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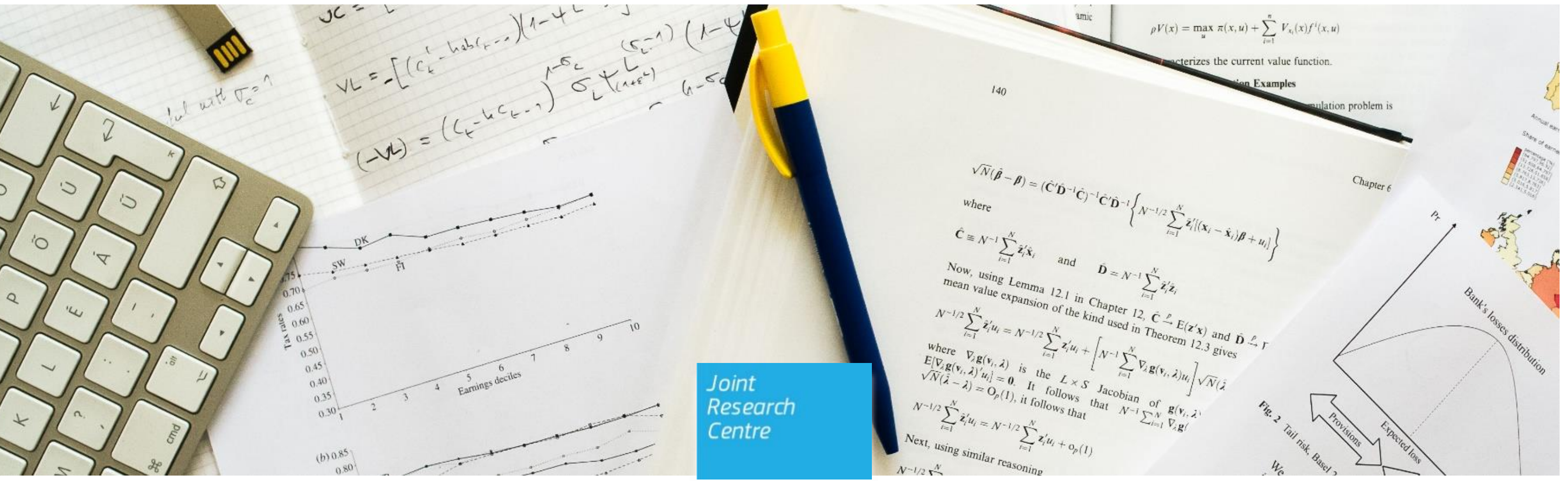

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ASSESSING THE ECONOMIC AND SOCIAL IMPACT OF TAX AND TRANSFER SYSTEM REFORMS: A GENERAL-EQUILIBRIUM MICROSIMULATION APPROACH[1]

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Abstract

We present a general-equilibrium behavioural microsimulation model designed to assess long-run macroeconomic, fiscal and social consequences of reforms to the tax and transfer system. The behaviour of labour supply is assessed along both the extensive and intensive margins, by merging the discrete choice and the elasticity of taxable income approaches. General-equilibrium feedback effects are simulated by embedding microsimulation in a parsimonious macro model of a small open economy. We estimate and calibrate the model to Hungary, and then perform three sets of simulations. The first one explores the impact of personal income tax reductions that are identical in cost but different in structure. The second one compares three different tax shift scenarios, while the third one evaluates actual policy measures between 2008 and 2013. The results suggest that while a cut in the marginal tax rate of high-income individuals may boost output, it does not have a significant employment effect. On the other hand, programs like the Employee Tax Credit do have a significant employment effect. We find that the policy measures introduced since 2008 substantially increase income inequality in the long run; the contribution of the changes after 2010 are about four times that of the changes before 2010. Our results highlight that taking account of household heterogeneity is crucial in the analysis of the macroeconomic effects of tax and transfer reforms.

JEL Codes: H22, H31, C63

Keywords: behavioural microsimulation; linked micro macro model; tax system; transfers

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[1] Part of the work was done when Benczúr, Kátay and Kiss were at Magyar Nemzeti Bank (the central bank of Hungary), and then Kátay was at Banque de France. This research has been conducted before Kiss started to work at the European Commission. The views expressed here are of the authors and do not necessarily reflect the official view of MNB, Banque de France or the European Commission.

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1. INTRODUCTION

In this paper, we present a general-equilibrium behavioural microsimulation model designed to assess long-run macroeconomic, fiscal and social consequences of reforms to the tax and transfer system. We describe the model in detail, calibrate it to Hungary, and present simulations of hypothetical as well as actual Hungarian reforms from the period between 2008 and 2013.[3] Besides presenting a broad yet tractable new tool for policy analysis tailored to a particular country, we believe that we provide a useful input for policy discussions and evaluations in other European countries about the long-run economic and distributional effects of structural reforms.

The case of Hungary is particularly suited to illustrate the benefits of our approach. Changes to the tax and transfer system in Hungary were frequent, large and of various types in the last decade. The Personal Income Tax (PIT) code saw five major changes in the period of 2004-14. The most recent changes introduced a flat tax of 16% on all personal income, reducing the tax burden on high incomes substantially (and increasing somewhat the burden on low incomes). During the period of 2010-13, the generous Employee Tax Credit (ECT) scheme for low incomes was eliminated, while the child tax credit was expanded and a cut in employee contributions for younger, older and low-skilled workers was passed into law. Meanwhile, the maximum length of unemployment benefits has been cut from 12 to 3 months. Large changes in the tax and transfer system most often served one or more of the following three main purposes: consolidating the public budget, adjusting the system to the government's redistributive preferences, and stimulating the economy. While simple tools are generally sufficient to conduct a static fiscal assessment of a planned policy measure, a detailed assessment of the redistributive, labour market, and growth effects is far from straightforward.

Our microsimulation model has two important features. First, it is behavioural, which means that it takes into account the labour supply response of individuals at the intensive and extensive margin. This is done by merging the elasticity of taxable-income literature (see, for example: Gruber and Saez, 2002; Saez *et al.*, 2012) and the discrete choice labour supply literature (van Soest, 1995; Aaberge *et al.*, 1995; Bargain *et al.*, 2014). In particular, the intensive margin is interpreted as the number of effective hours worked, and the labour supply response at this margin is calibrated using estimates of the taxable-income elasticity for Hungary by Bakos *et al.* (2008) and Kiss and Mosberger (2015). The extensive margin is the participation decision, and the labour supply response at this margin is implemented using the discrete choice estimations of Galuščák and Kátay (2017).[4]

The second important feature is that labour supply shocks, resulting from individual behavioural responses to tax and transfer reforms, are fed into a long-run neoclassical model of a small open economy. This linked

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[3] First simulation results using the model are presented in a non-technical paper assessing the 2011 tax changes in Hungary (Benczúr *et al*., 2011)..

[4] We also performed similar simulation exercises based on the gains to work approach of Benczúr *et al.* (2012) and Benczúr and Kátay (2017). The results, which are very close to the ones presented in the paper, are available upon request.

micro-macro modelling approach has important advantages. Shifts in labour supply will, in the long run, lead to changes in wages, corporate profits and thus a change in the demand for capital. By embedding the labour supply model in a macro model, we can take account of these general-equilibrium feedback effects. More importantly, this approach enables us to assess the macroeconomic and labour market effects of changes to the corporate side of taxation. Still, the macro model is parsimonious and transparent: it consists of an aggregate production function and a capital supply curve, ensuring that input prices equal their marginal products and that capital supply is elastic.

Both main features of the model fit into recent tendencies in microsimulation modelling (see, e.g., Bourguignon and Spadaro, 2005; Williamson *et al.*, 2009; Gravelle, 2015; Aaberge and Colombino, 2015) for recent surveys.

Early work on incorporating behavioural responses includes work by Aaberge *et al.* (2000), Blundell *et al.* (2000), and Creedy and Duncan (2002). Immervoll *et al.* (2007) simulated the effects of two hypothetical welfare-reform scenarios in 15 European countries based on the EUROMOD microsimulation model. Immervoll *et al.* (2007) stress the importance of taking into account the behavioural labour-supply response not just at the intensive margin but also at the extensive margin, since the evaluation of a welfare reform hinges crucially at the extensive-margin response.

By now, the extensive margin adjustment has become a standard ingredient of labour supply estimations, assuming a discrete choice from a small set of possible hours worked (including inactivity, part-time, full-time and overtime, or sometimes a more refined set). The most frequently adopted methodology is based on Bargain *et al*. (2014). Aaberge and Colombino (2014) presents a large but still admittedly incomplete review of many analyses following similar approaches (Table 1 of Aaberge and Colombino, 2014).

