cash transfers – were tax exempt, unreported to the tax authorities. It also implies that pensioners are only

[8] The data we used form part of a panel dataset of 2004–05, representative of the total taxpayer population of 2004. Since the taxpayer population changed somewhat from one year to the next, we reweighted the sample, based on 2005 aggregate data on the number and characteristics (region and employment) of taxpayers.
[9] Our aim was to ensure that the distribution of employed and self-employed across regions was the same in the sample as in the original population. Thus we calculated the weights separately for the employed and the self-employed by region.

included if they had employment income (besides pensions). The pension, however, remained tax exempt in this case.

The definition of income compared in the two datasets is 'gross personal taxable income'. It is gross (i.e. before tax); it is personal rather than at household level; therefore, it adequately reflects the individual-based Hungarian taxation system; and it is taxable (i.e. it refers to positive income that is subject to tax). As pensions and benefits were exempt from tax, we did not include them in our definition of taxable income. Note that capital income other than self-employment income is not included in the definition of income used here.[10]

3.4 Methodology

We seek to assess the distributional implications of income tax evasion, which is a result of the underreporting of income to tax authorities. In order to assess this effect, we need to compare the distribution of True Incomes[11] and the distribution of Reported Incomes. Our definition of True Income includes (a) income that is not reported to the tax authority and is thus exempt from tax and (b) those income components that are liable to tax and are reported to the tax authority. We assume that True Income is revealed in the income survey (HBS), and Reported Income is reported to the tax authority.

The main methodological problem, however, is that there is no single dataset that includes both the True and the Reported Income of individuals: official tax return data contain no information on undeclared and tax-exempt income, and cannot, therefore, capture True Income; meanwhile, the survey data have no reliable information on Reported Income. Therefore, the joint distribution of the two income measures is unobservable.

Our estimation strategy is as follows: we impute individual Reported Income from tax return data to HBS by statistical matching, calculate average Reported Income as a

[10] Evasion of capital income might be an interesting research question, but most of this income is not included in the Household Budget Survey – probably because accurate measurement is not easy.

[11] As in Smeeding and Weinberg (2001), we use the expression 'true income' in the sense that it accounts for the impact of the black economy (a national accounts perspective). Note that we are not able to correct for measurement error in the survey – including, for instance, the non-voluntary non-reporting of income components (e.g. not inquired about or forgotten) (Atkinson *et al*. (1995) use 'true income' in this way).

function of individual characteristics, and then use these results to predict Synthetic Reported Income in the survey data.

The common set of individual characteristics, (X_i), that we can use for matching is limited. We have only three categorical variables: age group, gender, region, and information on income of the individual. Of course, there are other characteristics that correlate with tax evasion (for example schooling, occupational sector or household characteristics), but these are not observed in the APEH dataset and, therefore, cannot be used for matching.

Using only region, gender and age group (in addition to the source of income) for matching would not capture the dispersion of reported income within 'cells', that might distort distribution, and results in a matching of poor quality, where a substantial part of the variation in tax evasion would not be captured. To overcome this problem, we also included income dimension to the imputation by calculating quintiles for all groups in both datasets.

The method is the following. Using the three categorical variables available, we define 56 (4*2*7) subgroups ('cells'). For each of these groups we calculate group quintiles, where possible (or group average where the number of observations does not allow the categorisation into quintiles), and for each quintile calculate average Reported Income from the tax return data, and average True Income from the HBS. Thus, we impute quintile specific average income for each member of the given quintile within each 'cell', where it was possible.[12] Although this way we could ensure that the dispersion of incomes within 'cells' is also regarded, this method relies on the assumption that people do not re-rank within 'cells' as a result of underreporting. Including the group quintiles as a matching variable significantly improves the quality of the matching. In Chapter 3.5, we will present evidence for this. As a last step we define adjustment factors ($a_{j,k,l,q}$) for each quintile (or group) by dividing the average Reported Income by the average True Income.

$$a_{j,k,l,q} = \overline{y^r_{j,k,l,q}} \Big/ \overline{y_{j,k,l,q}}$$

[12] For those 'cells' where the number of observations wasn't sufficient to rank people in quintiles we allocated the 'cell' average instead of the quintile averages. The number of observations did not allow the categorization into quintiles for the self-employment income and other income. For wage income we could not allocate quintiles for females in the agegroup of 60-65 for Central Transdanubia, West Transdanubia, South Transdanubia and the North Great Plain, this is 4 groups out of the 56.

j = Age1, Age2, Age3, Age4 k = M, F l = H, C, W, S, N, G, P q=1, 2, 3, 4, 5

where:

> Age1 = 16–29 years, Age2 = 30–44 years, Age3 = 45–59 years, Age4 = 60–65 years
> M = male, F = female
> H = Central Hungary, C = Central Transdanubia, W = West Transdanubia, S = South Transdanubia, N = North Hungary, G = North Great Plain, P = South Great Plain
> q=quintile within the cell

We calculate adjustment factors separately by source of income, such as wage income, self-employment income and other taxable income.[13]

In the HBS, there is some measurement error with respect to income; therefore, the income of specific subgroups might be higher than in the tax records. To correct for this error, we top-code adjustment factors to 1, and do not allow for over-reporting.[14] We also check the sensitivity of the estimates to top-coding by carrying out all calculations with both sets of the adjustment factors (with and without top-coding), but regard the top-coded results as our baseline scenario.

We then use the adjustment factors to estimate the individual Synthetic Reported Income in the HBS: $y^r_{g_i} = a_g * y_{g_i}$, where y^r is Reported Income, y is True Income, g = j,k,l,q stands for the groups above and g_i is individual i of group g.

[13] (1) Wage income refers to employees and all their employment-related income that is part of the tax base. This also includes insurance-based maternity benefits. (2) Self-employment income is the sum of wage income from self-employment and other income from self-employment, e.g. dividend income. (3) Other taxable income is the sum of all other incomes that are part of the taxable income (e.g. income from intellectual activity) except capital and other types of income that are separately taxed.

[14] Instead of top-coding another option could have been to set the True Income to the Synthetic Reported Income where the adjustment factor shows overreporting. However this way a systematic bias would have been introduced in the analysis by only correcting true income for certain cells. Therefore we decided not to do the correction of true incomes but take them as reported.

After creating the individual Synthetic Reported Incomes in the HBS, we use a tax–benefit microsimulation model to calculate tax liabilities based on the tax function[15] and sum up net incomes of the household members to get (post-tax) disposable incomes.

$$z_h = \sum_{i=1}^{n_h} \left(y_i - T\left(y_i \right) + s \right)$$
$$z_h{}' = \sum_{i=1}^{n_h} \left(y_i - T\left(\hat{y}_i^r \right) + s \right)$$

where

z_h is post-tax disposable income of household h

y_i is individual True Income observed in the survey data

$\hat{y}_i^r$ is the estimated Synthetic Reported Income

$T(.)$ is the tax function

s is the tax-free social income

For each household (h), we sum up the individual members of the household as (i = 1, ..,n_h).

Thus, we get two disposable income measures: for the first, z_h, we assume that individuals pay tax based on their true income, for the second, $z_h{}'$, we assume that they only pay tax on their reported income. As a result, we can compare the two distributions of household disposable incomes: $F(z)$ and $F(z')$.

Our estimation may be biased for several reasons:

(i) For each member of group g, we assume the same ratio of underreporting and therefore, underestimate the variability of z'.[16] However the more groups we define, the

[15] On the features of the Hungarian tax policy see Appendix B.

[16] Instead of assuming that tax evasion is uniform within each group and doing some linear transportation, we could assume some more complicated functional form of tax evasion – for example, that under some threshold there is no tax evasion – and do binary choice modeling. However, based on other empirical studies, we suspect that tax evasion is more complex in Hungary – i.e. tax evasion is more common at the low- and the high-income levels and less acute at middle-income levels, since civil servants (who are typically found in the middle of the distribution) tend to evade relatively little. We would need a multinomial probit estimation or some other complicated modeling to capture tax evasion behaviour within each group. The problem we face here is the small number of observations in the HBS and the small number of individual characteristics we observe in the tax return data. Nevertheless, modeling the functional form of tax evasion could be a subject for future research.

greater the standard errors of our adjustment factors (a_g) will be. There is a trade-off between these two: the more groups (g) we define, the smaller will be the first variance, but the greater will be the second. The direction of the bias will depend on the sign of the covariance of underreporting of true income in the HBS and the tax evasion measure (i.e. cov(true income – reported true income in the HBS; evasion). If underreporting in the HBS correlates with tax evasion, then our estimates will be biased upwards. If, however, underreporting in the HBS is not systematic and this covariance is negative, then the estimates will be downward biased.

