The Elasticity of Taxable Income: Estimates and Flat Tax Predictions using the Hungarian Tax Changes in 2005[§]

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Abstract

Many Central and Eastern European countries are adopting flat tax schemes in order to boost their economies and tax revenues. Though there are signs that some countries do manage to improve on both fronts, it is in general hard to distinguish the behavioral response to tax changes from the effect of increased tax enforcement. This paper addresses this gap by estimating the elasticity of taxable income in Hungary, one of the outliers in terms of not having a flat tax scheme. We analyze taxpayer behavior using a medium-scale tax reform episode in 2005, which changed marginal and average tax rates but kept enforcement constant. We employ a Tax and Financial Control Office (APEH) panel dataset between 2004 and 2005 with roughly 215,000 taxpayers. Our 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, we quantify the impact of a hypothetical flat income tax scheme. Our calculations indicate that though there is room for a parallel improvement of budget revenues and after-tax income, those gains are modest (2.4% 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.

JEL codes: H24, H31

Keywords: elasticity of taxable income, tax reform, behavioral response, revenue estimation, flat tax.

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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. Although involving a large cut in personal income taxes and thus often having adverse implications for income inequality, such reforms tend to boost budget revenues. It is not immediate, however, that this is evidence for some kind of a Laffer curve, since the introduction of a flat tax always comes together with additional changes in tax rates (like an increase in capital income tax rates). More importantly, there is often an increase in enforcement as well.[1]

One cannot easily distinguish the influence of these factors from each other, though it would be essential for the design of tax reforms in any of these countries.[2] If there is indeed a substantial labor supply response, that is indicative of huge welfare gains from an overall shift away from labor income taxation, regardless whether it is a flat tax or not. If, on the other hand, there is little labor supply response, then the effect must be mostly due to increased enforcement, hence new reformers should concentrate their efforts on enhancing tax discipline, and use tax cuts mostly to compensate taxpayers for harsher enforcement; again, regardless whether all this takes a 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.[3]

This paper aims at quantifying the response of taxable income to changes in tax schedules in Hungary, one of the outliers in the CEE region without a flat tax. Using a medium-scale tax reform episode of 2005 and a large panel of personal income tax files, we obtain an estimate for the behavioral response of taxable income to the marginal and average tax rate, *keeping tax enforcement unchanged*.

In particular, we use a 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 behavior 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.

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[1] See for example: Ivanova *et al* (2005) on Russia, and Moore (2005) on Slovakia.

[2] Gorodnichenko *et al* (2008) is an empirical attempt to measure the response of tax evasion to the Russian tax reform, using a household panel survey.

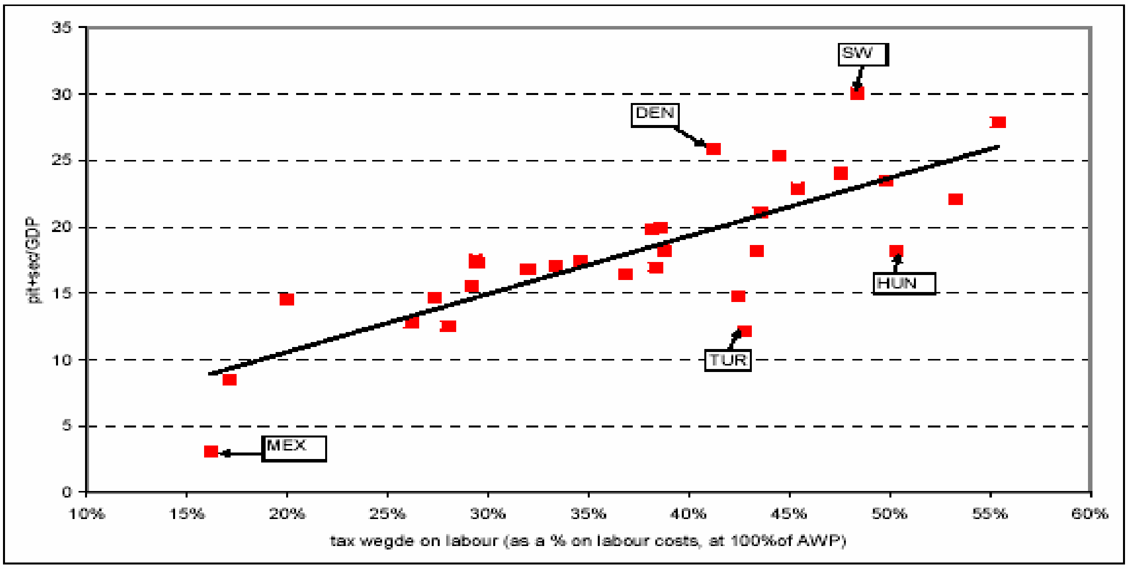
[3] This point is further elaborated in Papp and Takats (2008).