We, on the other hand, want to incorporate also the taxable income elasticity approach to the intensive margin adjustment, on top of the possibility of full-time or overtime work (this is similar to the approach taken by the Congressional Budget Office, see for example Harris and Mok, 2015). As argued by Feldstein (2000), concentrating only on hours worked has some practical and conceptual limitations. Data on hours worked might be imprecisely recalled and thus misreported by survey respondents. It can also miss effort and work intensity, or career concerns. For example, more effort might lead to a faster career development, higher wages and thus income, without necessarily observing higher hours worked. And unlike for hours worked for primary earners, there is evidence of a positive though moderate response to marginal tax rates (for example, Gruber and Saez, 2002; Saez *et al.* 2012; or Kiss and Mosberger, 2015 and Benczúr *et al.*, 2013 for Hungary). At the same time, some caution is warranted when interpreting taxable income elasticities as labour supply elasticities, since they may also reflect tax evasion. Section 2.2 discusses the relevance of the tax evasion margin for our Hungarian estimates.

Taxable income elasticity estimations typically require administrative tax data. These are less easily accessible than household budget surveys, and the two data sources cannot be merged because of data protection issues. We resolve this limitation by adopting a two-step approach. The first step is the extensive margin adjustment, which is interpreted as a shift in the probability of a full time job (part-time work is very limited in Hungary, as mentioned in Galuščák and Kátay, 2017). The intensive margin, on the other hand, represents work effort, conditional on working. This way, a shock to the aggregate effective labour supply may come from intensive adjustment if, with all employment probabilities held constant, some individuals change their work effort (conditional on employment) or extensive adjustment if, work effort held constant, the probability of work increases for some individuals.

Linking micro and macro models for policy analysis also fits into recent trends in microsimulation modelling. These approaches typically use Computable General Equilibrium (CGE) models to take account of the general-equilibrium effects (see Davies, 2009, for a recent survey). CGE models are complex tools allowing the researcher to model the consumption and labour supply behaviour of one or more representative households, and model the complex interrelations of wages and prices in several sectors of the economy. In most cases, the linked CGE-microsimulation method is used to assess the effects of trade opening, or other large macroeconomic shocks, on the income distribution in developing countries.

There is by now a growing number of applications of micro-macro models to questions of tax policy: an early example is Slemrod (1985), who focused on the incidence and the effects on portfolio choice of a hypothetical flat-rate income tax in the US. Early work used the linked CGE-microsimulation approach to model the effects of corporate taxation (Tongeren, 1994; Plumb, 2001).

There are a few papers that do not employ a CGE framework to close the model. Cameron and Ezzeddin (2000) use a regional input-output model to assess indirect effects of regional and federal tax and transfer policies in Canada, while Lattarulo *et al.* (2003) use a social-accounting-matrix based multiplier approach to model the income distribution of the Italian region of Tuscany. In both of these studies, the micro and the macro, models are fully integrated.

Closest to our focus are recent works on the interactions of labour supply and general-equilibrium feedbacks. Aaberge *et al.* (2004) analyse how endogenous labour supply interacts with long-term fiscal sustainability in Norway; Arntz *et al.* (2008) use such an approach to evaluate a hypothetical welfare reform in Germany; while Fuest *et al.* (2008) and Peichl (2009) simulate the effects of a hypothetical German flat-tax reform. Jongen *et al.* (2014) develop a detailed behavioural microsimulation tool for analysing Dutch tax and benefit reforms.

Barrios *et al.* (2016) extend the EUROMOD model with a behavioural and macroeconomic part, and apply it to various policy changes in Italy, Belgium and Poland. Ayala and Paniagua (2016) adopts a similar approach (with no macroeconomic part) to Spain.

Our approach differs from these studies by using a fully integrated, simple, single-sector macro model to calculate general-equilibrium effects. It has been first outlined in Benczúr *et al.* (2011), then further developed in Benczúr, Kátay and Kiss (2012), and eventually extended to the Czech Republic (Galuščák and Kátay, 2017) and Slovakia (Horváth *et al.*, 2017). Besides contributing to the scant literature on linked micro-macro modelling in transition economies,[5] our approach to micro-macro modelling keeps the macroeconomic model parsimonious and computationally easy.

In a closely related yet markedly different approach, Barrios *et al.* (2016) establish a link between the EUROMOD microsimulation model and QUEST, the European Commission's DSGE modelling suit. In their approach, however, integration is incomplete. The micro model first guides the calibration of and the shock entered into the DSGE model. The implied evolution of wages and employment is then fed back to microsimulation to calculate the distributional and fiscal impacts, but the labour supply response is not reassessed.

The parsimony of our macro model has the advantage that it is easy to see which assumptions and parameters are responsible for the nature of general-equilibrium feedback effects. This is in sharp contrasts with the complexity of most CGE or DSGE models. The parsimony of the macro model also minimizes potential theoretical and practical inconsistencies between the micro and macro models, without the need for aggregating heterogeneous agents into a representative one (as proposed by Magnani and Mercenier, 2009; and also adopted by Barrios *et al.*, 2016). Finally, it allows both models to be fully integrated: information is not restricted to flow only one way (either from the macro model to the microsimulation in a 'top-down' approach, or the other way round in a 'bottom-up' approach). The modules are repeatedly run in an automatic iterative process until they reach full convergence.

The cost of parsimony on the macro side is that shifts among sectors (both in production and in consumption) are ignored. We believe that this cost is significantly lower for our application than it may be in other cases. The interrelations of various sectors (agriculture, formal, informal) are in the very focus of studies on developing countries, especially in the analysis of sector-specific macroeconomic shocks (e.g., trade liberalisation in agriculture). In contrast, sector-specific concerns are not central for our focus, which is the reaction of labour supply to changes in the tax and transfer system and its repercussions for the whole economy. The fact that the Hungarian economy is fully integrated into the European Economic Area reinforces the point that a simple small open economy macro model is appropriate. As Davies (2009, p. 60) puts it: "In the case of national subregions, or countries embedded in free-trade areas, it can be argued that microsimulation may adequately be combined with pure macro models. That is, CGE modelling may not be necessary."

Using our model, we perform three sets of simulations. The first one explores the impact of personal income tax reductions that are identical in cost but different in structure: an across-the-board rate cut, a plain flat

[5] In his survey, Davies (2009, p. 60) makes this point: "Currently, several groups of development researchers are putting these two approaches [microsimulation and CGE modelling] together, and in some cases adding macroeconomic and financial modelling as well. With a few conspicuous exceptions, little such work is being done for the transition economies."

tax, a flat tax with a zero rate at the bottom, and a flat tax with a tax credit scheme at the bottom. The second one compares three different tax shift scenarios: a personal income tax cut financed by a corporate tax hike, a VAT hike, or a transfer tightening. Finally, the third one evaluates actual Hungarian policy measures between 2008 and 2013.

The results from our hypothetical policy simulations show that while a cut in the marginal tax rate of high-income individuals may boost output, it does not have a significant employment effect. On the other hand, programs like the Employee Tax Credit do have a significant employment effect. An across-the-board personal income tax cut financed by a corporate tax hike leads to a very small increase in labour use, but its output effect is negative, driven by the elastic response of capital. If a similar personal income tax cut is financed by a VAT hike, the employment and GDP effects are positive. Transfer tightening seems very effective in boosting employment, since it creates very strong financial incentives for work. It is important to keep in mind though that our model abstracts from potentially important features of transfers like the impact of unemployment insurance duration on matching efficiency, or an increase in poverty. In actual policy considerations, these should also be taken into account.

Simulating the effects of recent actual policy changes, we find that measures passed in the two years before the 2010 elections increase long-run employment and GDP, but there is no significant adjustment at the intensive margin of labour supply. In contrast, measures passed since 2010 produce a large gain at the intensive margin, but employment is expected to increase only due to cuts in the unemployment benefit. Both policy packages are found to substantially increase income inequality in the long run (the contribution of the changes after 2010 is about four times that of the changes before 2010). The cumulative change has the potential to place Hungary at the median of the EU-27, in a marked change from its original ranking as the country with the 6th most equal income distribution.

It is important to note that we find quantitatively large behavioural responses and fiscal feedbacks. For example, different personal income tax cut scenarios with a static revenue cost of 0.3% of GDP can lead to a 0.3-3.2% increase of GDP. At the same time, the static fiscal cost of such packages can turn to a sizable gain in the long run, ranging up to 0.6% of GDP. This is not because of particularly large labour supply elasticities. Instead, it is partly because of the high starting level of non-linearity in the Hungarian tax system, and partly because the reforms we consider are not marginal. The 2010-13 tax reform, for example, has cut the top marginal tax rate from 40 to 20%. The hypothetical reform scenarios were also motivated by actual tax reform debates in 2008-09.[6]

The rest of the paper is structured as follows. In the next section, we give a detailed description of the principles of the model: we describe the data, our approach to modelling labour supply adjustment, and the main elements and some limitations of the small macro model in which the microsimulation is

[6] See, for example, Kátay (2009), available only in Hungarian.

embedded. Section 3 presents results of the simulations, followed by various robustness checks in Section 4. The final section offers some concluding remarks. Some details are presented in the Appendix.

2. DESCRIPTION OF THE MODEL

2.1. Data

The microsimulation model runs on the 2008 wave of the Household Budget Survey (HBS) compiled by Hungary's Central Statistical Office. Though we have access to more recent waves as well, we decided to stick to the last pre-crisis year, where the assumption of the economy being 'in steady state' is more plausible. The data set provides detailed information on nearly 20,000 individuals (including information on their labour market status and income) living in nearly 8,000 households. Our analysis relies strongly on household characteristics when modelling labour supply and eligibility for social transfers. For this reason, we could not base our analysis on tax return data, since these do not include information about household characteristics (not even the number of children).