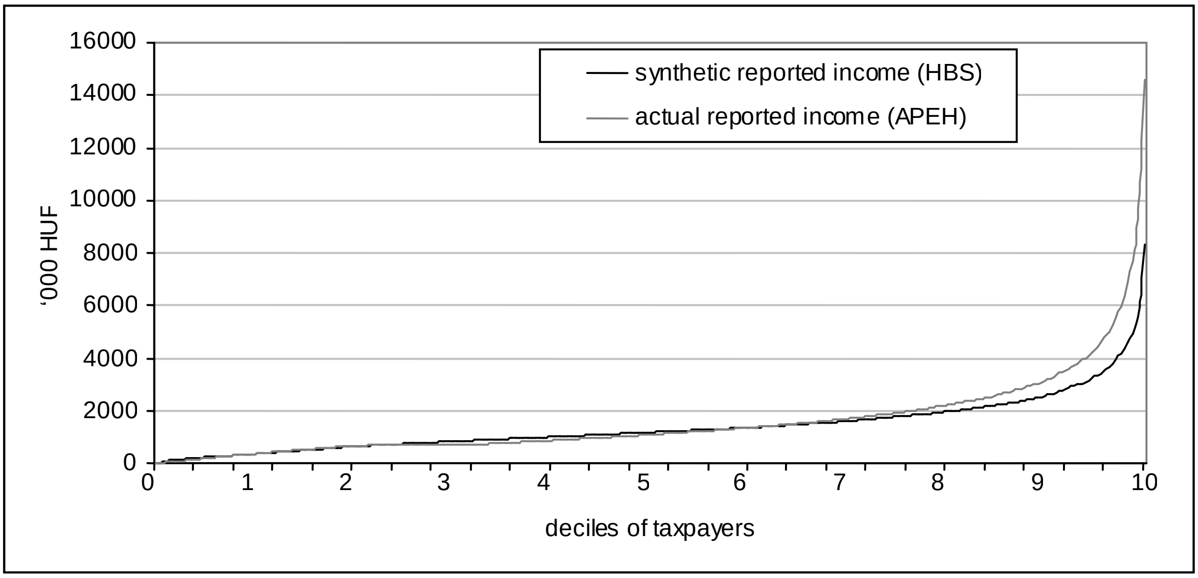
(ii) Our results crucially depend on the assumption that tax evaders reveal their true income in the income survey (HBS). Some papers (e.g. Fiorio and D'Amuri 2005) argue for this assumption; others, especially those who use the consumption-based approach to estimate income underreporting (e.g. Pissarides and Weber 1989; Lyssiotou *et al* 2004), suppose that income in surveys is underreported. But even these studies use a group of individuals as a reference population and assume that this reference population does not underreport survey income. Normally, the reference population is the employed, and researchers calculate income underreporting among the self-employed in comparison. We assume that survey incomes are 'true' in the sense that there is no financial incentive to conceal income in an anonymous survey.

However we should recall that Kézdi (1998) and Molnár (2005) found incomes to be underreported in Hungarian household surveys, Kézdi (1998) estimated this underreporting to 20%. Should income be partly concealed in the HBS our figures for underreporting will be lower bound estimates. If high income individuals conceal a greater share of their income, as Kézdi (1998) found, the estimated underreporting will be more downward biased for these high income groups.

Another issue is the correlation of measurement error between household members. Although we cannot use information on the household in the imputation, underreporting is likely to be correlated across household members. If individual income of household members are similar then the bias will essentially the same as presented. However if household members have different individual incomes, e.g. the head of household belongs to the top while his or her spouse to the low or middle income groups, then this omitted information will cause further biases. Depending in the actual structure of the intra-household income distribution the bias in the middle income groups might be higher and proportionately the difference between the high, and the low/middle income groups might be smaller then suggested above.

(iii) The two datasets contain data from different individuals who only share a few characteristics. Although we have two random samples of the same underlying population, there is sampling error in both datasets, which will bias our results. As already discussed above, the HBS sample underestimates the aggregate gross employment income of the population by about 8%. The APEH dataset is a 5% sample of the total taxpayer population; therefore, the sampling error is significantly smaller. In fact, we did not find a significant difference between the aggregate and the sample based aggregate income measures. Since the True Income measures based on the HBS are probably underestimated the calculated underreporting will be downward biased.
The distribution of the Synthetic and the actual Reported Income of taxpayers is shown in Figure 3.1. The synthetic distribution overlaps with the distribution of Reported Income coming from the APEH dataset for the bottom eight deciles, but, as expected, it underestimates the actual distribution of taxable income among high-income taxpayers. The average Reported Income, Synthetic Reported Income and the corresponding confidence intervals by region, gender and age group are presented in Appendix D. When comparing the reported income measures based on the two datasets we see that in the not-topcoded case most p-values are high: in 34 out of the 56 groups the p-value is 90% or more (for 44 out of the 56 groups the p-value is above 80%). For these groups we cannot reject the hypothesis that the HBS and the APEH group averages are equal. For the top-coded case however the p-values are significantly lower. It is only 5 groups out of the 56 where the p-values are above 80%.

Figure 3.1 Distribution of the synthetic (HBS) and actual (APEH) reported income



Note: own calculations based on 2005 HBS and APEH tax returns.

(iv) Choice of functional form of tax evasion might also bias our results. We assume that tax evasion is uniform within each group that is a linear transportation in essence. Based on other empirical studies, we suspect that tax evasion is more complex in Hungary: i.e. tax evasion is more common at the low- and the high-income levels and less acute at middle-income levels, since civil servants (who are typically found in the middle of the distribution) tend to evade relatively little. However, the small number of observations in the HBS and the small number of individual characteristics we observe in the tax return data does not allow a more complex modeling of the tax evasion function within cells without increasing the standard errors of the adjustment factors to a very high degree. The possible implications of the greater share of underreporting of high income individuals have been discussed under point (ii).

3.5 Results: Extent of under-reporting

According to our calculations, income underreporting runs at 8-18% on average (see Table 3.2). The extent of income underreporting varies across income groups, but is at its highest in the three poorest deciles (ranging from 17% to 27%) and in the richest decile (21%). Thus, the poor benefit most from income tax evasion in proportion to their income, while the rich benefit most in purely monetary terms.

Table 3.2. Underreporting of taxpayers by level of income under different specifications

Income decile of taxpayers by True Income	True Income	Rate of underreporting	
		(1) Underreporting not top-coded	(2) Underreporting top-coded
1 (poorest)	302	-17%	17%
2	696	17%	24%
3	899	17%	21%
4	1075	17%	19%
5	1250	14%	18%
6	1436	13%	18%
7	1693	9%	14%
8	2020	3%	13%
9	2578	1%	14%
10 (richest)	4574	6%	21%
Total	*1691*	*8%*	*18%*

Notes:
Underreporting = (True Income - Reported Income)/True Income
*Reported Income = Adjustment Factor * True Income*
Top-coded means that adjustment factors are maximized to 1, not allowing for income over-reporting.
Mean income by income group is annual gross personal income in thousand forints. True Income is as observed in the HBS dataset. Income quantiles of taxpayers were generated on the basis of True Income, excluding those earning zero or negative incomes.

We used two different sets of adjustment factors. First, we allowed the income of certain subgroups to be higher in the tax records than in the income survey (‘not top-coded’). Second, we top-coded our adjustment factors to 1 and did not allow over-reporting (‘top-coded’).

We find that underreporting is quite different for different population groups. The self-employed[17] tend to underreport the most: about two-thirds (65%) of their income is not reported as a tax base to the tax authority. By contrast, employees generally comply with tax rules, with an overall rate of underreporting of 4% (Table 3.3). Other income is underreported by 8%. These results are in line with, e.g., Slemrod (2007), who reported that based on tax audit data, non-business income in the US was underreported by 4%, whereas business income on average was underreported by 43%. Within this latter the nonfarm proprietor income underreporting was 57%.

Underreporting is highest in the highest-income region – Central Hungary (including the capital, Budapest). One explanation for this might be the region's greater share of economic sectors that are particularly prone to tax evasion: much of the construction industry and the service sector are to be found in and around the capital. In terms of underreporting, Central Hungary is followed by a rich region (West Transdanubia) and a poor one (South Great Plain). The rates for underreporting are 12%.

Tax evasion is higher among men, which is likely to be associated with differences in risk aversion: women are usually more risk averse, which reduces income underreporting. Our calculations also show that men underreport both wage income and self-employment income more than women do. We also found that the elderly (especially those around retirement age) underreport more than younger age groups do.[18] A study of the situation in Estonia (Kriz *et al* 2007) came up with similar findings: men and the elderly are more likely to evade payroll and income taxes. Basing his investigation on a specific survey in Hungary, Tóth (2008) also found that men tend to underreport wages more than women do.

[17] We define the self-employed as those who earned at least 1 HUF from any kind of self-employment in the reference period.
[18] The difference between the rates of underreporting by age groups is statistically significant.

Table 3.3. Underreporting by main source of income, region, age and gender

	Population share	True Income	Synthetic Reported Income	Underreporting
Main income source				
Wages/salaries	90%	1630	1569	4%
Self-employment	10%	2490	883	65%
Region				
Central Hungary	31%	2189	1802	18%
Central Transdanubia	11%	1507	1391	8%
West Transdanubia	12%	1646	1441	12%
South Transdanubia	7%	1432	1305	9%
North Hungary	12%	1468	1390	5%
North Great Plain	13%	1440	1315	9%
South Great Plain	14%	1529	1341	12%
Gender				
Male	50%	1946	1615	17%
Female	50%	1488	1385	7%
Age group				
16–29	18%	1299	1175	10%
30–44	39%	1766	1516	14%
45–59	41%	1850	1631	12%
60–65	2%	1867	1474	21%

Notes:
Underreporting = (True Income - Reported Income)/True Income
*Reported Income = Adjustment Factor * True Income*
Here we present results for the case where adjustment factors are top-coded. Top-coding means that adjustment factors are maximized to 1, not allowing for income over-reporting.
Mean income by income group is annual gross personal income in thousand forints. True Income is true taxable income as observed in the HBS dataset.