The feature that marginal tax rates are heavily influenced by the deduction status of the taxpayer 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.

Our focus on taxable income as opposed to labor supply itself is motivated by a long research line in public economics (Feldstein, 2002). The early research focusing on the effect of taxation on labor supply – as reviewed by Heckman (1993) – suggested that the labor supply of primary earners is rather insensitive to tax rates. Following the seminal paper of Feldstein (1995), a new literature has emerged which has been analyzing a broader context of labor supply. This approach is based on the observation that taxable income can vary not only with labor 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 both 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.

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 labor tax rates in Hungary is an issue interesting on its own right. In an OECD comparison, Hungary has the third highest overall labor tax wedge; while its labor income tax revenue per GDP ratio is around the OECD median (see Figure 1).

Figure 1. Labor tax wedges and labor income tax revenue per GDP ratios in OECD countries



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

This aggregate cross-section evidence suggests an important elasticity of taxable income to taxation. Maybe surprisingly, our results 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 (0.33), and for some groups, it is as high as 0.45, meaning that high marginal tax rates do lead to substantial distortions in certain income ranges.

The population average coefficient of *average tax rates* (the income effect) is zero for the upper 70% of the income distribution, and, unlike Gruber and Saez (2002), we find a very significant and substantial income effect for the upper 20% (-0.27). It means that the *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 work more, almost matching the reduction due to higher marginal tax rates. Consequently, an uncompensated tax increase (when marginal rates are raised but tax brackets are not adjusted to compensate taxpayers for losses) is very likely to increase revenues.

Now consider a flat tax experiment which is designed to be revenue neutral without any behavioral 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[4] simulation shows a parallel improvement in budget revenues and after-tax income (2.4% and 1.4%, respectively). Though positive, these improvements are rather modest. Moreover, there are important changes in the 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 get quite 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 degree due to 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). Given that the majority of entrepreneurial income is taxed separately in Hungary, it is

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[4] 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).

less surprising to find a low elasticity for taxable income. In fact, the surprising finding is that high income individuals do exhibit substantial elasticities even without having access to deductions from the tax base.

The paper 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 the flat tax simulation exercise, while section 6 concludes. Finally, the Appendix contains some skipped details.

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):

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

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, 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 then 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 of 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[5] 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 individuals, and find that estimates for the elasticity of taxable income range between -0.6 and 0.2. Focusing on regressions which contain a measure for mean reversion in income, their baseline estimates are between 0 and 0.2.

In contrast, Ljunge and Ragan (2005) obtain comparable compensated elasticities to Gruber and Saez (2002), 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.