The HBS, however, comes with a weakness. While it is a representative survey of households living in Hungary along many dimensions, the income distribution of individuals observed in the data set does not exactly match the official tax data. As is reportedly typical of survey data, the top of the income distribution is underrepresented. A possible solution to this problem is the matching of datasets: a multiple matching between individual tax returns and individuals observed in the survey is a method often used to resolve this problem. Our approach to correct the wage distribution is different but has a very similar effect. Before the actual microsimulation, we include a wage-correction stage. This is done by comparing, percentile for percentile, the average gross wage income of individuals in the HBS and in tax return data for 2008. For most of the income distribution, the differences between both data sets are not large (less than 10%). The difference, however, grows bigger in the top 10% of the income distribution, reaching almost 50% in the top percentile. Thus, in the top part of the distribution we multiply the wage income of individuals in the HBS by a percentile-specific factor to match the wage income distribution in the tax return data. (The method is robust to the choice of the lowest percentile included in the correction; it is important, however, that the top 30 percentiles are included.) This step makes the static fiscal assessments based on our microsimulation model reliable.

2.2. Microsimulation

The behavioural microsimulation model takes into account two types of behavioural adjustment on the individual level: labour supply response at the intensive and extensive margin. Labour supply response at the intensive margin means that individuals change their work intensity (hours, work effort, etc.) after a change in their marginal or average tax rate. The general view is that such a behavioural response exists for high-income earners (mostly in response to marginal rate changes) but less in the lower ranges of the income distribution. Labour supply response at the extensive margin means that an individual exits the labour force if the financial gains to market work decrease (and vice versa). The general view is that this type of behavioural adjustment is more significant in the case of secondary earners, low-income earners, women with children, young workers and the elderly. For an overview of such findings, see, e.g., Meghir and Phillips 2010.

In this paper, the labour supply response at the intensive margin is calibrated based on estimations by Kiss and Mosberger (2015) of the elasticity of taxable income with respect to the tax rates. They employ administrative tax data and estimate the compensated elasticity of taxable income with respect to the marginal net-of-tax rate to be approximately 0.2 for high earners. We apply this elasticity to the top fifth of wage earners; lower-income households are assumed to have no labour supply response at the intensive margin (Bakos *et al.*, 2008 and its updated estimates reported in Benczúr *et al.*, 2013 provide estimations that support this type of dependence of the elasticity on income). Robustness of the results with respect to these elasticities is investigated in Section 4.

A note is in order about the interpretation of the taxable-income elasticity as labour-supply response. Some studies (especially in the U.S.) found that part of the response in taxable income to taxation is due to tax optimisation (through itemised deductions) and has, therefore, little to do with additional real economic activity. For Hungary, however, there are good reasons to view the taxable income elasticity as labour-supply response. First, itemised cost deductions are negligible in the Hungarian personal income tax system. Correspondingly, the existing estimations on Hungarian data are lower than taxable-income elasticities estimated in the US. Second, Kiss and Mosberger (2015) present additional indirect evidence that supports this interpretation. Firstly, their estimated elasticity does not differ significantly between those individuals who have wage income only and those who have multiple sources of income (dividend, entrepreneurial income, etc.). Plausibly, the former group has less opportunity for tax avoidance and evasion. Secondly, they find no support for income shifting in the tax-reform episode they investigate.

The labour supply response at the extensive margin is calibrated based on the estimations of Galuščák and Kátay (2017). They pool eleven consecutive waves of the HBS to estimate a standard discrete choice structural labour supply model for Hungary (and also for the Czech Republic). In this framework, originally proposed by van Soest (1995), individuals choose between a discrete set of hours of work yielding different utilities. As part-time work is relatively rare in Hungary (less than 5% before the crisis), only two labour-market states are considered: full time work (or seeking full time work) and inactive. Assuming that the utility U_{ij} that individual *i* derives from choosing full-time work (*j=1*) or inactivity (*j=0*) is represented by a random utility model of the form $U_{ij} = V_{ij} + \varepsilon_{ij}$, where V_{ij} is a deterministic term and ε_{ij} is an i.i.d. type I extreme value distributed random term, the probability of being economically active is given by:

$$P_{i,j=1} = P\left[V\left(c_{i1}, 1-l_1, Z_i, \theta, \eta_1\right) - V\left(c_{i0}, 1, Z_i, \theta\right) > \varepsilon_{i0} - \varepsilon_{i1}\right].$$

Here V_{ij} is conditional on the individual's net disposable income if he works full time (c_{i1}) or if he stays out of the labour force (c_{i0}), leisure ($1 - l_1$, with total time endowment normalised to 1), a vector of individual characteristics Z_i and preference parameters θ, and fixed costs of work η_1. With only two labour market states, the participation decision is a simple logit model that can be estimated using standard maximum likelihood techniques.

The study finds that the labour supply response at the extensive margin is strongest for low-wage groups and married women. Table A1 reports the conditional marginal effects relevant for the present study.[7]

To assess the order of magnitudes of these extensive margin effects, it is instructive to compare them to the 'consensus' 0.25 value of aggregate (steady state) net wage elasticity reported by Chetty *et al.* (2013). The net wage marginal effects in Table A1 are somewhat larger, but they are not directly comparable: the reported marginal effects indicate the effect of one percent increase in net wage on the probability of being active (or on the participation rate) in *percentage points*, as opposed to the elasticity measures in Chetty *et al.* (2012) indicating the *percentage change* in employment to the same shock. To produce the equivalent of the exercise by Chetty *et al.* (2012), one needs to increase the net wage of all individuals by 1% and look at its employment or participation effect. The resulting 0.28% increase in participation implies an elasticity of 0.28, quite in line with the consensus value.

To further study the impact of transfer reforms on the extensive margin, we report the result of an additional labour supply simulation exercise. We simulate the effects of the cut in maternity benefit comparable to the one that took place in 1995. Köllő (2009) found a positive though often insignificant effect of this measure on the activity of mothers with infants, while Szabó-Morvai (2013) found a negative though delayed effect of the reversal of the reform. Our estimates imply a 0.09% increase in total employment, which corresponds to a roughly 1.02% increase in employment of the target group (women with children).[8] This is consistent with a positive but statistically not always significant treatment effect.

The labour-supply response at the extensive margin is implemented in the microsimulation the following way. Every individual of working age is assigned an individual-specific baseline activity probability based on the underlying logit estimates (and not on some group-specific conditional marginal effect) of Galuščák and Kátay (2017). The labour-supply response at the extensive margin is modelled as an adjustment of this probability after any change to the tax and transfer system. This procedure means that we must simulate,

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[7] Galuščák and Kátay (2017) also report results for a "reduced form" or "gains-to-work model", in which the probability of being active depends on the net income an individual can achieve when out of work and the "financial gains to work", i.e. the change in disposable income due to taking up a full-time job (which equals the net wage minus lost transfers). Such an approach also requires an integrated microsimulation tool, to assess the counterfactual values of income: the transfers that the currently active would get if they quit or lose their job, and the transfers the currently inactive would lose if they took up work. The estimated elasticities for this model are very similar to those obtained with the standard structural model. We performed all simulations presented in this paper using this alternative labour supply model. The simulation results are very close to our baseline findings. For the sake of brevity, these results are not presented in the paper, but are available from the authors upon request.

[8] According to 2008 values in our database, total employment is 4,080,525. A 0.09% increase adds 3,672 to the employed population, which is 1.02% of all the mothers with infants (a group of about 360,000).

for every working individual, what transfers they would receive if they did not work and, for every inactive individual, how much extra income (net of taxes and including potentially lower transfers) they would earn if they did choose to work (gains to work). Aggregate effective employment of the economy is then equal to the sum of (potential) gross hourly wages of all individuals weighted by their employment probability. This latter is measured as individuals' participation probabilities minus their group-specific unemployment probabilities conditional of being active. This implicitly assumes that labour is homogenous, and relative wages reflect relative productivities.

This formulation of the extensive margin means that the intensive response is reinterpreted as well: it represents work effort, conditional on working. In sum, a shock to the aggregate effective labour supply may come from intensive adjustment if, with all employment probabilities held constant, some individuals change their work effort (conditional on employment) or extensive adjustment if, work effort held constant, the probability of work increases for some individuals. Our model is programmed in a way that extensive and intensive adjustment can be switched on or off independently from each other.

The microsimulation proceeds in the following steps: (1) given the changes in the tax and transfer system, a static microsimulation is conducted first.[9] It calculates how much each individual gains (or loses) as a consequence of the changes. It also calculates the changes in the marginal and average effective tax rates (relevant for the intensive-margin response), the gains to work and the hypothetical amount of transfers one would get at zero hours worked (relevant for the extensive-margin response). (2) These updated measures are fed back to the participation logit estimation (yielding a change in the individuals' probability of being active) and to the intensive-margin response (effective hours worked conditional on being employed). Summing up over individual changes in labour supply, the aggregate labour supply shock is obtained. (3) This is fed into the macro model, which calculates general-equilibrium effects on wages and the capital stock. (4) Based on the general-equilibrium change of the wage level, the microsimulation is repeated. This iterative process is repeated until convergence; that is, until the general equilibrium of the economy is consistent with the reform-induced labour supply shock.