Comparison of results with and without group quintiles as matching variable

As mentioned in the Methodology, it is not straightforward whether including the quintiles within the 56 cells as a matching variable is necessary. Although in general it is better to include more matching variables, however if the more variables do not significantly improve the quality, then only extra noise is added to the estimation. Therefore it is essential to check if adding the income information to the matching improves the quality.

First, Table 3.4 compares income underreporting with and without using the income quintile information as a matching variable. In the first two columns underreporting is presented by income deciles when only the region, age group and gender variables are used for matching, and in the last two columns we present our baseline case, where also group quintile information is used.[19]

Average income underreporting is somewhat different if we leave out the quintile averages as a matching variable. In the top-coded specification, the difference is substantial: 13% versus 18% of underreporting whereas for the not-topcoded case the difference is rather small: 9% versus 8%. The distribution of underreporting by income levels changes substantially if we include the quintile averages as a matching variable. It lowers underreporting in the bottom two deciles from 25-30% to 17-24%. Underreporting becomes higher in the middle income groups: from 8-14% to 13-19%. In the 8-9 deciles, underreporting again becomes lower when including the quintile averages from 8-13% to 1-14%. Including quintile averages has a different effect on the distribution of underreporting in the top-coded and not-topcoded cases.

Although the magnitude of underreporting is somewhat different in the deciles with the two sets of matching variables, the main finding that income underreporting has a U-shape (highest for the low and high income groups) remained unchanged.

[19] Recall that within-group quintiles can only be used as a matching variable for the wage income as for self-employment and other income the number of observations is insufficient.

Table 3.4. Underreporting of taxpayers by level of income

Income decile of taxpayers by True Income	Rate of underreporting – using region, agegroup and gender for matching		*Rate of underreporting – using region, agegroup, gender and group quintiles for matching*	
	(1) Underreporting not top-coded	(2) Underreporting top-coded	*(1) Underreporting not top-coded*	*(2) Underreporting top-coded*
1 (poorest)	26%	30%	*-17%*	*17%*
2	25%	29%	*17%*	*24%*
3	14%	18%	*17%*	*21%*
4	10%	14%	*17%*	*19%*
5	9%	13%	*14%*	*18%*
6	8%	12%	*13%*	*18%*
7	9%	13%	*9%*	*14%*
8	8%	12%	*3%*	*13%*
9	10%	13%	*1%*	*14%*
10 (richest)	13%	16%	*6%*	*21%*
Total	*9%*	*13%*	*8%*	*18%*

Notes: Underreporting = (True Income - Reported Income)/True Income
*Reported Income = Adjustment Factor * True Income*
Top-coded means that adjustment factors are maximized to 1, not allowing for income over-reporting.
Mean income by income group is annual gross personal income in thousand forints. True Income is as observed in the HBS dataset. Income quintiles of taxpayers were generated on the basis of True Income, excluding those earning zero or negative incomes.

As Tables E.1 and E.2. in Appendix E shows in case of adding the group quintiles as a matching variable, the adjustment factors display substantial heterogeneity between the 56 cells (by region, gender and age group). The average distance between the adjustment factors in the lowest and the highest income quintiles are rather different by the 56 groups. It varies between 0 and 8,7 for the not top-coded case and between 1 and 7,2 for the top-coded case. On average, it is the lowest in North Hungary (1,45) and highest in Central Hungary (3) for the not top-coded case (lowest in North Hungary and highest in South Great Plain for the top-coded case). It shows that the inclusion of this information captures a great heterogeneity in the sample therefore it is an important matching variable. We can conclude that, although the main findings are robust to the exclusion of this matching variable, the quality of the matching is significantly improved by the inclusion.

3.6 Results: Distributional implications

In order to reveal the effects of tax evasion on progressivity and the distribution of incomes, we use a tax–benefit microsimulation model[20] that takes into account interactions between the elements of the tax and benefit system and household members. The total Synthetic Reported Income for each individual comprises the sum of the synthetic reported wage income, synthetic reported self-employment income and synthetic reported other income.

Although income underreporting happens at the individual level due to the personal income tax system, the effects on the income distribution can only be measured at the household level. Total household disposable income depends on the true income of each household member. Income underreporting as such modifies total household income, but the impact is largely dependent on the tax system and on the system of cash benefits. The use of a tax–benefit model allows us to take account of the complexity of the tax system, including the fact that only some income components are subject to tax as well as the potential interaction between specific cash benefit and tax policies (benefit entitlements may also change as a result of tax evasion).

As was discussed in the section on methodology, we aim to estimate the effect of tax evasion on the distribution of disposable 'net income'. We calculate net income thus:

$$z_i = y_i - T\left(y_i^r\right) + s$$

where z_i is total personal disposable income for individual i; y_i is individual True Income; y_i^r is Reported Income; $T(.)$ is the tax function; and s is the tax-free social transfers received by individual i. We then sum up net incomes of the household members to get (post-tax) disposable incomes:

$$z_h = \sum_{i=1}^{n_h}\left(y_i - T\left(y_i^r\right) + s\right)$$

[20] For simulation purposes, we use some of the Stata algorithms of HKFSZIM, a microsimulation model that was developed and programmed in the Ministry of Finance and the Office of the Fiscal Council. We programmed the 2005 Hungarian tax and benefit rules. We use HBS as representative data for the population.

Note that, in Hungary, social transfers (s) are untaxed – with the exception of insurance-based maternity benefits, which are included in labour income.

We now present the findings of our microsimulation. In this section, we model all major direct tax and cash benefit policies in 2005 and consider their interactions, based on the HBS. Using our adjustment factors for income underreporting, we are able to assess the impact of tax evasion on household incomes and their distribution (against the hypothetical counterfactual of full compliance).

Table 3.5. Fiscal and distributional implications of tax evasion

		Underreporting not top-coded		Underreporting top-coded	
	Full compliance	Tax evasion	Difference	Tax evasion	Difference
Average equivalised PIT payment by households (HUF, annual)	209 897	192 801	-8,1%	167 083	-20,4%
Poverty line (HUF, monthly)	46 649	46 713	0,1%	47 524	1,9%
Poverty rate (FGT a=0)	0,11	0,11	1,5%	0,12	5,7%
Poverty gap (FGT a=1)	0,03	0,03	2,4%	0,03	4,0%
Gini	0,26	0,27	3,7%	0,28	6,7%
P90/P10	3,17	3,21	1,2%	3,37	6,3%
P75/P25	1,79	1,79	0,2%	1,82	1,6%
P90/P50	1,83	1,85	1,0%	1,92	5,0%
Atkinson e=0.5	0,06	0,06	10,1%	0,07	15,2%
Atkinson e=2	0,22	0,23	4,8%	0,24	9,0%
Kakwani	0,33	0,32	-0,2%	0,31	-5,2%
Reynolds-Smolensky	0,07	0,05	-20,6%	0,04	-46,2%
Suits	0,37	0,36	-2,2%	0,34	-8,1%

Notes: full compliance provides estimates of income tax variables, assuming that true incomes as observed in the HBS are reported to the tax authorities. Tax evasion provides estimates of the same variables, assuming incomes are underreported to the tax authorities by the adjustment factors (region, sex, etc.). FGT refers to the Foster Greer Thorbecke family of poverty indices.
Income concept: equivalized household income, annual.
For a detailed description of the above measures see Appendix A.

The limitations of our model are that, for specific income types, the number of observations is very small; for some others, there are measurement errors (e.g. property incomes, agricultural incomes, intellectual activities). Certain specific tax rules (especially tax credits) are simplified in the model, as there is no adequate information in the HBS (e.g. on donations to charities). These modelling features are unlikely to affect the estimated implications of tax evasion, since the expectation is that they have a similar impact on the results under both the full compliance scenario and the tax evasion scenario.

If underreporting increases by income, the statistical matching procedure that we follow somewhat dampens the distributive effects of underreporting. In order to minimise this effect, we have included the income quintiles within cells as a matching variable and took account of the increasing rate of underreporting with income.

The fiscal implications of tax evasion are substantial: the average PIT burden of households is 8–20% lower because of income underreporting.

Income inequality and poverty are significantly higher with tax evasion. The Gini coefficient increases by 4–7% and the P90/P10 ratio by 1–6%. Similarly, the Atkinson index rises for both alternative values of the inequality aversion parameter.[21] The poverty line rises by around 2%, whereas the poverty rate and poverty gap increase by about 2-6%.