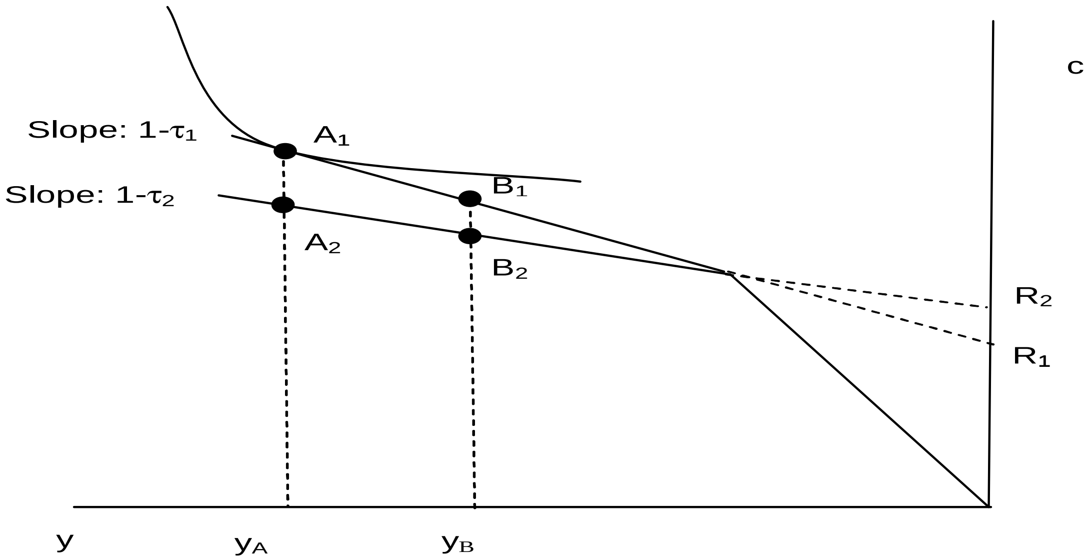
[5] Gruber and Saez (2002) work with virtual income instead of the average tax rate. Virtual income is the intercept of the budget line using the current tangent (one minus the marginal tax rate) as its slope. Non-labor income differs from virtual income as long as the marginal tax rate is not constant.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

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 ('labor') *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 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 2.

Figure 2. The nonlinear budget set



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

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

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

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

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)*,[6] we get

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

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 behavioral 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 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:

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

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 $cov(\Delta log(1-MTR_i), u_i) \neq 0$. To overcome this problem, the usual procedure[7] 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 final period ATR by the synthetic ATR. We calculate this synthetic ATR (SATR) similarly to SMTR.

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[6] This term is a straightforward reinterpretation of virtual income in the specification of Gruber and Saez (2002). See the Appendix for more details.

[7] 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. The first property is satisfied by construction, because they are calculated using the 2004 income inflated to 2005; while for the second, we consider various first stage diagnostics. We also report a test for the exogeneity of realized tax rates (the C-statistics, see Baum *et al*, 2003 for details).

Marginal tax rate (MTR)

The variable of interest is the difference of the logarithm of the tax price 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.[8] 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.[9] The full impact of all changes (including the "bracket creep" of not adjusting tax brackets to inflation) is summarized by Figure 3, which plots the change between the log of the 2004 and the synthetic tax price as a function of 2004 income in our dataset (for better visibility, we drop individuals above an annual income of 10,000,000[10] and use a 5% random sample). According to this figure, it is the 636,000-4,000,000 income range (30 to 95 percentile of the income distribution) that features substantial variation in the synthetic MTR.

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

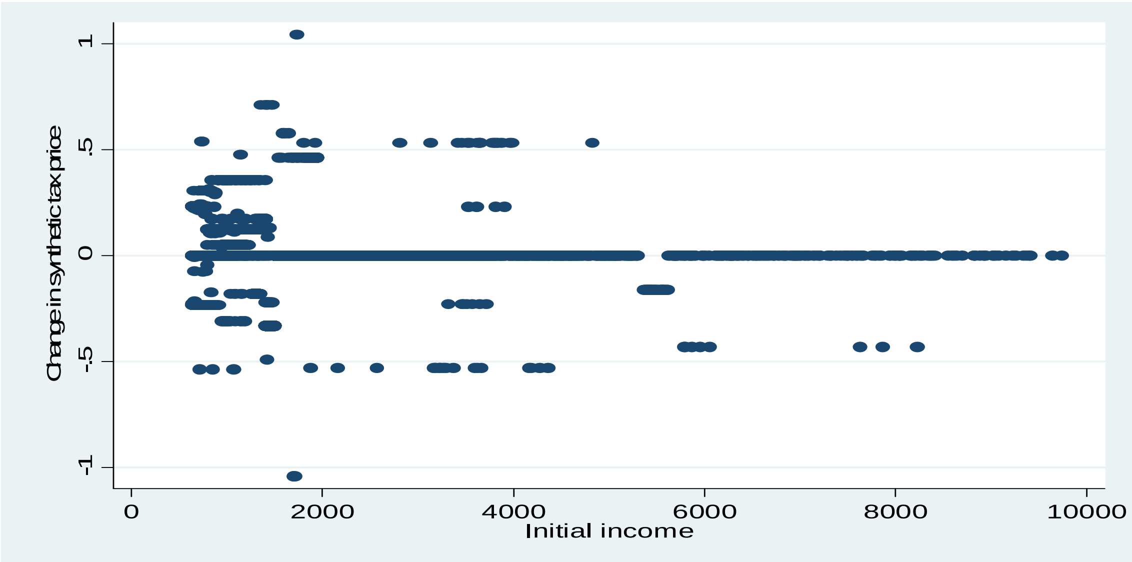
[8] Elements of the social benefit system also have incentive effects and affect the marginal *effective* tax rate. It is important to note that in our analysis we only take into account the effects of the tax schedule, tax credit and social security contribution modifications and not the changes in 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.