2.3. General equilibrium

The general-equilibrium macro model is a long-run model of a small open economy. Thus, capital supply is almost perfectly elastic. Capital and labour are paid their marginal products, according to a constant-returns-to-scale production function. This minimalistic, very general structure makes the model tractable, transparent, nesting the steady state of many complex DSGE models as well. In the following, we sketch the main ingredients of the model, with further details presented in the Appendix. Since the labour supply shock comes from microsimulation and we are not interested in the change in sectoral consumption patterns, the general-equilibrium model does not detail the household side.

[9] Our static microsimulation module partly builds on a tax-benefit model created by Benedek, Elek and Szabó (2009).

The production function of the representative firm exhibits constant elasticity of substitution (CES).[10] The profit-maximisation problem of firms can be formulated as:[11]

$$\max\left(\alpha K^{\beta}+(1-\alpha)L^{\beta}\right)^{\frac{1}{\beta}}(1-\tau_s)-w(1+\tau_W)L-\frac{r}{1-\tau_K}K.$$

Here, τ_s is the effective tax rate on sales (representing, in the baseline, the effects of the local business tax), w is the gross wage, τ_W is the rate of employer-side social security contributions (equivalent to a payroll tax), τ_K is the effective tax rate on capital and $\frac{r}{1-\tau_K}$ is the net user cost of capital.

The model is closed by the equation that determines the aggregate supply of capital. Capital is provided by an international capital market. Its supply is modelled in a reduced form: $\widehat{K}=\eta\hat{r}$, where η is the elasticity of capital supply *K* with respect to the after-tax rate of return *r* (and $\hat{x}$ denotes the percentage change of variable x).

To interpret the comparative statics implied by this stylized macro model, let us first look at the case of perfectly elastic capital supply ($\eta=\infty$). In this case, the domestic rate of return is pinned down by the international rate and is thus constant ($\hat{r}=0$). The capital-labour ratio must also stay constant which, in turn, implies that wages will also stay constant (perfectly elastic labour demand). We thus get the usual result that with perfectly elastic capital supply the capital stock adjusts to shocks, so that the capital-labour ratio and factor prices can return to their equilibrium values. For example, if there is a positive labour-supply shock following a tax cut, capital accumulation will follow in identical proportion, so that a new equilibrium is reached with an unchanged capital-labour ratio.

If capital is calibrated to be imperfectly elastic (which will be the case in our baseline), wages will decrease and the return on capital will increase somewhat after an increase in aggregate labour supply. While capital accumulation will mitigate these effects, it will not neutralise them completely.

The model is calibrated using data from national accounts, fiscal statistics and previous estimations (Kátay and Wolf, 2004 in particular). The Appendix contains all the details of the procedure.

2.4. Limitations

Based on a limited set of ingredients (most importantly the estimated behavioural elasticities and the small-open economy macro framework), the model is able to give an assessment of the long-term effects of changes of the tax and transfer system to the macroeconomy and the government budget. However, to ensure its tractability and transparency, one has to accept some simplifications.

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[10] Previous estimations of factor demand and the substitutability between labour and capital rejected that the Cobb-Douglas production function can be used. See Kátay and Wolf (2004) for an estimation of the demand for capital.
[11] We write the firm's problem in net terms, so it does not contain the value-added tax (VAT). The VAT is, however, included in the net wage entering the labour supply decision.

(1) The model is suitable for comparative statics exercises. The dynamics of the adjustment path from pre-reform to post-reform steady state equilibrium is not modelled.
(2) Since the model is supply-driven, the consumption-savings decision of households is not modelled. Economic growth is determined by the supply of labour and capital. The consumption decision affects our results in only one way: it affects the fiscal effects through the VAT. Our simplified assumption that all disposable income is consumed by households admittedly results in the (short-run) overestimation of the VAT effect of policy measures.
(3) The model is not closed on the side of government. Budget balance is not enforced either directly or by an assumption that higher debt results in higher interest rates paid on government debt. This simplification is innocuous if the policy measures analysed are approximately budget neutral or small in magnitude; or the objective is to perform a technical projection (no other policy change). Otherwise, the macroeconomic effects estimated by the model are overly optimistic in the case of measures that weaken the position of the government budget, and vice versa.
(4) The search-and-matching mechanisms on the labour market are not modelled explicitly. If a policy measure changes the equilibrium unemployment rate of any demographic or skill group, the model will not take this into account. It might be, for instance, that shortened eligibility for unemployment benefits, in addition to strengthening job-search incentives, reduces the success rate and average quality of matches between job openings and the unemployed. In this case the long-run employment and the output effect of the transfer cut will be overestimated by the model. Horváth *et al.* (2017) extends a similar modelling framework with a search and matching block, and estimates the model for Slovakia. Overall, their results are not affected strongly by the incorporation of a job search mechanism.

3. SIMULATION RESULTS

We present results from three sets of simulations. First, we analyse four different versions of a personal income tax (PIT) cut. Second, we analyse three complex hypothetical policy packages that are approximately revenue neutral in the absence of behavioural responses. Third, we analyse actual changes of the tax and transfer system between 2008 and 2013. In this latter case, we complement the analysis by simulating the long-run value of certain inequality measures before and after the reforms, and also identify winners and losers of reforms by income quintiles.

Tables 1 to 3 in this section contain two main panels (Table 3 has an additional one, showing distributional effects). The first panel shows the macroeconomic effects: figures are to be interpreted as percentage changes of macroeconomic variables *in levels* as compared to the scenario with no change in legislation. For example, Table 1 indicates that an ‘across-the-board’ tax cut would increase the level of long-run GDP by 0.37%.

The second panel in each table presents the fiscal effects: the unit of these figures is billion Hungarian forints (HUF) at 2008 prices. To facilitate the interpretation of these figures we note that, on average, 1 EUR was equivalent to about HUF 270 during the period 2008-2011. Therefore, a tax package that costs HUF 95 billion is the equivalent of about EUR 0.35 billion (or about 0.35% of Hungary's GDP in 2008).

The tables below show the *static* and *dynamic* effects of various policy packages. The static effect is calculated before the labour supply reaction of individuals (or any macroeconomic adjustment) takes place. It is however assumed that additional disposable income is consumed by households: static fiscal effects therefore include an indirect VAT effect. While this is a technical assumption that is plausible in the long run, for realistic short-run fiscal assessments the VAT effect has to be discounted. Dynamic effects include all the adjustments: a labour supply response of individuals at the intensive and extensive margins and general-equilibrium macroeconomic effects.

Table 1 shows the static and dynamic effects of three scenarios in which PIT revenues decrease by about HUF 95 billion (or 0.35% of GDP) before behavioural changes. All three scenarios are defined as changes relative to the 2008 PIT system. In 2008, there were three tax brackets in the Hungarian PIT. The lower rate was 18% and applied to income up to approximately the average yearly income; a rate of 36% applied to income above that up to the pension contribution ceiling; and a rate of 40% applied to income above that. Besides the PIT, individuals paid social security contributions at a rate of 17% up to the pension contribution ceiling and 7.5% above that. In 2008 the employee tax credit (ETC; in Hungarian: *adójóváírás*) reduced the PIT liability of individuals earning the monthly minimum wage (HUF 69,000 ≈ EUR 250) to almost zero. The ETC was phased out at a rate of 9% around the average yearly income.

In the first scenario of Table 1 ('across-the-board PIT cut'), all three PIT rates are reduced by 1 percentage point. In the second scenario, an entirely flat tax system with a 20.1% rate is introduced. In the third scenario, a 0% tax rate applies to income up to the minimum wage, and a rate of 31% to income above that (in this scenario the ETC is eliminated). In the fourth scenario, a single basic tax rate applies to all taxpayers (26.2%), but there is an ETC that makes the minimum wage PIT-free and is phased out roughly similarly to the actual 2008 ETC. The parameters of the scenarios were adjusted so that all four have a direct fiscal cost (not counting the indirect VAT effect) of about HUF 95 billion (the parameters of the PIT scenarios are summarised in Table A2 of the Appendix).

Table 1 shows that different ways of reducing the PIT burden have starkly different aggregate effects. It immediately implies that inserting a change in an economy-wide average tax rate (tax revenues per tax base) into a standard macro model would be highly misleading. In terms of the employment effect, it is only positive in the first scenario, while it is most negative in the plain flat-rate scenario.[12] This means that those tax reforms will have a positive employment effect that keep the average tax rate low for low earners. The most significant employment gain is observed in the case of the 'across-the-board' tax cut (a gain of 0.27%),

[12] For a larger tax rate reduction package, the employment effects would turn positive but their ranking would remain similar.

since in this scenario the average (and marginal) tax rate is lowest for low-income earners above the minimum wage, influencing their financial gains to work positively. The finding that employment gains depend mostly on the average tax burden of low incomes is consistent with the fact that in Hungary, as in most countries, inactivity is concentrated among the low-skilled groups, thus their incentives for participation matters most for employment.