Tax evasion reduces the progressivity of the income tax system quite substantially. The Kakwani and the Suits indices indicate a decline of up to 8%, while the redistributive effect of the tax system as measured by the Reynolds-Smolensky index falls significantly as well. In these calculations, we consider the impact of both personal income taxes and social security contributions – in other words, all taxes on labour at the employee level. The fall in progressivity is a consequence of the relatively higher level of income underreporting among high-income groups (as we indicated earlier, the underreporting of low-income groups is higher than average, but most of these are taxed at a low or zero effective tax rate).

We have the revisit the problem of underreporting in the HBS when evaluating the results. Recall that Kézdi (1998) estimated that underreporting in a household survey was around 20% in 1997. Both Kézdi (1998) and Molnár (2005) concluded that underreporting was higher in high income groups. If these problems are present at the 2005 HBS then income underreporting is in fact greater than the estimated 8-18% calculated by our method. Should underreporting in the HBS be still around 20% than

[21] Note that the extent of the change is greater when the inequality aversion parameter is smaller (e=0.5), when less weight is attached by society to redistribution to the poor. (The potential range of e is from 0, which means that the society is indifferent to redistribution, to infinity, where the society is concerned only with the position of the poorest income group.)

the estimated total underreporting will increase by this magnitude. However in lack of more recent results it is impossible to tell the magnitude of the bias of our results.

Underreporting in the HBS would also have implications for the fiscal and distributional effects of underreporting. If high income groups underreport more in the HBS, as Kézdi (1998) found, then both the personal income tax gap and the increase in poverty measures and progressivity will increase. Again, in lack of the exact measures the extent of this bias is impossible to estimate, it greatly depends on the relative differences between low, middle and high income groups. However, in this case our results will surely be downwards biased. If we accept Molnár's (2005) finding that misreporting of incomes was the highest among low and high income groups then the implications are more difficult to assess. Since low income groups pay PIT with a low effective rate the PIT gap will still be downwards biased, but the poverty and progressivity implications depend on the relative measures between low and high income groups. If low income groups underreport in the HBS to a higher share than high income groups than the change in poverty rates and progressivity might be lower than our estimates. If high income groups underreport a greater share than low income groups that these estimates will be downward biased too.

Policy implications

We found that income underreporting is highest in the three poorest deciles (ranging from 17% to 24%) and in the richest decile, surpassing income underreporting by middle-to-high income groups. A similar U-shape was found in Greece by Matsaganis and Flevotomou (2008) and in the US by Johns and Slemrod (2008). Note that owing to the progressive tax scheme and tax allowances, the effective tax rate is greater for those with high incomes, while wage income at or around the minimum wage is virtually tax free.

Compared to other countries, estimated tax evasion in Hungary is quite high, but not outstandingly so. In Greece, the tax gap with respect to personal income taxes was found to be 25% (Matsaganis and Flevotomou, 2008). In the USA, the tax gap (taking account of all federal taxes, rather than just income tax, as in our case) was estimated to be 17% in the early 1990s and was found to be relatively unchanged over the previous 20 years (Andreoni *et al*, 1998). A third of US taxpayers were found to underreport their income.

Should Hungarian policymakers turn a blind eye to (or even connive at) the high rate of underreporting in the lowest three deciles? There may be a case based on equity for tolerating tax evasion. 'If the poor had more oppor tunity of evading taxes than the rich, or were better at it […] then the egalitarian policy maker might have good reason to smile indulgently on evasion: up to a point anyway' (Cowell, 1985:185). Note, however, that there is a high share of the self-employed among those with low incomes. According to our calculations, around half of the self-employed have incomes at or below the level of the minimum wage. The self-employed have greater opportunity than wage earners to underreport their incomes, even in countries with high tax morale – a fact that hampers horizontal equity.

An important implication of our findings is that, since tax evasion is not uniform across the various social groups, the tax authorities can target certain groups for audit, thus improving their efficiency. We make no assessment in this study of how taxpayers might react to policy changes.

3.7 Conclusions

This chapter has estimated the incidence of income tax evasion in Hungary using a random sample of the administrative tax records of around 230,000 individuals, not hitherto accessible to researchers. Gross incomes declared in the administrative tax returns are compared with those declared in the HBS (a nationally representative income survey), on the assumption that tax evaders are more likely to report their true income in the course of an anonymous interview. We have estimated income underreporting among those people who declared at least some income to the tax authorities, leaving out those individuals who did not declare any income. The method we have applied provides the first microdata-based estimates for personal income tax evasion in Hungary.

Our estimates show that the average rate of underreporting is 8–18%, though this conceals big variations between the self-employed (who conceal around two-thirds of their income) and employees. Men are more likely to hide their incomes than are women, probably because they are less risk averse than women. The rate of underreporting is found to be highest among taxpayers at the bottom and the top ends of the distribution. Thanks to the progressive tax scheme and tax allowances, the effective tax rate is quite different at the low and high income levels: high-income earners face high effective tax rates, while wage income at or around the minimum wage is basically tax free. Therefore, the similar rate of underreporting implies quite different actual tax payments at the two ends of income distribution. Because of the progressivity of the tax system, evasion by top earners has more of an impact on the state budget.

Using the estimated rates of underreporting, we use a tax–benefit microsimulation model to simulate the tax payment and disposable income of households. We calculate the distributional implications of underreporting by comparing the scenarios of full compliance and tax evasion, taking account all major direct taxes and cash benefits, as well as the way they interact with one another. Tax evasion reduces households' average personal income tax payment of by 8-20%. The poverty rate and income inequality are higher when taking account of underreporting, which shows that high earners tend to evade more in absolute terms. In the scenario that takes account of tax evasion, the progressivity of the tax system is lower than intended.

In the policy debate, tax evasion is often attributed exclusively to the high level of taxes in Hungary, or else to a culture of 'free-riding' by citizens. Policymakers tend to be concerned primarily with the fiscal loss that results from tax evasion. Our results contribute a new aspect to this debate: since effective tax rates are higher for high earners, their income underreporting reduces progressivity. The reduced progressivity of the income tax scheme is likely to alter the social outcomes of the policies pursued, and this may undermine the equity of income redistribution. We have also shown that specific rates of tax evasion vary substantially by social group, and that these differences alter income inequality, poverty and tax progressivity. As long as tax evasion persists, informed policy decisions that seek to promote social welfare need to consider its implications. More knowledge of the magnitude of tax evasion is thus essential if government wishes to evaluate the redistributive effect of taxes, either over time or after certain fiscal reforms.

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Appendix

A. Definitions

Our definition of gross taxable income based on variables in the Household Budget Survey:

<u>Wage income</u>

- Gross income from main employment (munkáltatótól, főállású munkaviszonyból származó bruttó jövedelem)
- Gross income from secondary employment (másodállásból, mellékfoglalkozásból származó jövedelem)
- Maternity benefit (gyed)
- Childbirth benefit (terhességi gyermekágyi segély)

<u>Self-employment income</u>

- Labour income from self-employment (egyéni vagy társas vállalkozásból származó jövedelem (kivét, munkabér címén))
- Other entrepreneurial income that is part of the aggregate tax base (összevont adóalapba tartozó vállalkozói jövedelmek)
- Other entrepreneurial income that is not part of the aggregate tax base (nem összevont adóalapba tartozó vállalkozói jövedelmek)

<u>Other income that is part of the aggregate tax base</u>

- Redundancy pay (végkielégítés összege)
- One-off contract payment (egyszeri megbízásból származó jövedelem)
- Income from intellectual activity (szellemi alkotásból származó jövedelem)
- Tips (borravaló, hálapénz)

All poverty and progressivity measures are calculated using Stata programme by own programming and with the Stata codes

povdeco (http://ideas.repec.org/c/boc/bocode/s366004.html by S. Jenkins)

ineqdeco (http://ideas.repec.org/c/boc/bocode/s366002.html by S. Jenkins) and

progres (http://ideas.repec.org/c/boc/bocode/s456867.html by A. Peichl and P. Van Kerm)

- Poverty line is a relative measure, 60% of the median equivalised household income

- Poverty rate (FGT a=0) is a headcount ratio, the number of persons below the poverty line divided by the number of persons in the total population, a poverty index from the Foster, Greer and Thorbecke (1984) class

- Poverty gap (FGT a=1) measures the mean aggregate income shortfall relative to the poverty line across the whole population, where the non-poor have a shortfall of zero, also a poverty index from the Foster, Greer and Thorbecke (1984) class

- The Gini coefficient is a measure of the inequality of distribution, takes a value of 0 when total equality and 1 when total inequality. It is calculated based on the Lorenz curve measuring the ratio of the area between the line of equality and the Lorenz curve

- P90/P10, P75/P25 and P90/P50 are ratios of percentile measures of the income distribution, P90, P75, P50, P25 and P10 standing for the 90th, 75th, 50th, 25th and 10th percentile respectively

- The Atkinson indices are inequality indices, where in A(e) e is the inequality aversion parameter. The more positive e > 0 is, the more sensitive A(e) is to income differences at the bottom of the distribution.

- The Kakwani index is a measure of tax progressivity defined as twice the area between the taxpayment's concentration curve and the Lorenz curve.

- The Reynold-Smolenski index measures the difference between the Gini coefficients of the pre-tax and the post-tax incomes.