[9] 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).

[10] 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.

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 from 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.

Figure 3. Change in the log of the synthetic tax price in our sample



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 HUF), 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.[11] 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.

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[11] 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 15 for details.

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 labor 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.[12] 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.

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 (due to a negative correlation between the income innovation u_i and initial income y_{0i} of equation 3, which then leads to correlations with initial tax rates). The exclusion of low income taxpayers from the sample limits 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 an income-dependent intercept and initial income coefficient (following Gruber and Saez, 2002). These should 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_i and y_{0i}.

The synthetic change in the marginal (average) tax rate is the difference in 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[13] are inflated to 2005 using the official central bank annual average inflation for 2004 (6.8%). The 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 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.

[12] 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.

[13] Some allowances correspond to delayed claims. We assume that these are predetermined, thus the inflated allowance was set equal to the realized allowance.

Table 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. Means and standard deviations of variables

Variable	Total working sample		Income above 636th	
	Mean	Std. Dev.	Mean	Std. Dev.
∆log taxable income	0.10	0.57	0.03	0.39
∆log (1 - marginal tax rate)	0.02	0.23	0.04	0.26
∆log (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
∆log (1 - average tax rate)	0.01	0.07	0.01	0.07
∆log (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
Region	3.49	2.20	3.44	2.19
Budapest dummy	0.18	0.39	0.19	0.39
Regional capital dummy	0.41	0.49	0.42	0.49
Observations	209892		146676	

4. ESTIMATION RESULTS

Table 2 presents our basic results for the upper 70% of the income distribution (those who earned at least the minimum wage in 2004). 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. 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 are perfect for the instruments.

The estimates for the tax price are significant in all specifications and vary between 4.97%-7.43% 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; Aarbu and Thoresen, 2001: 0.21, for Norway; Ljunge and Ragan, 2005: 0.35 for Sweden). The difference between these elasticities can be a natural consequence of the characteristics of the different tax systems, even if individuals in different countries exhibit identical behavioral responses (Slemrod 1998).

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, 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.

Table 2. Main results, 2004 income above 636,000

Δlog taxable income	Model 1	Model 2	Model 3	Model 4	Model 5
Δlog (1 - marginal tax rate)	**0.0743****	**0.0528****	**0.0501****	**0.0497****	**0.0648****
	(0.011)	(0.011)	(0.011)	(0.011)	(0.016)
Δlog (1 - average tax rate)			0.145*	0.334**	-0.0671
			(0.064)	(0.067)	(0.065)
Log 2004 gross income		-0.0231**	-0.0252**	-0.0305**	
		(0.0022)	(0.0025)	(0.0028)	
Wealth				0.0291**	0.0262**
				(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**	0.0140**
				(0.0034)	(0.0034)
Family				-0.00372	-0.00631**
				(0.0022)	(0.0021)
Gender				0.00777**	0.00743**
				(0.0022)	(0.0021)
Region				0.00124*	0.00120*
				(0.00059)	(0.00056)
Budapest				0.0131**	0.0142**
				(0.0043)	(0.0041)
Regional capital				-0.00182	-0.00265
				(0.0028)	(0.0026)
Constant	0.0288**	0.199**	0.213**	0.0148	
	(0.0011)	(0.016)	(0.018)	(0.025)	
Anderson canonical	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	5706.51	2927.41
For the average tax rate			3549.76	3327.21	2579.61
Observations	146676	146676	146676	146676	146676

*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.