Table 1. Personal income tax scenarios

	Across-the-board PIT cut		Flat tax (20.1%)		2 tax rates (0% + 32%)		1 tax rate (26.2%) + tax credit	
	Macroeconomic impact (%)							
Effective labour	0.39		3.38		1.00		1.55	
Employment	0.27		-0.33		-0.19		-0.17	
Capital stock	0.32		2.76		0.82		1.25	
GDP	0.37		3.16		0.94		1.44	
Average gross wage	-0.04		-0.26		-0.07		-0.13	
Disposable income	1.25		3.39		1.67		2.03	
	Fiscal impact (Billion HUF)							
	static	dynamic	*static*	dynamic	*static*	dynamic	*static*	dynamic
Personal income tax	*-94.2*	-86.8	*-102.1*	-47.5	*-98.7*	-71	*-96.5*	-63.7
Employee contributions	*0*	4	*0*	35.2	*0*	10	*0*	14.8
Employer contributions	*0*	9.9	*0*	86.4	*0*	25.7	*0*	40
Taxes on consumption	*17.1*	20.1	*19.8*	54.8	*17.9*	27	*17.7*	32.9
Taxes on capital	*0*	2.3	*0*	20.2	*0*	6	*0*	9.2
Taxes on sales	*0*	1.7	*0*	14.7	*0*	4.4	*0*	6.7
Transfers	*0*	4	*-0.3*	-1.3	*0*	-3.4	*0*	-2.4
Change of budget balance	*-77.1*	-44.8	*-82.6*	162.5	*-80.8*	-1.3	*-78.8*	37.5

Note: The upper panel of the table shows percentage changes of macroeconomic variables in levels. The bottom panel shows fiscal effects in HUF billion expressed in 2008 prices. (Positive numbers indicate an improvement of the government balance. In 2008, nominal GDP was HUF 26,545 billion. During the period 2008-2011 the exchange rate was EUR 1 ≈ HUF 270.) Static effects are short-run, immediate effects with no behavioural adjustment, but with all extra income consumed. Dynamic effects include labour supply reaction of individuals as well as long-run, general-equilibrium macroeconomic effects. The VAT estimate is based on a simplifying assumption.

The ranking of the four scenarios is very different with respect to the incentives of top earners. Effective marginal tax rates were relatively high in Hungary in 2008 and a one-percentage point across-the-board tax cut of the first scenario does little to change that: the 0.39% increase of effective labour comes almost exclusively from the adjustment at the extensive margin. In contrast, in the other three scenarios individuals in the top 20% of the income distribution increase their labour intensity so that aggregate effective labour increases by 3.38% (flat-tax scenario), 1% (two-rate scenario) and 1.55% (single-rate scenario with ETC).

Since the only macroeconomic shock here is the labour supply shock, GDP and the capital stock adjusts almost perfectly in proportion to the effective labour supply. This improves public finances in the long run relative to the static effect (as can be seen in the bottom panel of Table 1).

These results illustrate that the ranking of scenarios depends on the criteria used. While an across-the-board tax cut has the highest employment effect (since, unlike the three other scenarios, it decreases the tax burden of low- and middle income individuals), the scenario with a flat tax performs best in terms of GDP. The across-the-board tax cut comes in last according to this criterion. The two-rate system without ETC is dominated by the single-rate system with ETC in every aspect. Both the two-rate system and the ETC keep the average tax rate zero at the minimum wage, but the ETC is less costly. This relative budget surplus can be used for lowering marginal tax rates for high earners, which creates additional incentives at the intensive margin and therefore stimulate the economy.

Table 2 shows three scenarios that are approximately revenue neutral in their direct static effect. Each scenario is the combination of two measures: one that costs about HUF 95 billion and another that improves the government balance by about the same amount. All scenarios are hypothetical but are similar to policies proposed or enacted in Hungary in recent years. In the first scenario we introduce the across-the-board PIT cut (as analysed above) and balance the budget by increasing the effective tax rate on capital earnings (equivalent to an increase of the corporate income tax, CIT). In the second scenario, we introduce the same across-the-board PIT cut and finance it by an increase in the VAT.[13] In the third scenario, the labour tax cut is financed by a roughly 33% overall cut in transfer payments.[14]

In the first scenario, the employment gain of the PIT cut is neutralised by the increase in the effective tax rate on capital. The overall effect on GDP is negative which makes the government balance deteriorate through the dynamic effects. This is a reflection of the fact that in this long-run open-economy model the capital stock adjusts very sensitively to the rate of return on capital.

The second scenario shows that the positive effect of a PIT cut more than counterbalances the negative effect of a comparable VAT increase. Although disposable income declines significantly, the overall effect of a VAT increase is rather limited (compare the first column of Table 1 to the second column of Table 2). Most of the adjustment takes place at the intensive margin; the employment rate remains almost the same. Unlike PIT, the VAT also affects non-taxable benefits and other non-labour income, i.e. the purchasing

[13] As discussed already in the context of Table 1, the static revenue effect of this scenario includes the increase in VAT revenues due to the PIT cut (HUF 17.1 billion, like in the previous scenario). The direct VAT revenue increase is thus 115.7-17.1=98,6 billion, indeed just balancing the cost of the PIT cut.

[14] All transfer payments (maternity, unemployment and social support) are decreased by 33%, including their minimum and maximum amounts. Its gross effect is HUF 108.3 billion, while the net fiscal effect is HUF 94.3 billion (including decreased employee contribution revenue on transfer payments).

power of non-employed individuals. As a consequence, the negative substitution effect of a VAT increase is at least partly counterbalanced by a positive income effect.

Table 2: Tax shift scenarios with a neutral direct fiscal effect

	Capital tax increase + labour tax cut		VAT increase + labour tax cut		Transfer decrease + labour tax cut	
	Macroeconomic impact (%)					
Effective labour	0.06		0.28		1.58	
Employment	0.08		0.24		2.01	
Capital stock	-2.82		0.21		1.31	
GDP	-0.95		0.26		1.49	
Average gross wage	-1.27		-0.03		-0.12	
Disposable income	0.38		-0.17		0.84	
	Fiscal impact (Billion HUF)					
	static	dynamic	*static*	dynamic	*static*	dynamic
Personal income tax	*-94.2*	-130.9	*-94.2*	-89.6	*-94.5*	-76.7
Employee contributions	*0*	-14.9	*0*	2.8	*-14*	1.8
Employer contributions	*0*	-32.9	*0*	7.1	*0*	39.4
Taxes on consumption	*17.1*	6.1	*115.7*	117.9	*0.1*	13.6
Taxes on capital	*93.6*	80.3	*0*	1.6	*0*	9.5
Taxes on sales	*0*	-4.4	*0*	1.2	*0*	6.9
Transfers	*0*	1.3	*0*	3.5	*108.3*	131.3
Change of budget balance	*16.5*	-95.4	*21.5*	44.5	*-0.1*	125.8

Note: The upper panel of the table shows percentage changes of macroeconomic variables in levels. The bottom panel shows fiscal effects in HUF billion expressed in 2008 prices. (Positive numbers indicate an improvement of the government balance. In 2008, nominal GDP was HUF 26,545 billion, while during the period 2008-2011 the exchange rate was EUR 1 ≈ HUF 270.) Static effects are short-run, immediate effects with no behavioural adjustment, but with all extra income consumed. Dynamic effects include labour supply reaction of individuals as well as long-run, general-equilibrium macroeconomic effects. The VAT estimate is based on a simplifying assumption.

In the third scenario, the model predicts that restricting transfer payments increases employment by 1.74% (compare the third column of Table 2 to the first column of Table 1), and it also boosts GDP considerably. However, it is important to note that transfer payments (unemployment benefits in particular) may have important effects that are not incorporated in our model. For example, the shortening of the unemployment benefit period will make the individuals want to find a job earlier and therefore they increase their labour supply, but a shorter job-search period may also impair the quality of employee-employer matches. Furthermore, such a policy may have adverse effects on income inequality and poverty.

In the last set of policy packages analysed, Table 3 shows the simulated effects of changes to the tax and transfer system that actually took place from 2008 to 2010 and from 2010 to 2013.[15] As elections were held in 2010, these columns correspond to changes passed by the Socialist majority in the legislature before the elections and the Conservative majority after the elections.

During the period from 2008 to 2010, there were some changes in the transfer system (both the so-called thirteenth-month pension payments and sick leave payments were cut) but these do not enter into our simulations as they do not have a significant effect on the labour supply choice of individuals. At the same time, the following tax policy changes took place. The VAT was increased from 20% to 25% (which translates in our model to an increase of the effective consumption tax rate from 18.2% to 19.4%), partially paying for a five-percentage-point cut in employer contributions (from 32% to 27%). At the same time, PIT rates were adjusted so that middle-income taxpayers got a notable tax relief. In particular, the three tax brackets were consolidated into two, with the upper limit of the lowest tax bracket increased significantly. The rates increased slightly in the meantime: the lower tax rate became 21.6% (instead of 18%) while the upper tax rate 40.6% (instead of 36% and 40%).