- The Suit index compares the cumulative share of income received by taxpayers, ordered from lowest to highest, to their cumulative share of taxes paid: S = 1-L/K where K denotes the area below the line of proportionality, and L denotes the area below the Lorenz curve of tax payments against income

B. Features of Hungarian tax policy

The income tax system is subject to frequent (mostly annual) change, both to the tax rates and to the tax brackets. Some of this might be explained by the indexation to inflation; but in most cases the changes reflect changing policy priorities, which sometimes focus on raising revenue and at other times on lowering the tax burden.

Table B1. Personal income tax brackets (in HUF) and rates

2003		2004		2005		2006	
Tax bracket	Rate	Tax bracket	Rate	Tax bracket	Rate	Tax bracket	Rate
0–650,000	20%	0–800,000	18%	0–1,500,000	18%	0–1,550,000	18%
650,001–1,350,000	30%	800,001–1,500,000	26%				
1,350,001–	40%	1,500,001–	38%	1,500,001–	38%	1,550,001–	36%

As well as PIT, in 2004 employers had to pay a total of 32% in social security contributions on labour incomes. Employee social security contributions amounted to 13.5%. These rates were relatively stable and remained the same between 2004 and 2006.

Budget revenue from personal income taxes made up 6.6% of GDP in 2005 (European Commission 2007). The Hungarian budget, however, relies heavily on indirect taxes, and in 2005 received some 53% more from VAT than from PIT.[22]

With respect to the distribution of the tax burden in the country: in 2005 about a third of taxpayers paid the higher marginal tax rate of 38% on some of their total income.

[22] Ministry of Finance, Hungary, balance sheet of the central government annual budget. Downloaded on 14 January 2009 from www.pm.gov.hu

C. Descriptive and summary statistics

Table C1. Main characteristics of the taxpayers in the administrative and survey datasets

Number of observations

APEH				HBS			
Region	Employed	Self-empl.	Total	Region	Employed	Self-empl.	Total
Central Hungary	55097	3465	58562	Central Hungary	2463	373	2836
Central Transdanubia	18632	1279	19911	Central Transdanubia	961	86	1047
West Transdanubia	18017	1266	19283	West Transdanubia	990	123	1113
South Transdanubia	21320	1314	22634	South Transdanubia	626	54	680
North Hungary	18977	1148	20125	North Hungary	1067	78	1145
North Great Plain	24161	1650	25811	North Great Plain	1092	101	1193
South Great Plain	21556	1577	23133	South Great Plain	1138	118	1256
Total	177760	11699	189459	Total	8337	933	9270

Share (%)

APEH	Employed	Self-empl.	Total	HBS	Employed	Self-empl.	Total
Central Hungary	29%	2%	31%	Central Hungary	27%	4%	31%
Central Transdanubia	10%	1%	11%	Central Transdanubia	10%	1%	11%
West Transdanubia	10%	1%	10%	West Transdanubia	11%	1%	12%
South Transdanubia	11%	1%	12%	South Transdanubia	7%	1%	7%
North Hungary	10%	1%	11%	North Hungary	12%	1%	12%
North Great Plain	13%	1%	14%	North Great Plain	12%	1%	13%
South Great Plain	11%	1%	12%	South Great Plain	12%	1%	14%
Total	94%	6%	100%	Total	90%	10%	100%

Number of observations

APEH	Employed	Self-empl.	Total	HBS	Employed	Self-empl.	Total
Male	95606	8203	103809	Male	3996	624	4620
Female	108201	5520	113721	Female	4341	309	4650
Total	203807	13723	217530	Total	8337	933	9270

Share (%)

APEH	Employed	Self-empl.	Total	HBS	Employed	Self-empl.	Total
Male	44%	4%	48%	Male	43%	7%	50%
Female	50%	3%	52%	Female	47%	3%	50%
Total	94%	6%	100%	Total	90%	10%	100%

Notes: APEH: administrative data from the tax authority, HBS: Household Budget Survey.

Table C2. Number and share of observations in each cells by the three variables (region, gender, age group) and by employment status in the administrative and survey datasets

HBS		15-29		30-44		45-59		60+		
Employee		Male	female	male	female	male	female	Male	female	Total
	Central Hungary	224	266	430	486	441	563	31	22	2463
	Central Transd.	105	111	160	174	173	225	10	3	961
	West Transd.	108	114	203	178	179	193	11	4	990
	South Transdan.	60	43	123	120	127	144	6	3	626
	North Hungary	85	77	224	206	230	235	6	4	1067
	North Great Pl.	101	113	217	238	170	236	7	10	1092
	South Great Pl.	99	118	235	241	221	206	10	8	1138
Entrepreneur										
	Central Hungary	22	6	106	47	95	80	14	3	373
	Central Transd.	6	1	27	14	27	9	1	1	86
	West Transd.	12	2	35	13	40	20	1	0	123
	South Transdan.	5	2	14	3	22	7	1	0	54
	North Hungary	1	2	20	16	25	14	0	0	78
	North Great Pl.	4	6	35	11	30	13	2	0	101
	South Great Pl.	7	1	30	14	40	22	2	2	118
										9270

		15-29		30-44		45-59		60+	
Employee		male	female	male	female	male	female	Male	female
	Central Hungary	2,42%	2,87%	4,64%	5,24%	4,76%	6,07%	0,33%	0,24%
	Central Transd.	1,13%	1,20%	1,73%	1,88%	1,87%	2,43%	0,11%	0,03%
	West Transd.	1,17%	1,23%	2,19%	1,92%	1,93%	2,08%	0,12%	0,04%
	South Transdan.	0,65%	0,46%	1,33%	1,29%	1,37%	1,55%	0,06%	0,03%
	North Hungary	0,92%	0,83%	2,42%	2,22%	2,48%	2,54%	0,06%	0,04%
	North Great Pl.	1,09%	1,22%	2,34%	2,57%	1,83%	2,55%	0,08%	0,11%
	South Great Pl.	1,07%	1,27%	2,54%	2,60%	2,38%	2,22%	0,11%	0,09%
Entrepreneur									
	Central Hungary	0,24%	0,06%	1,14%	0,51%	1,02%	0,86%	0,15%	0,03%
	Central Transd.	0,06%	0,01%	0,29%	0,15%	0,29%	0,10%	0,01%	0,01%
	West Transd.	0,13%	0,02%	0,38%	0,14%	0,43%	0,22%	0,01%	0,00%
	South Transdan.	0,05%	0,02%	0,15%	0,03%	0,24%	0,08%	0,01%	0,00%
	North Hungary	0,01%	0,02%	0,22%	0,17%	0,27%	0,15%	0,00%	0,00%
	North Great Pl.	0,04%	0,06%	0,38%	0,12%	0,32%	0,14%	0,02%	0,00%
	South Great Pl.	0,08%	0,01%	0,32%	0,15%	0,43%	0,24%	0,02%	0,02%

APEH

Employee	15-29 male	female	30-44 male	female	45-59 male	female	60+ Male	female	Total
Central Hungary	4937	5528	9421	11504	8030	11637	1260	1381	53698
Central Transd.	2178	2094	3563	3465	2990	3565	274	228	18357
West Transd.	2066	2050	3376	3363	3043	3517	240	195	17850
South Transdan.	2353	2621	4137	4439	3086	3942	254	237	21069
North Hungary	2275	2012	3739	3638	2917	3732	269	204	18786
North Great Pl.	2906	2720	4795	4870	3687	4472	294	210	23954
South Great Pl.	2582	2478	4129	4140	3250	4111	332	278	21300
Entrepreneur									
Central Hungary	147	118	672	460	842	671	183	172	3265
Central Transd.	75	39	307	174	336	235	46	33	1245
West Transd.	75	54	312	161	341	215	50	26	1234
South Transdan.	69	47	336	167	352	203	59	38	1271
North Hungary	60	57	282	152	282	201	48	39	1121
North Great Pl.	111	76	390	232	425	269	49	42	1594
South Great Pl.	85	62	346	210	416	280	62	39	1500
									186244

Employee	15-29 male	female	30-44 male	female	45-59 male	female	60+ Male	female
Central Hungary	2,65%	2,97%	5,06%	6,18%	4,31%	6,25%	0,68%	0,74%
Central Transd.	1,17%	1,12%	1,91%	1,86%	1,61%	1,91%	0,15%	0,12%
West Transd.	1,11%	1,10%	1,81%	1,81%	1,63%	1,89%	0,13%	0,10%
South Transdan.	1,26%	1,41%	2,22%	2,38%	1,66%	2,12%	0,14%	0,13%
North Hungary	1,22%	1,08%	2,01%	1,95%	1,57%	2,00%	0,14%	0,11%
North Great Pl.	1,56%	1,46%	2,57%	2,61%	1,98%	2,40%	0,16%	0,11%
South Great Pl.	1,39%	1,33%	2,22%	2,22%	1,75%	2,21%	0,18%	0,15%
Entrepreneur								
Central Hungary	0,08%	0,06%	0,36%	0,25%	0,45%	0,36%	0,10%	0,09%
Central Transd.	0,04%	0,02%	0,16%	0,09%	0,18%	0,13%	0,02%	0,02%
West Transd.	0,04%	0,03%	0,17%	0,09%	0,18%	0,12%	0,03%	0,01%
South Transdan.	0,04%	0,03%	0,18%	0,09%	0,19%	0,11%	0,03%	0,02%
North Hungary	0,03%	0,03%	0,15%	0,08%	0,15%	0,11%	0,03%	0,02%
North Great Pl.	0,06%	0,04%	0,21%	0,12%	0,23%	0,14%	0,03%	0,02%
South Great Pl.	0,05%	0,03%	0,19%	0,11%	0,22%	0,15%	0,03%	0,02%

D. Average income and confidence intervals by cells

Tables D1. and D2. compare the average reported income in the APEH dataset and the average synthetic reported income in the HBS dataset in the not top-coded and top-coded cases for the goups based on region, gender and age group. Confidence intervals, p-values and t-values are calculated from the HBS dataset. The H0 hypothesis is that the APEH and HBS average values are equal. P-values show the probability that the H0 is incorrectly rejected.