The results change substantially if we concentrate on a middle income sample (2004 income above 2,000,000, top 20%). As Table 3 shows, the coefficient for our key regressor is now around 0.3. Initial income is still significant and it decreases the tax 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.

Table 3. Main results, 2004 income above 2.000,000

∆log taxable income	Model 1	Model 2	Model 3	Model 4	Model 5
∆log (1 - marginal tax rate)	**0.402****	**0.325****	**0.268****	**0.289****	**0.336****
	(0.052)	(0.051)	(0.047)	(0.050)	(0.059)
∆log (1 - average tax rate)			-0.654**	-0.388**	-0.271*
			(0.11)	(0.12)	(0.12)
Log 2004 gross income		-0.0763**	-0.0849**	-0.0776**	
		(0.0064)	(0.0065)	(0.0068)	
Wealth				0.0162**	0.0162**
				(0.0041)	(0.0042)
Age				0.0209**	0.0216**
				(0.0022)	(0.0022)
Age squared				-0.000280**	-0.000288**
				(0.000027)	(0.000027)
Entrepreneurship				0.0194**	0.0201**
				(0.0053)	(0.0054)
Family				-0.0120**	-0.0113*
				(0.0044)	(0.0045)
Gender				0.00258	0.00265
				(0.0043)	(0.0044)
Region				0.00142	0.00156
				(0.0012)	(0.0012)
Budapest				0.0146	0.0146
				(0.0074)	(0.0076)
Regional capital				-0.00432	-0.00469
				(0.0055)	(0.0056)
Constant	0.0171**	0.634**	0.721**	0.291**	
	(0.0022)	(0.051)	(0.053)	(0.075)	
Anderson canonical	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	361.99	317.51
For the average tax rate			867.33	763.83	747.01
Observations	41819	41819	41819	41819	41819

*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.

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 0.336 and an uncompensated elasticity of 0.065 in the top 20% sample; and an elasticity of 0.065 in the top 70% sample, both compensated and uncompensated.

Robustness

First we explore whether the age composition of our sample matters. Table 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 above 636,000, the tax price elasticity tends to decrease as we restrict the age composition; while for the sample above 2,000,000, the tax price elasticity increases, and the income effect coefficient becomes smaller. These changes, however, are quite modest in size.

Table 4. 2SLS regression results for different age groups

	Income above 636,000			Income above 2,000,000		
Δlog taxable income	All ages	18-60	23-55	All ages	18-60	23-55
Δlog (1 - marginal tax rate)	**0.0648****	**0.0592****	**0.0575****	**0.336****	**0.352****	**0.357****
	(0.016)	(0.016)	(0.014)	(0.059)	(0.060)	(0.060)
Δlog (1 - average tax rate)	-0.0671	-0.0519	-0.0299	-0.271*	-0.237	-0.158
	(0.065)	(0.064)	(0.063)	(0.12)	(0.12)	(0.12)
First stage partial F						
For the marginal tax rate	2927.41	2857.43	2981.33	317.51	308.24	298.15
For the average tax rate	2579.61	2523.10	2355.27	747.01	738.03	697.90
Observations	146676	143185	129961	41819	40451	36238

*Robust standard errors in parentheses. * significant at 5%; ** significant at 1%*
The p-values for the Anderson canonical 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: 636,000-2,000,000 is roughly the range where the employee tax credit still applies; 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 is the cutoff for the new deduction phase-out introduced in 2005.

The numbers in Table 5 suggest that the 0.0648 overall tax price elasticity is a mix of an even lower elasticity (0.0291) in the range of 636,000-2,000,000 and a much higher elasticity above 2,000,000. This higher elasticity, on the other hand, comes mostly from the income range 2,000,000-4,000,000. Above 4,000,000 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).[14] The income effect, on the other hand, comes mostly from high earners. This apparent backward bending labor 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.