During the period 2010 to 2013, the most important change affecting the transfer system was the shortening of the maximum period of unemployment benefits from 12 months to 3 months. The changes to the tax system included a radical cut in the top PIT rate (from 40.6% to 20.3%), a large expansion of the child tax credit, a 1.5 percentage point increase in the employee contributions and a further increase of the VAT to 27% as well as significant increases in excise taxes (taken into account, similarly to the VAT, in the effective tax rate on consumption). The ETC was eliminated in 2012, to be replaced by an employer-contribution relief for young, old and unskilled employees starting in 2013. At the same time, a CIT cut took place, counterbalanced by extraordinary (‘crisis’) taxes on the banking and telecommunication sectors as well as large retail companies. We fed these changes into the model by changing the effective tax rate on capital from 7.3% to 6.2%. In calculating this, we took into account only that part of the extraordinary taxes that are to be made permanent, based on the stated intentions of the government (i.e., about one-third of the bank tax). A further sectoral tax, passed into law in 2012, is to be levied on bank transactions starting from 2013. We accounted the bank transaction tax partly as a tax on consumption, partly on sales as it is paid by businesses, too. Altogether, we estimate that the effective tax rate on consumption increases from 19.4% in 2010 to 23.2% in 2013; while the effective tax rate on sales increases from 1.65% in 2010 to 2.28% in 2013. The exact parameters used in the simulations of actual changes between 2008 and 2013 are summarised in Table A3 of the Appendix.

In both periods 2008-2010 and 2010-2013, Parliament enacted legislation that restricted retirement. In 2009, the regular retirement age was increased from 62 to 65 (the transition occurring between 2014 and

[15] The 2013 scenario takes into account measures announced until August 2012.

2022). A law passed in 2011 restricts the possibilities of retiring before the official retirement age with some occupational exceptions (although rules became stricter even for the occupational groups with a special treatment). These reforms are, however, difficult to incorporate into our modelling framework, so we decided not to quantify their effects.

Table 3 shows that while both periods saw a net cut in PIT and employer contributions, and an increase in the effective consumption tax rate, this was accompanied by different measures in other parts of the tax and transfer system. Measures between 2008-2010 had a negative overall static fiscal effect of about HUF 576 billion (about 2.2% of GDP), although savings not accounted for in our simulations counterbalanced these measures to a large extent. In contrast, measures in the period 2010-2013 have an approximately neutral static fiscal effect, with cuts in the unemployment benefit, increases of employee contributions and taxes on sales and consumption making up for foregone PIT revenue.

Table 3 also shows that the policy packages of both periods differ in their macroeconomic effect. Mainly due to the cut in employer contributions, the changes between 2008 and 2010 increase long-run employment by 1.24% and GDP by 0.97%. Since top marginal rates remained unchanged during this period, there is less adjustment at the intensive margin. In contrast, the combination of cuts in the CIT, PIT and unemployment benefits in the period 2010-2013 are estimated to increase long-run employment by 2.12% and the long-run level of GDP by 5.18%. Here, the employment effect is entirely due to the cuts in unemployment benefits. Since the PIT cuts are concentrated at high incomes, they increase effective labour supply, and thus GDP, but employment to a much smaller degree. The employment effects of the elimination of the ETC and the introduction of targeted employer contribution relief roughly cancel out.

When interpreting the simulated effects of the policy package of the period 2010-2013, we must note that there is serious uncertainty about a number of measures including those that are to come into effect only in 2013 (especially the targeted employer contribution relief and the bank transactions tax). Also, the phasing-out of temporary 'crisis taxes' is far from complete, which means that we might underestimate the current effective tax rate on capital and its expected future value as perceived by capital owners.

When analysing the 2008-2013 tax and transfer packages, we also evaluated measures of inequality and the incidence of the gains and losses. The inequality measures, resulting from a dynamic simulation, are shown in the bottom of Table 3. They correspond to equivalised disposable household income per capita. It is important to note that our reported inequality measures for the 2008 baseline are obtained using predicted transfers and – for non-employed individuals – wages, to ensure their comparability with the simulated values for 2010 and 2013. This leads to an overestimation of the 2008 Gini coefficient (which was 25.2, according to Eurostat data).

Table 3: Long-run effects of actual changes of the tax and transfer system

	2008-2010		2010-2013	
	Macroeconomic impact (%)			
Effective labour	1.01		5.05	
Employment	1.24		2.12	
Capital stock	0.90		5.42	
GDP	0.97		5.18	
Average gross wage	4.45		2.18	
Disposable income	3.60		1.92	
	Fiscal impact (Billion HUF)			
	static	dynamic	*static*	dynamic
Personal income tax	*-309.8*	-189.5	*-404.4*	-312.5
Employee contributions	*134.7*	208.9	*105.4*	211.7
Employer contributions	*-522.6*	-395.5	*-294.9*	-151.9
Taxes on consumption	*138.9*	194.5	*397*	502.5
Taxes on capital	*0*	6.2	*-103*	-66.7
Taxes on sales	*-24.1*	-19.9	*168.6*	200.1
Transfers	*6.8*	23	*114.3*	129.8
Change of budget balance	*-576.1*	-172.3	*-17*	513
	Impact on income inequality			
	2008		2010	2013
Gini index	27.18		28.07	32.04
P90/P10	3.12		3.33	3.78
P90/P50	1.76		1.84	2.01
P50/P10	1.78		1.81	1.88

Note: The upper panel of the table shows percentage changes of macroeconomic variables in levels. The middle panel shows fiscal effects in HUF billion expressed in 2008 prices. (Positive numbers indicate an improvement of the government balance. In 2008, nominal GDP was HUF 26,545 billion, while during the period 2008-2011 the exchange rate was EUR 1 ≈ HUF 270.) Static effects are short-run, immediate effects with no behavioural adjustment, but with all extra income consumed. Dynamic effects include labour supply reaction of individuals as well as long-run, general-equilibrium macroeconomic effects. The VAT estimate is based on a simplifying assumption.

Table 3 shows that both sets of tax policy changes increase income inequality: the long-run Gini index is estimated to increase by somewhat less than a point (from 27.18 to 28.07, a 3.27% increase) due to the changes up to 2010 and by a bit less than four additional points (to 32.04, an additional 14.14% increase) due to the changes up to 2013.

This is a truly significant increase in inequality. The same cumulative percentage increase in Hungary's original 25.2 Gini coefficient would have taken the country from the sixth lowest position (after Slovenia, Slovakia, Sweden, the Czech Republic and Denmark) to the median (29.71). The actual 2013 and 2014 Gini values were 28.3 and 28.6, both at the eleventh lowest position.

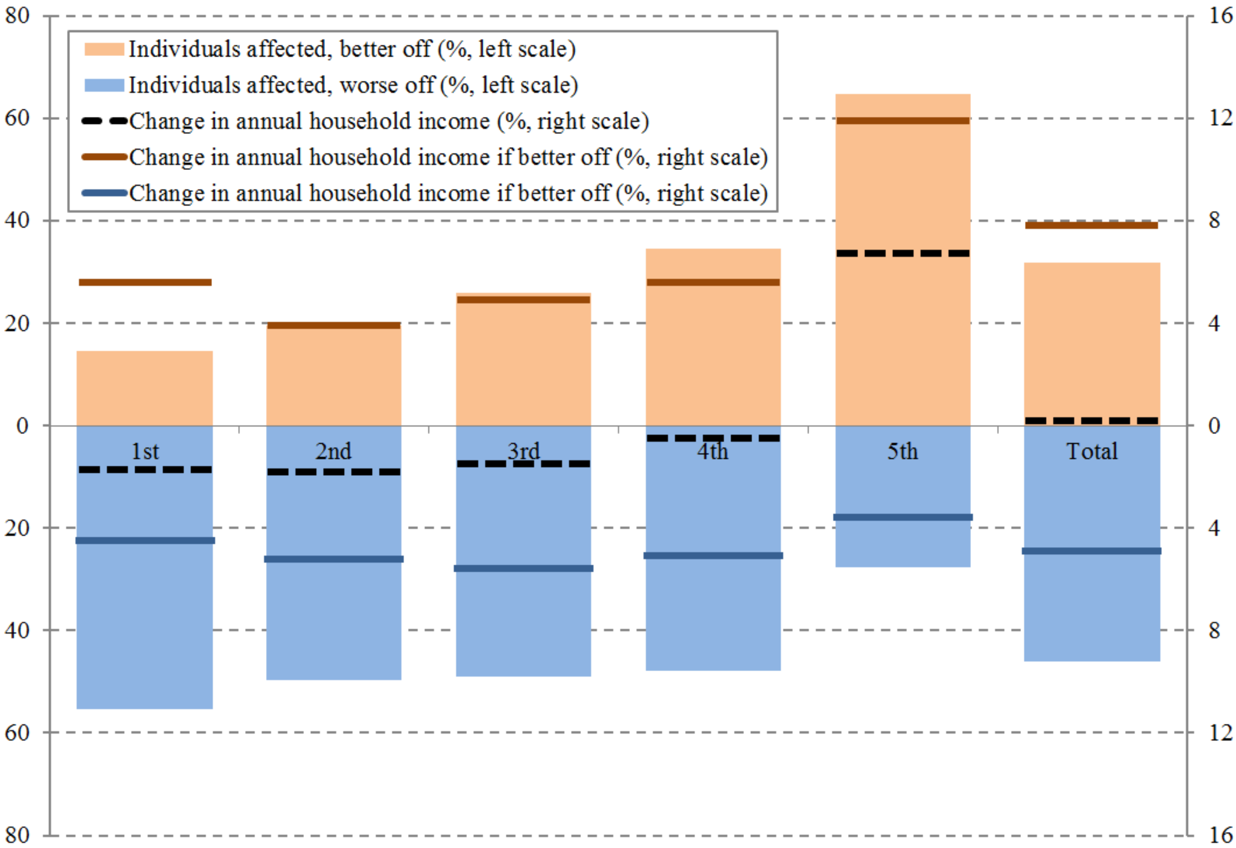
The other three inequality measures in Table 3 also show growing income inequality but they also help to identify which part of the income distribution the change comes from. The measure P50/P10 shows that the gap between the median earner and individuals around the 10th percentile of the income distribution grows only a little as a consequence of the reforms. There is more significant growth in the gap between the 90th percentile and the median. There is an interesting difference between the development of this measure and the Gini index. While the increase in the P90/P50 ratio is more concentrated to the second period, this applies much more to the increase in the Gini coefficient. This reflects the fact that the 2010-2013 cut in top marginal tax rates caused an increase in income inequality even *within the top 10 percent*, a development that is not captured by the P90/P50 measure.[16]