Table D1. Average reported income in the APEH and average synthetic reported income in the HBS – not top-coded, p- and t-values and confidence intervals by cells

INCOME NOT TOPCODED

Region	sex	age gr	average income in APEH	average income in HBS	st,dev in HBS	conf_interval_b	conf_interval_t	p-value	t-value
Kozep-Mo	male	16-29	1 487 973	1 464 095	1 312 818	1 299 227	1 628 963	0,78	- 0,29
Kozep-Mo	male	30-44	2 140 974	2 142 000	2 344 462	1 943 074	2 340 926	0,99	0,01
Kozep-Mo	male	45-59	2 195 277	2 196 010	2 314 357	1 999 638	2 392 382	0,99	0,01
Kozep-Mo	male	60-65	1 991 342	2 101 368	2 955 999	1 213 287	2 989 448	0,80	0,25
Kozep-Mo	female	16-29	1 376 364	1 371 578	1 180 787	1 230 623	1 512 532	0,95	- 0,07
Kozep-Mo	female	30-44	1 757 378	1 751 015	1 568 173	1 617 581	1 884 450	0,93	- 0,09
Kozep-Mo	female	45-59	2 060 576	2 054 011	1 903 436	1 906 610	2 201 412	0,93	- 0,09
Kozep-Mo	female	60-65	1 485 045	1 506 034	1 644 273	827 311	2 184 756	0,95	0,06
Koz-Dunantul	male	16-29	1 323 618	1 279 353	1 034 756	1 084 715	1 473 992	0,65	- 0,45
Koz-Dunantul	male	30-44	1 739 005	1 731 279	1 403 640	1 528 783	1 933 776	0,94	- 0,08
Koz-Dunantul	male	45-59	1 694 156	1 691 403	1 490 212	1 483 610	1 899 195	0,98	- 0,03
Koz-Dunantul	male	60-65	1 084 326	1 218 595	1 145 143	449 277	1 987 912	0,71	0,39
Koz-Dunantul	female	16-29	1 122 474	1 108 915	828 636	953 761	1 264 069	0,86	- 0,17
Koz-Dunantul	female	30-44	1 321 889	1 317 021	899 221	1 187 645	1 446 398	0,94	- 0,07
Koz-Dunantul	female	45-59	1 491 755	1 489 682	1 142 356	1 342 551	1 636 813	0,98	- 0,03
Koz-Dunantul	female	60-65	891 129	892 263	659 727	- 157 509	1 942 035	1,00	0,00
Ny-Dunantul	male	16-29	1 304 728	1 269 708	969 954	1 094 382	1 445 035	0,69	- 0,40
Ny-Dunantul	male	30-44	1 726 989	1 757 831	1 783 477	1 530 085	1 985 577	0,79	0,27
Ny-Dunantul	male	45-59	1 627 757	1 652 325	1 682 419	1 428 258	1 876 392	0,83	0,22
Ny-Dunantul	male	60-65	1 289 640	1 314 394	1 751 004	201 859	2 426 929	0,96	0,05
Ny-Dunantul	female	16-29	1 045 552	1 039 441	828 401	887 087	1 191 795	0,94	- 0,08
Ny-Dunantul	female	30-44	1 244 245	1 248 528	1 218 767	1 074 577	1 422 479	0,96	0,05
Ny-Dunantul	female	45-59	1 411 178	1 407 913	1 170 215	1 249 857	1 565 969	0,97	- 0,04
Ny-Dunantul	female	60-65	799 456	796 244	373 491	201 936	1 390 552	0,99	- 0,02
Del-Dunantul	male	16-29	1 209 107	1 209 374	948 968	974 231	1 444 516	1,00	0,00
Del-Dunantul	male	30-44	1 505 571	1 494 235	1 309 351	1 273 015	1 715 456	0,92	- 0,10
Del-Dunantul	male	45-59	1 557 308	1 545 950	1 452 778	1 310 759	1 781 140	0,92	- 0,10
Del-Dunantul	male	60-65	1 473 227	1 257 742	1 443 388	- 77 169	2 592 653	0,71	- 0,39
Del-Dunantul	female	16-29	1 040 794	996 340	763 988	766 813	1 225 868	0,70	- 0,39
Del-Dunantul	female	30-44	1 277 841	1 257 523	1 082 335	1 064 332	1 450 713	0,84	- 0,21
Del-Dunantul	female	45-59	1 446 071	1 440 062	1 153 724	1 254 547	1 625 578	0,95	- 0,06
Del-Dunantul	female	60-65	1 003 946	797 676	643 053	- 799 755	2 395 108	0,63	- 0,56
Eszak-Mo,	male	16-29	1 263 239	1 237 970	897 292	1 045 590	1 430 349	0,79	- 0,26
Eszak-Mo,	male	30-44	1 573 548	1 565 299	1 241 375	1 408 759	1 721 838	0,92	- 0,10
Eszak-Mo,	male	45-59	1 619 942	1 634 644	1 375 832	1 464 969	1 804 319	0,86	0,17

Eszak-Mo,	male	60-65	1 119 826	934 684	1 335 331	- 466 660	2 336 027	0,75	- 0,34
Eszak-Mo,	female	16-29	1 118 618	1 102 284	837 973	914 588	1 289 980	0,86	- 0,17
Eszak-Mo,	female	30-44	1 292 543	1 280 812	931 876	1 157 554	1 404 070	0,85	- 0,19
Eszak-Mo,	female	45-59	1 472 180	1 472 711	1 063 540	1 339 964	1 605 459	0,99	0,01
Eszak-Mo,	female	60-65	827 939	770 517	423 896	96 004	1 445 029	0,80	- 0,27
E-Alfold	male	16-29	1 153 469	1 143 168	911 646	966 742	1 319 594	0,91	- 0,12
E-Alfold	male	30-44	1 436 320	1 445 643	1 150 992	1 302 846	1 588 440	0,90	0,13
E-Alfold	male	45-59	1 561 759	1 571 995	1 443 358	1 370 736	1 773 255	0,92	0,10
E-Alfold	male	60-65	1 564 499	1 295 644	1 318 263	282 337	2 308 951	0,56	- 0,61
E-Alfold	female	16-29	1 065 141	1 052 443	870 980	894 333	1 210 553	0,87	- 0,16
E-Alfold	female	30-44	1 262 039	1 255 934	916 079	1 141 592	1 370 276	0,92	- 0,11
E-Alfold	female	45-59	1 484 769	1 477 618	1 166 169	1 332 061	1 623 176	0,92	- 0,10
E-Alfold	female	60-65	995 749	1 010 810	1 021 585	280 012	1 741 608	0,96	0,05
D-Alfold	male	16-29	1 163 151	1 156 115	854 281	991 590	1 320 639	0,93	- 0,08
D-Alfold	male	30-44	1 441 697	1 441 454	1 783 291	1 225 757	1 657 150	1,00	- 0,00
D-Alfold	male	45-59	1 477 194	1 475 008	1 312 433	1 315 041	1 634 976	0,98	- 0,03
D-Alfold	male	60-65	1 305 872	1 333 762	1 393 568	448 331	2 219 193	0,95	0,07
D-Alfold	female	16-29	1 032 352	1 026 643	798 240	881 737	1 171 548	0,94	- 0,08
D-Alfold	female	30-44	1 240 343	1 240 135	927 938	1 125 697	1 354 574	1,00	- 0,00
D-Alfold	female	45-59	1 399 191	1 393 771	1 141 728	1 244 779	1 542 764	0,94	- 0,07
D-Alfold	female	60-65	1 065 014	1 168 939	1 201 260	309 609	2 028 269	0,79	0,27

Table D2. Average reported income in the APEH and average synthetic reported income in the HBS – top-coded, p- and t-values and confidence intervals by cells