Table 5. 2SLS regression results for different income groups

∆log taxable income	636,000 to top	636,000 to 2,000,000	2,000,000 to top	2,000,000 to 4,000,000	2,000,000 to 6,000,000	4,000,000 to top
∆log (1 - marginal tax rate)	**0.0648****	**0.0291**	**0.336****	**0.450****	**0.378****	**-0.0748**
	(0.016)	(0.015)	(0.059)	(0.060)	(0.060)	(0.30)
∆log (1 - average tax rate)	-0.0671	0.0445	-0.271*	-0.0558	-0.0434	-0.938*
	(0.065)	(0.077)	(0.12)	(0.13)	(0.13)	(0.45)
First stage partial F						
For the marginal tax rate	2927.41	3031.61	317.51	288.81	313.82	25.34
For the average tax rate	2579.61	1818.15	747.01	665.80	677.25	102.82
Observations	146676	104857	41819	31494	37609	10325

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

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.[15] As Table 6 suggests, the estimates change very little.

Summing up, we find lower elasticities for our larger sample than other empirical studies. Concentrating on a medium-high income sample, on the other hand, 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

[14] 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.

[15] 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.

entitled to some cost deductions in Hungary, but their coverage and impact is very limited.[16] This is likely to reduce tax price elasticity, as a major margin of adjustment is 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.

Table 6. The inclusion of taxpayers with problems in their reported employee tax credit

∆log taxable income	636,000 -		636,000-2,000,000		2,000,000-	
	without	with	without	with	without	With
∆log (1 - marginal tax rate)	**0.0648****	**0.0562****	**0.0291**	**0.0334***	**0.336****	**0.335****
	(0.016)	(0.014)	(0.015)	(0.015)	(0.059)	(0.060)
∆log (1 - average tax rate)	-0.0671	-0.0153	0.0445	0.104	-0.271*	-0.244
	(0.065)	(0.066)	(0.077)	(0.078)	(0.12)	(0.13)
First stage partial F						
For the marginal tax rate	2927.41	3557.65	3031.61	3260.50	317.51	317.33
For the average tax rate	2579.61	2618.52	1818.15	1879.79	747.01	728.47
Observations	146676	150141	104857	108247	41819	41894

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

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 items.

The single tax rate is chosen such that the proposal is revenue neutral in case of no behavioral response. 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. [17]

Let us stress that this reform does not change the overall tax rate below the minimum wage. Our reasons are twofold: on the on hand, we do not have reliable estimates for taxpayer

[16] In our sample, roughly 10% of all taxpayers report some cost deductions. The average deduction, however, is 163, compared to the average income of 3041 in this group. Running separate regressions for this group reveals no significant difference in their tax price elasticity.

[17] Ivanova *et al* (2005) gives an international comparison: flat tax personal income tax rates range from 12% to 19%. They 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.

behavior below the minimum wage; and on the other hand, a raise in the marginal and the average tax rate for this income group is likely to involve substantial social tensions.[18]

We apply this tax scheme to 2005 income data under three scenarios. Scenario 1 assumes no behavioral effect at all. Scenario 2 assumes no income effects and the appropriate substitution effect (an elasticity of 0.0291 for incomes in 684,000-2,000,000 and 0.336 above 2,000,000). Scenario 3 works with the same substitution effect and adds the income effect (a parameter of -0.271) above 2,000,000.

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 behavioral 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 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.[19]

Figure 4 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[20] (in a 2% random sample for better visibility). It is immediate to see 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; while the latter is quite desirable, since taxable income is quite sensitive to the tax price in that income range.

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).

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[18] 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.

[19] 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. As there is no income effect below an initial income of 2,000,000 and the substitution effect would not make anyone from this range to reduce their income below the minimum wage, 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.

[20] Notice that the post-reform ATR is not a monotonic function of *pre-reform* income (it nevertheless holds for *post-reform* income). This is due to the fact that the pre-reform MTR is not uniquely determined by pre-reform income, thus the link between pre-reform income and the change in the tax price (which sets post-reform income) is not unique, either.