Another way microsimulation can help us analyse the distributional effects of tax and transfer changes is to calculate the average gains and losses of certain types of households in the population. Figure 1 reports the static results of such an exercise based on the 2010-2013 policy package (that included a tax cut for high-income earners, a significant extension of the child tax credit, the elimination of the ETC affecting low and middle-income earners, and a cut in the unemployment benefit). We divided households into quintiles based on equivalised income (household income corrected for household size and composition according to the modified OECD equivalence scale) and asked the following questions: How many individuals live in households in a given income quintile who gained (lost) as a consequence of the reforms? How much in average annual income did households gain (loose) as a consequence of the reforms? The results presented are static: they were calculated without any behavioural response.

The last column of Figure 1 shows that the 2010-2013 policy package made more individuals worse off than better off, and that the winning households gained more than what the losing households lost. In absolute numbers, about 4.5 million individuals live in households that were made worse off while about 3.1 million individuals live in households that were made better off. The average gain of a household made better off is about HUF 444 thousand (about EUR 1640) while the average loss of a household made worse off is about HUF 124 thousand (about EUR 450). The average of the change in annual income is slightly positive.

Figure 1: Static simulation of the incidence of actual changes, 2010-2013

[16] Our percentile ratios are similar to the ones published by Eurostat for 2008: According to Eurostat data, the P90/P50 ratio was 1.70 while the P50/P10 was 1.76.



Note: Household quintiles defined based on equivalised income

Figure 1 also presents the average gains and losses by quintile. Column 5 shows that only households in the top quintile are clear winners of the changes, while the bottom three quintiles suffered an overall income loss. The effect on the fourth quintile was approximately neutral: the average of the change in annual income is near zero but negative.

Information about the gains and losses within quintiles reinforces the notion that gains from the tax changes are concentrated in the top of the income distribution. There are more than twice as many winners than losers in the top quintile, while in each of the bottom four quintiles the losers outnumber the winners by far. In addition, winners in the top quintile gained around 12% of their total annual net income, while winners in the lower quintiles increased their net income by about 4-5.5%. The fact that there are winners and losers in all quintiles reflects another significant element of the 2010-2013 tax changes: a redistribution of income from families without children to the ones with children. This redistribution is the effect of the extension of the child tax credit (in 2011) and the elimination of the ETC (in 2012).

The immediate distribution effects shown in Figure 1 are likely to be dampened in the long run by the targeted employer contribution relief passed into law in 2012, to the degree that it is passed on to the employees in their gross wages. However, this is a dynamic effect that cannot be taken into account in this static ('on-impact') simulation.

4. ROBUSTNESS OF THE RESULTS

We perform two sets of robustness checks. The first focuses on how the simulated effects of the 2010-2013 policy package depend on the behavioural labour supply elasticities underlying the analysis. The second exercise focuses on the robustness of the results to the calibrated macro parameters.

Table 4 shows the effects of the 2010-2013 policy package under different behavioural assumptions. In this table, each column corresponds to a separate run of the microsimulation model, while the rows correspond to the most important macroeconomic and fiscal variables.

Table 4: Robustness of the simulations to labour supply elasticities: The changes of 2010-2013

	Baseline	No behavioural change (only macro)	Only extensive response	Only intensive response		
				Baseline elasticities	With income effect	Higher elasticity with income effect
Effective labour	5.05	0.00	2.00	2.89	0.57	3.73
Employment	2.12	0.00	2.07	0.00	0.00	0.00
Capital stock	5.42	1.19	2.85	3.64	1.69	4.35
GDP	5.18	0.42	2.30	3.15	0.96	3.95
Average gross wage	-0.48	-0.12	-0.27	-0.31	-0.15	-0.37
Disposable income	1.92	-1.13	0.02	0.69	-0.85	1.17
Change of budget balance	513	146	294	354	194	417

Note: Results from dynamic simulations. See the text for parameter values of the alternative intensive-margin elasticities.

The first column of Table 4 repeats the results of the fifth column of Table 3: it shows the simulated effects of the 2010-2013 policy package under the baseline behavioural assumptions. In contrast, the second column shows the results of the simulation if both margins of individual adjustment are ‘switched off’. Here there is no change in labour supply at all (since it is perfectly inelastic); but changes of taxes on corporate income, sales and consumption affect the macroeconomic equilibrium.

In the third column, individual adjustment at the extensive margin is ‘switched on’. The policy package is estimated to increase long-term employment by 2.07%, thereby raising GDP by 2.3% and improving the dynamic fiscal balance.

In the last three columns, focus is on the adjustment at the intensive margin: on the one hand, this is a controversial issue in the literature (see, for example, the discussion by Meghir and Phillips, 2010); on the other hand, the impact of the 2010-2013 tax reform crucially depends on the elasticity of taxable income.

In this exercise, adjustment at the extensive margin is 'switched off' but adjustment at the intensive margin does take place. The first of these uses the 'baseline elasticity' as taken from the study of Kiss and Mosberger (2015). That study finds that higher-income earners are somewhat responsive to the marginal net-of-tax rate; the estimated elasticity is 0.2. In the simulation model this elasticity is applied to the top 20% of earners; individuals with lower incomes are assumed not to adjust along the intensive margin. The point estimate of the income effect in the study of Kiss and Mosberger is sizable but very imprecisely estimated; therefore, the baseline income effect was chosen to be zero.

The results from this 'baseline elasticity' simulation support the view that most of the stimulative effect of the 2010-2013 policy package comes from labour supply adjustment at the intensive margin. Due mainly to the cuts in the marginal tax rate of high earners, the policy package is estimated to add, under these assumptions, 2.73-2.89 percentage points to the level of GDP and to the effective labour supply in the long run (compare column 4 to column 2).

The next column of Table 4 ('Baseline elasticity plus income effect') repeats this analysis including a non-zero income effect. The parameter chosen in the simulation is -0.5 (applied to the top 20% of the income distribution); this is the point estimate by Kiss and Mosberger (2015) of the parameter (the elasticity of reported income with respect to the average net-of-tax rate). The simulation shows that an income effect of this magnitude dampens the stimulative effects of the policy package to about one-sixth: effective labour supply and GDP is increase only by 0.54%.

The last column of Table 4 shows results from a simulation where the elasticities describing the adjustment at the intensive margin are taken from the other available Hungarian study by Bakos *et al.* (2008). For higher income earners, they estimated a higher elasticity than Kiss and Mosberger (0.34 instead of 0.2) with an income effect of -0.27. In later follow-ups, as indicated by Benczúr *et al.* (2013), the marginal tax rate elasticity was found to be closer to the Kiss and Mosberger results. Nevertheless, it is still a reasonable alternative to postulate an even larger substitution effect (also coinciding with the 'consensus' intensive margin elasticity of Chetty *et al.*, 2012) and a moderately negative income effect which leads to an almost-zero uncompensated elasticity. We find that the estimated effects of the 2010-2013 policy package with these alternative elasticities are similar to, but somewhat higher than, the results estimated with the baseline elasticities in column 4. The two parametric differences between the estimations of Bakos *et al.* (2008) and Kiss and Mosberger (2015) have the opposite effect, nearly cancelling out.