INCOME TOPCODED

Region	sex	age gr	average income in APEH	Average income in HBS	Sd. dev. in HBS	conf_interval_b	conf_interval_t	p value	t value
Kozep-Mo	male	16-29	1 487 973	1 408 490	1 243 410	1 252 338	1 564 641	0,32	- 1,00
Kozep-Mo	male	30-44	2 140 974	1 846 187	1 824 775	1 691 356	2 001 018	0,00	- 3,74
Kozep-Mo	male	45-59	2 195 277	1 894 175	1 746 619	1 745 976	2 042 375	0,00	- 3,99
Kozep-Mo	male	60-65	1 991 342	1 590 625	1 661 777	1 091 372	2 089 878	0,11	- 1,62
Kozep-Mo	female	16-29	1 376 364	1 333 147	1 125 200	1 198 828	1 467 465	0,53	- 0,63
Kozep-Mo	female	30-44	1 757 378	1 524 469	1 196 926	1 422 624	1 626 314	0,00	- 4,49
Kozep-Mo	female	45-59	2 060 576	1 749 985	1 431 936	1 639 096	1 860 873	0,00	- 5,50
Kozep-Mo	female	60-65	1 485 045	1 234 994	1 526 675	604 814	1 865 175	0,42	- 0,82
Koz-Dunantul	male	16-29	1 323 618	1 188 668	876 859	1 023 730	1 353 605	0,11	- 1,62
Koz-Dunantul	male	30-44	1 739 005	1 525 913	1 081 735	1 369 856	1 681 970	0,01	- 2,69
Koz-Dunantul	male	45-59	1 694 156	1 484 436	1 145 627	1 324 692	1 644 181	0,01	- 2,59
Koz-Dunantul	male	60-65	1 084 326	1 020 099	1 152 426	245 888	1 794 309	0,86	- 0,18
Koz-Dunantul	female	16-29	1 122 474	975 376	617 424	859 770	1 090 983	0,01	- 2,52
Koz-Dunantul	female	30-44	1 321 889	1 133 862	680 177	1 036 000	1 231 723	0,00	- 3,79
Koz-Dunantul	female	45-59	1 491 755	1 288 075	837 381	1 180 224	1 395 926	0,00	- 3,72
Koz-Dunantul	female	60-65	891 129	691 400	678 670	- 388 515	1 771 315	0,60	- 0,59
Ny-Dunantul	male	16-29	1 304 728	1 048 846	637 082	933 689	1 164 004	0,00	- 4,40
Ny-Dunantul	male	30-44	1 726 989	1 619 757	1 513 504	1 426 486	1 813 028	0,28	- 1,09
Ny-Dunantul	male	45-59	1 627 757	1 417 680	1 272 097	1 248 260	1 587 100	0,02	- 2,44
Ny-Dunantul	male	60-65	1 289 640	1 190 943	1 717 769	99 525	2 282 362	0,85	- 0,20
Ny-Dunantul	female	16-29	1 045 552	941 692	667 545	818 921	1 064 462	0,10	- 1,68
Ny-Dunantul	female	30-44	1 244 245	1 205 827	1 079 385	1 051 770	1 359 884	0,62	- 0,49
Ny-Dunantul	female	45-59	1 411 178	1 269 865	912 971	1 146 554	1 393 176	0,02	- 2,26
Ny-Dunantul	female	60-65	799 456	796 244	373 491	201 936	1 390 552	0,99	- 0,02
Del-Dunantul	male	16-29	1 209 107	829 035	587 592	683 437	974 634	0,00	- 5,21
Del-Dunantul	male	30-44	1 505 571	1 284 671	972 923	1 120 292	1 449 051	0,01	- 2,66
Del-Dunantul	male	45-59	1 557 308	1 345 320	1 166 415	1 156 489	1 534 151	0,03	- 2,22
Del-Dunantul	male	60-65	1 473 227	815 117	1 079 606	- 183 352	1 813 586	0,16	- 1,61
Del-Dunantul	female	16-29	1 040 794	888 522	689 318	681 427	1 095 616	0,15	- 1,48
Del-Dunantul	female	30-44	1 277 841	1 115 990	837 570	966 488	1 265 491	0,03	- 2,14
Del-Dunantul	female	45-59	1 446 071	1 232 965	864 353	1 093 979	1 371 950	0,00	- 3,03
Del-Dunantul	female	60-65	1 003 946	797 676	643 053	- 799 755	2 395 108	0,63	- 0,56
Eszak-Mo,	male	16-29	1 263 239	950 243	629 372	815 305	1 085 180	0,00	- 4,61
Eszak-Mo,	male	30-44	1 573 548	1 468 799	1 073 062	1 333 484	1 604 114	0,13	- 1,52
Eszak-Mo,	male	45-59	1 619 942	1 487 665	1 173 883	1 342 895	1 632 434	0,07	- 1,80
Eszak-Mo,	male	60-65	1 119 826	934 684	1 335 331	- 466 660	2 336 027	0,75	- 0,34
Eszak-Mo,	female	16-29	1 118 618	932 859	651 727	786 880	1 078 838	0,01	- 2,53
Eszak-Mo,	female	30-44	1 292 543	1 203 335	813 899	1 095 682	1 310 988	0,10	- 1,63
Eszak-Mo,	female	45-59	1 472 180	1 327 203	854 844	1 220 505	1 433 902	0,01	- 2,68
Eszak-Mo,	female	60-65	827 939	714 000	423 427	40 233	1 387 767	0,63	- 0,54
E-Alfold	male	16-29	1 153 469	1 098 564	880 643	928 138	1 268 990	0,52	- 0,64
E-Alfold	male	30-44	1 436 320	1 406 378	1 176 440	1 260 424	1 552 332	0,69	- 0,40
E-Alfold	male	45-59	1 561 759	1 496 207	1 337 719	1 309 677	1 682 736	0,49	- 0,69
E-Alfold	male	60-65	1 564 499	836 483	666 895	323 862	1 349 104	0,01	- 3,27
E-Alfold	female	16-29	1 065 141	845 286	686 648	720 638	969 934	0,00	- 3,49
E-Alfold	female	30-44	1 262 039	1 151 536	753 282	1 057 514	1 245 558	0,02	- 2,31
E-Alfold	female	45-59	1 484 769	1 350 131	955 572	1 230 860	1 469 403	0,03	- 2,22
E-Alfold	female	60-65	995 749	592 507	519 308	221 017	963 998	0,04	- 2,46
D-Alfold	male	16-29	1 163 151	1 004 009	591 938	890 009	1 118 009	0,01	- 2,77

D-Alfold	male	30-44	1 441 697	1 426 033	1 744 961	1 214 973	1 637 093	0,88	- 0,15
D-Alfold	male	45-59	1 477 194	1 391 202	1 214 523	1 243 168	1 539 235	0,25	- 1,14
D-Alfold	male	60-65	1 305 872	1 087 199	1 319 488	248 836	1 925 561	0,58	- 0,57
D-Alfold	female	16-29	1 032 352	925 447	615 278	813 755	1 037 139	0,06	- 1,90
D-Alfold	female	30-44	1 240 343	1 134 485	781 254	1 038 137	1 230 834	0,03	- 2,16
D-Alfold	female	45-59	1 399 191	1 244 897	889 465	1 128 824	1 360 970	0,01	- 2,62
D-Alfold	female	60-65	1 065 014	1 020 766	1 142 443	203 512	1 838 020	0,91	- 0,12

E. Dispersion of adjustment factors within cells for wage income

Tables E1. and E2. present the average, highest and lowest adjustment factors for wage income within each region, gender age group 'cell' and the average maximum/minimum distance between the highest and lowest adjustment factors within these groups, when group quintils are also added as matching variables.

Table E1. Average, lowest and highest adjustment factor by group quintiles within each cell and the distance of the lowest and highest quintile averages within each cell for wage income, not top-coded

Region	Gender	Agegr	No. Obs.	Mean	Sd.dev.	Min	Max	Max/Min	Average max/min
Kozep-Mo	male	16-29	246	0,82	0,16	0,62	1,05	1,70	2,98
Kozep-Mo	male	30-44	536	1,78	1,89	0,63	5,51	8,70	
Kozep-Mo	male	45-59	536	0,79	0,22	0,55	1,18	2,17	
Kozep-Mo	male	60-65	31	0,71	0,30	0,39	1,16	2,95	
Kozep-Mo	female	16-29	272	0,76	0,20	0,45	1,04	2,32	
Kozep-Mo	female	30-44	533	0,97	0,16	0,82	1,27	1,54	
Kozep-Mo	female	45-59	643	1,01	0,15	0,83	1,24	1,50	
Kozep-Mo	female	60-65	25	0,49	0,37	0,00	1,05	0,00	
Koz-Dunantul	male	16-29	111	0,83	0,23	0,54	1,17	2,15	1,82
Koz-Dunantul	male	30-44	187	1,01	0,26	0,66	1,34	2,02	
Koz-Dunantul	male	45-59	200	0,87	0,22	0,57	1,19	2,08	
Koz-Dunantul	male	60-65	9	0,24	0,21	0,00	0,49	0,00	
Koz-Dunantul	female	16-29	112	1,02	0,16	0,84	1,32	1,56	
Koz-Dunantul	female	30-44	188	1,16	0,26	0,92	1,60	1,74	
Koz-Dunantul	female	45-59	234	0,94	0,23	0,58	1,27	2,18	
Koz-Dunantul	female	60-65	4	1,12	0,00	1,12	1,12	1,00	
Ny-Dunantul	male	16-29	120	1,08	0,24	0,84	1,46	1,73	2,27
Ny-Dunantul	male	30-44	238	0,89	0,17	0,67	1,16	1,72	
Ny-Dunantul	male	45-59	219	2,25	2,46	0,90	7,14	7,98	
Ny-Dunantul	male	60-65	10	0,26	0,22	0,00	0,51	0,00	
Ny-Dunantul	female	16-29	116	0,94	0,18	0,67	1,22	1,81	
Ny-Dunantul	female	30-44	191	0,87	0,11	0,75	1,05	1,40	
Ny-Dunantul	female	45-59	213	0,95	0,14	0,75	1,14	1,51	
Ny-Dunantul	female	60-65	3	0,83	0,00	0,83	0,83	1,00	
Del-Dunantul	male	16-29	65	1,87	0,88	1,09	3,55	3,24	1,91
Del-Dunantul	male	30-44	137	0,84	0,26	0,50	1,29	2,57	
Del-Dunantul	male	45-59	149	0,92	0,15	0,76	1,19	1,57	
Del-Dunantul	male	60-65	4	1,27	0,13	1,08	1,36	1,26	
Del-Dunantul	female	16-29	45	1,25	0,36	0,98	1,96	2,00	
Del-Dunantul	female	30-44	123	0,86	0,22	0,55	1,22	2,21	
Del-Dunantul	female	45-59	151	0,99	0,15	0,88	1,29	1,47	
Del-Dunantul	female	60-65	3	0,59	0,00	0,59	0,59	1,00	
Eszak-Mo,	male	16-29	86	1,30	0,12	1,12	1,44	1,29	1,45
Eszak-Mo,	male	30-44	244	0,91	0,13	0,78	1,14	1,46	
Eszak-Mo,	male	45-59	255	0,85	0,23	0,47	1,14	2,42	
Eszak-Mo,	male	60-65	6	0,22	0,31	0,00	0,80	0,00	
Eszak-Mo,	female	16-29	79	1,11	0,13	0,87	1,26	1,45	