Figure 4. Average and marginal tax rates: before and after the flat income tax scheme

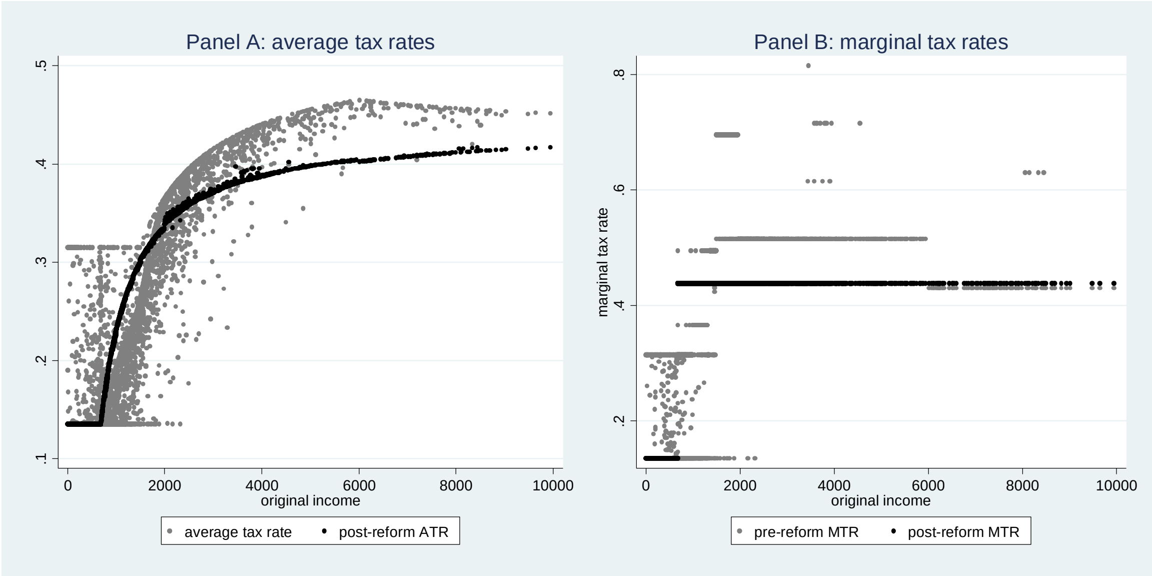


Table 7 summarizes the main implications of our flat income tax. Without a behavioral response, there is no change in budget revenues and taxable income. Adding the substitution effect leads to a 3.18% increase in revenues, together with a 1.87% increase in after-tax income. These numbers become somewhat smaller as we add the income effect: a 2.37% increase in revenues and a 1.38% increase in after-tax income.

There are, however, notable changes in the income distribution. 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 4). The Gini coefficient of pretax income increases from 0.46023 to 0.46544; while for after-tax income, it increases from 0.38529 to 0.40110.[21]

To illustrate the detailed incidence of the tax reform and the impact of behavioral responses, Figure 5 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 behavioral responses. There is a small decline in decile 4, and a very sizable fall in deciles 5-7. In deciles 4-6, the behavioral response works against taxpayers as they experience a small increase in their marginal tax rates as well. In decile 7, the behavioral response mollifies the impact of higher average tax rates; while in decile 8, it turns an income loss into an income gain. Finally, deciles 9 and 10 experience a sizable

[21] 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.