Eszak-Mo,	female	30-44	222	1,03	0,10	0,92	1,16	1,27	
Eszak-Mo,	female	45-59	249	1,00	0,09	0,92	1,18	1,27	
Eszak-Mo,	female	60-65	3	1,05	0,00	1,05	1,05	1,00	
E-Alfold	male	16-29	105	1,04	0,04	0,96	1,09	1,13	2,53
E-Alfold	male	30-44	252	1,47	1,01	0,89	3,46	3,91	
E-Alfold	male	45-59	200	0,97	0,15	0,83	1,23	1,48	
E-Alfold	male	60-65	6	1,19	0,50	0,42	1,99	4,69	
E-Alfold	female	16-29	119	1,28	0,13	1,11	1,45	1,31	
E-Alfold	female	30-44	249	1,00	0,09	0,93	1,18	1,28	
E-Alfold	female	45-59	249	0,93	0,11	0,79	1,14	1,44	
E-Alfold	female	60-65	6	1,07	0,75	0,40	2,00	5,01	
D-Alfold	male	16-29	106	0,97	0,23	0,80	1,40	1,75	2,63
D-Alfold	male	30-44	265	0,83	0,12	0,72	1,02	1,43	
D-Alfold	male	45-59	261	0,91	0,12	0,75	1,06	1,42	
D-Alfold	male	60-65	7	0,58	0,35	0,24	1,01	4,26	
D-Alfold	female	16-29	119	1,00	0,14	0,89	1,27	1,43	
D-Alfold	female	30-44	255	1,00	0,15	0,84	1,18	1,40	
D-Alfold	female	45-59	228	0,92	0,16	0,79	1,23	1,56	
D-Alfold	female	60-65	7	0,53	0,39	0,14	1,09	7,84	

Table E2. Average, lowest and highest adjustment factor by group quintiles within each cell and the distance of the lowest and highest quintile averages within each cell for wage income, top-coded

Region	Gender	Agegr	No. Obs.	Mean	Sd.dev.	Min	Max	Max/Min	Average max/min
Kozep-Mo	male	16-29	246	0,81	0,15	0,62	1,00	1,62	1,53
Kozep-Mo	male	30-44	536	0,83	0,16	0,63	1,00	1,58	
Kozep-Mo	male	45-59	536	0,76	0,16	0,55	1,00	1,83	
Kozep-Mo	male	60-65	31	0,67	0,23	0,39	1,00	2,54	
Kozep-Mo	female	16-29	272	0,75	0,19	0,45	1,00	2,22	
Kozep-Mo	female	30-44	533	0,91	0,07	0,82	1,00	1,21	
Kozep-Mo	female	45-59	643	0,94	0,06	0,83	1,00	1,21	
Kozep-Mo	female	60-65	25	0,48	0,35	0,00	1,00	0,00	
Koz-Dunantul	male	16-29	111	0,79	0,18	0,54	1,00	1,84	1,26
Koz-Dunantul	male	30-44	187	0,88	0,13	0,66	1,00	1,51	
Koz-Dunantul	male	45-59	200	0,84	0,17	0,57	1,00	1,74	
Koz-Dunantul	male	60-65	9	0,24	0,21	0,00	0,49	0,00	
Koz-Dunantul	female	16-29	112	0,95	0,06	0,84	1,00	1,19	
Koz-Dunantul	female	30-44	188	0,98	0,03	0,92	1,00	1,09	
Koz-Dunantul	female	45-59	234	0,87	0,16	0,58	1,00	1,72	
Koz-Dunantul	female	60-65	4	1,00	0,00	1,00	1,00	1,00	
Ny-Dunantul	male	16-29	120	0,93	0,08	0,84	1,00	1,19	1,12
Ny-Dunantul	male	30-44	238	0,86	0,13	0,67	1,00	1,48	
Ny-Dunantul	male	45-59	219	0,96	0,05	0,90	1,00	1,12	
Ny-Dunantul	male	60-65	10	0,26	0,22	0,00	0,51	0,00	
Ny-Dunantul	female	16-29	116	0,89	0,12	0,67	1,00	1,48	
Ny-Dunantul	female	30-44	191	0,86	0,10	0,75	1,00	1,33	
Ny-Dunantul	female	45-59	213	0,92	0,10	0,75	1,00	1,33	
Ny-Dunantul	female	60-65	3	0,83	0,00	0,83	0,83	1,00	
Del-Dunantul	male	16-29	65	1,00	0,00	1,00	1,00	1,00	1,28
Del-Dunantul	male	30-44	137	0,78	0,17	0,50	1,00	1,99	
Del-Dunantul	male	45-59	149	0,88	0,09	0,76	1,00	1,32	
Del-Dunantul	male	60-65	4	1,00	0,00	1,00	1,00	1,00	
Del-Dunantul	female	16-29	45	1,00	0,01	0,98	1,00	1,02	
Del-Dunantul	female	30-44	123	0,81	0,15	0,55	1,00	1,80	
Del-Dunantul	female	45-59	151	0,93	0,04	0,88	1,00	1,13	
Del-Dunantul	female	60-65	3	0,59	0,00	0,59	0,59	1,00	
Eszak-Mo,	male	16-29	86	1,00	0,00	1,00	1,00	1,00	1,09
Eszak-Mo,	male	30-44	244	0,88	0,09	0,78	1,00	1,28	
Eszak-Mo,	male	45-59	255	0,82	0,20	0,47	1,00	2,11	
Eszak-Mo,	male	60-65	6	0,22	0,31	0,00	0,80	0,00	
Eszak-Mo,	female	16-29	79	0,97	0,05	0,87	1,00	1,15	
Eszak-Mo,	female	30-44	222	0,98	0,03	0,92	1,00	1,09	
Eszak-Mo,	female	45-59	249	0,96	0,03	0,92	1,00	1,08	
Eszak-Mo,	female	60-65	3	1,00	0,00	1,00	1,00	1,00	
E-Alfold	male	16-29	105	0,99	0,01	0,96	1,00	1,04	1,45
E-Alfold	male	30-44	252	0,95	0,05	0,89	1,00	1,13	
E-Alfold	male	45-59	200	0,92	0,07	0,83	1,00	1,20	
E-Alfold	male	60-65	6	0,90	0,24	0,42	1,00	2,36	
E-Alfold	female	16-29	119	1,00	0,00	1,00	1,00	1,00	
E-Alfold	female	30-44	249	0,96	0,03	0,93	1,00	1,08	
E-Alfold	female	45-59	249	0,90	0,07	0,79	1,00	1,27	
E-Alfold	female	60-65	6	0,73	0,27	0,40	1,00	2,50	

D-Alfold	male	16-29	106	0,88	0,09	0,80	1,00	1,25	2,37
D-Alfold	male	30-44	265	0,83	0,11	0,72	1,00	1,39	
D-Alfold	male	45-59	261	0,90	0,10	0,75	1,00	1,34	
D-Alfold	male	60-65	7	0,57	0,34	0,24	1,00	4,20	
D-Alfold	female	16-29	119	0,95	0,04	0,89	1,00	1,12	
D-Alfold	female	30-44	255	0,93	0,07	0,84	1,00	1,19	
D-Alfold	female	45-59	228	0,88	0,08	0,79	1,00	1,27	
D-Alfold	female	60-65	7	0,51	0,35	0,14	1,00	7,20	