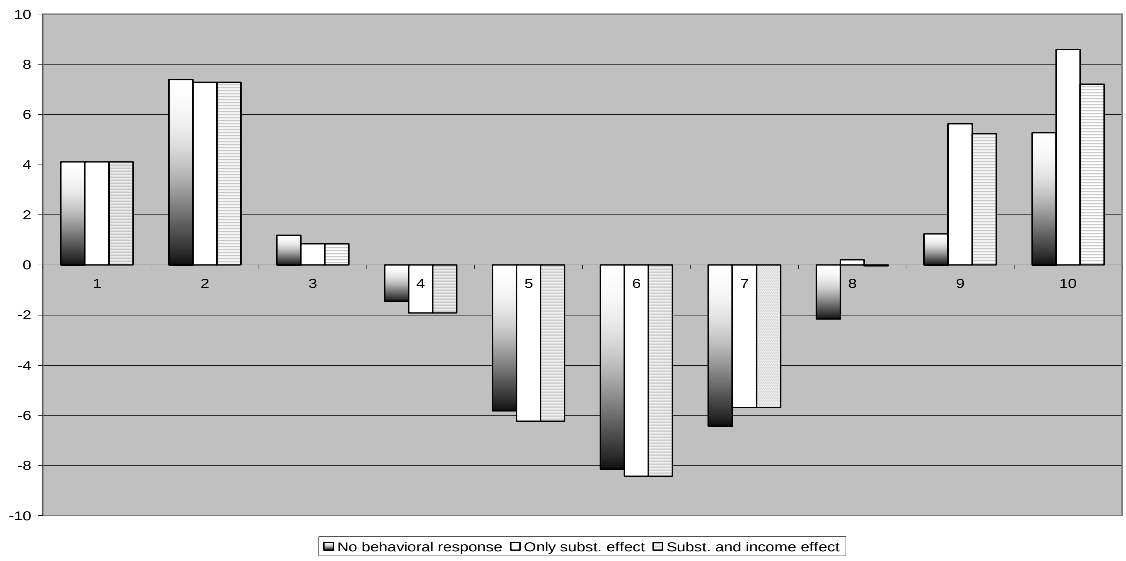
increase in their income. The behavioral response is most notable in decile 9, increasing the gain from 1.23% to 5.23%.

Table 7. Implications of a flat income tax scheme

	Behavioral effects considered		
	none	only subst.	subst. and income
Percentage change in total			
revenue	0.03	3.18	2.37
pretax income	0	2.29	1.70
after-tax income	-0.02	1.87	1.38
Pretax income, % change in			
p90/p10	0	5.07	4.15
p90/p50	0	5.64	4.71
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	0.468	0.46544
After-tax income, % change in			
p90/p10	0.07	4.61	3.78
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	0.40353	0.40110

For a full description of the three scenarios, see the main text.

Figure 5. The percentage change in after-tax income by 2005 after-tax income deciles



In summary, this simulation exercise clearly illustrates the importance of the elasticity of taxable income to changes in the marginal tax rate. 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 7 and Figure 5 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 5).

6. CONCLUSION

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 usually it is 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 behavioral 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, on the other hand, a decrease in marginal tax rates may indeed lead to a substantial increase in income generation, but that 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 such that there is no effect on budget revenues in case of no behavioral responses. 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 2.4% 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 tax price elasticity estimate. As compared to the US, where much of the elasticity is likely to be due to itemized deductions, Hungarian wage earners cannot deduct much from their tax base, meaning that the elasticity we find may be much closer to a true "generalized" labor 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. 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.

A possible extension of this analysis could be to control for other characteristics of taxpayers, such as the level of education or occupation. Using a different dataset, such as survey data, would allow for these controls, but data reliability and size of the dataset would probably be lower and a detailed simulation of tax allowances would not be possible. The use of a longer panel may also improve the results because (1) the tax changes in the beginning of 2005 might have long effects on the taxable income and (2) it allows to investigate other changes in the tax system (e.g. the change in the top rate from 2006 to 2007) and to apply a richer set of controls for initial income. This will be resolved by time. Finally, a further step can be to investigate the effect and nature of tax optimization more directly. A particular avenue we are pursuing is to analyze the role of deductions in determining taxpayer behavior.

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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 2005; OECD, 2004 and 2005).

1. 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 panel A of Table A1 changed to the schedule in panel B.

Table A1. Tax schedule in 2004 and 2005

	Panel A: 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
	Panel B: 2005	
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

2. The maximum amount of the supplementary employee tax credit was increased from 540 per month to 1240 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%.[22]
3. 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%.[23] 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%).

[22] 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.

[23] 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.

4. 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 change 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:

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

Notice that Gruber and Saez (2002) do no deduct the *dy/y* term. That distorts the parameters – their estimates need to be divided by $1-\phi$, 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

$$\tau = \tau(y,\ \lambda) \quad \text{and} \quad R = R(y,\ \lambda),$$

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.[24] 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 – does not change with income levels).

Equation (4) can still be estimated by single equation IV. We run (4) by using the two excluded exogenous variables, *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.

[24] 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.