In the second set of robustness checks, we analyse how the simulation results depend on the most relevant calibrated macro parameters. Table 5 presents results from three types of alternative simulations against the baseline results from column 5 of Table 3. First, the elasticity of capital supply (parameter η) is modified: the corner cases of perfectly elastic capital supply ($\eta = \infty$) and perfectly inelastic capital supply ($\eta = 0$) are analysed. Second, the capital income share parameter is modified from the baseline value of 0.35 to 0.3 and 0.4. Finally, the production-function parameter governing the substitutability between labour and capital (parameter β) is modified. This parameter is given in our model as $\beta = \frac{\sigma-1}{\sigma}$. While we chose $\sigma = 0.8$ as our baseline, as a robustness check we ran simulations with $\sigma = 0.7$ and $\sigma = 0.9$.

Table 5: Robustness to the calibrated macro parameters: The changes of 2010-2013

	Baseline	Capital elasticity (instead of 15)		Capital share (instead of 0.35)		K-L substitution (instead of 0.8)	
		eta = ∞.	eta = 0	rK/Y = 0.3	rK/Y = 0.4	sigma = 0.7	sigma = 0.9
Effective labour	5.05	5.15	4.56	5.04	5.07	4.76	5.03
Employment	2.12	2.19	1.78	2.11	2.13	2.14	2.11
Capital stock	5.42	6.70	0.00	5.28	5.57	5.50	5.24
GDP	5.18	5.69	2.97	5.11	5.27	5.02	5.10
Average gross wage	-0.48	0.04	-2.62	-0.55	-0.39	-0.27	-0.56
Disposable income	1.92	2.35	0.09	1.87	2.00	1.88	1.85

Note: Results from dynamic simulations.

All three types of changes in the parameters can ultimately be described by how they affect the reaction of the capital stock to changes in the marginal return of capital. Table 5 confirms that capital (and thus output, wages and effective labour) reacts more sensitively (1) the more elastic the supply of capital is; (2) the higher the income share of capital is; and, finally, (3) the more substitutable the factors of production are.

Looking at the capital-supply elasticity scenarios as compared to the baseline (the first three columns of Table 5) we see that our baseline calibration of $\eta = 15$ is closer to the perfectly elastic case than to the perfectly inelastic case. Columns 4 and 5 show that, within a plausible range, the capital-income share parameter does not affect results very sensitively. Finally, the last two columns of Table 5 show how the results are affected by moving the factor-substitutability parameter. The results show that moving away from the extreme Cobb-Douglas case (of $\beta = 0$) make capital adjust more sensitively to changes in its marginal product.

5. CONCLUSION

In this paper, we present a simple, tractable yet rich general-equilibrium behavioural microsimulation model, designed to assess long-run output, employment, fiscal and distributional consequences of reforms to the tax and the transfer system. We estimate and calibrate the model to Hungary, and then we simulate three sets of scenarios. First, we analyse four different ways of tax relief in the personal income tax system. Second, we analyse three complex hypothetical proposals that are fiscally neutral without behavioural change. Last, we analyse actual changes of the tax and transfer system between 2008 and 2013.

The results of the first two exercises show that the desirability of different tax policy scenarios depends greatly on the criterion used. If the main objective is employment growth, policymakers should keep (or decrease) the average tax burden of low incomes as low as possible, since the lower-wage, mostly low-skilled, groups — where the large part of the inactivity is concentrated in most countries — are the most sensitive to change in their financial gains to work. The most efficient way of keeping the average tax rate low for low-income earners is the Employee Tax Credit (ETC): similarly to a system with a zero lower tax rate, the ETC keeps the average tax rate low at low incomes, but it imposes a smaller burden on the budget. This budget surplus can be used for various policy measures such as, for example, lowering marginal tax rates for higher earners.

Our simulation exercises provide evidence that the tax system and the transfer system should be taken into account simultaneously. For example, in countries where some transfers are taxed as income, a tax rate cut (or increase) will also affect positively (negatively) the net transfers one can get at zero hours worked, which will, *ceteris paribus,* decrease (increase) individuals' incentives to work.

The highest long-run employment gain can be obtained if the tax cut is financed by transfer tightening. Such a policy package affects individuals' gains to work and therefore willingness to work both at the transfer and at the net wage side. However, it is important to keep in mind that our model is solely based on financial incentives and do not take into account some potentially important features of the economy such as labour market frictions and skill mismatches. For example, the shortening of the unemployment benefit period will make the individuals want to find a job earlier and therefore they increase their labour supply, but a shorter job-search period may also impair the quality of employee-employer matches. This effect is not taken into account by the model and, as a result, we might overestimate the employment effect of such a measure. Furthermore, such a policy may have adverse effects on income inequality and poverty.

If the main objective is to boost labour productivity and GDP, different policy measures should be applied. As individuals at the top of the income distribution are relatively responsive at the intensive margin, decreasing the marginal tax rates improves incentives at the top of the income distribution and boosts effective labour and GDP in the long-run. Similar results can be obtained by decreasing capital taxes. This latter policy is especially effective in small open economies where capital supply is highly elastic.

In the third exercise, we evaluate the impact of actual tax and transfer changes in the two years before the general elections in 2010 and three years after. We find that the packages of the two governments during this period have different macroeconomic effects. The changes between 2008 and 2010 increase long-run employment and GDP; but there is no significant adjustment at the intensive margin. In contrast, the changes between 2010 and 2013 produce a large gain at the intensive margin of labour supply, but employment is expected to increase only due to cuts in the unemployment benefit. Both policy packages are found to increase income inequality in the long run (the changes after 2010 about four times more than the changes before 2010); the cumulative change has the potential to move Hungary to the median of EU member states from its original ranking as the country with the 6th most equal income distribution among the EU-27.

At a general, methodological level, our microsimulation model has two important features. First, it is behavioural, which means that it takes into account the labour supply response of individuals at the intensive and extensive margin. This is done by merging the elasticity of taxable-income literature and the discrete choice labour supply literature. Second, the labour supply shocks that result from individual behavioural responses to tax and transfer reforms are fed into a long-run neoclassical model of a small open economy.

This linked micro-macro modelling approach allows us to trace general-equilibrium feedback effects through labour demand, capital demand and capital supply. More importantly, this approach enables us to assess the macroeconomic and labour market effects of changes to the corporate side of taxation. Still, the macro model is parsimonious and transparent: it consists of an aggregate production function and a capital supply curve, ensuring that input prices equal their marginal products and that capital supply is elastic. The overall simplicity and tractability of the model makes it easily extendable to fiscal analysis in other countries as well.

REFERENCES

Aaberge, Rolf, John K. Dagsvik, and Steinar Strom (1995): Labour Supply Responses and Welfare Effects of Tax Reforms. *Scandinavian Journal of Economics* 97(4), 635–59.

Aaberge, Rolf, Ugo Colombino, Erling Holmøy, Birger Strøm and Tom Wennemo (2004): Population ageing and fiscal sustainability: Integrating detailed labour supply models with CGE models. In Ann Harding and Anil Gupta (eds.): *Modelling our Future: Social Security and Taxation, Vol. I,* Elsevier, 259-290.

Aaberge, Rolf, Ugo Colombino and Steinar Strom (2000): Labour supply responses and welfare effects from replacing current tax rules by a flat tax: Empirical evidence from Italy, Norway and Sweden. *Journal of Population Economics* 13 (4), 595-621.

Aaberge, Rolf and Ugo Colombino (2014): Labour Supply Models. In Cathal O'Donoghue (ed.), *Handbook of Microsimulation Modelling*, Emerald Group, 167-221.

Arntz, Melanie, Stefan Boeters, Nicole Gürtzgen and Stefanie Schubert (2008): Analysing welfare reform in a microsimulation-AGE model: The value of disaggregation. *Economic Modelling* 25, 422-439.

Ayala, Luis and Milagros Paniagua (2016): Behavioural Microsimulation of the Impact of In-Work Benefits on Female Labour Supply and Income Distribution: Evidence from Spain. EQUALITAS Working Paper No. 39.

Bakos, Péter, Péter Benczúr and Dóra Benedek (2008): The elasticity of taxable income: Estimates and flat tax predictions using the Hungarian tax changes in 2005. MNB Working Paper 2008/7, Central Bank of Hungary.

Bargain, Oliver, Kristian Orsini, and Andreas Peichl (2014): Comparing labour supply elasticities in Europe and the United States new results. *Journal of Human Resources*, 49(3), 723-838.

Benczúr, Péter and Gábor Kátay (2017), The Gains to Work Model of Labour Supply, mimeo.

Benczúr, Péter, Gábor Kátay and Áron Kiss (2012): Assessing changes of the Hungarian tax and transfer system: A general-equilibrium microsimulation approach. Working Paper 2012/7, Central Bank of Hungary.

Benczúr, Péter, Gábor Kátay, Áron Kiss and Olivér Rácz (2014): Income taxation, transfers and labour supply at the extensive margin. Working Papers 487, Banque de France.

Benczúr, Péter, Gábor Kátay, Áron Kiss, Balázs Reizer and Mihály Szoboszlai (2011): Analysis of changes in the tax and transfer system with a behavioural microsimulation model. *MNB Bulletin* (October), Central Bank of Hungary.

Benczúr, Péter, Áron Kiss and Pálma Mosberger (2013): The elasticity of taxable income. In: Péter Benczúr, Károly Fazekas and Álmos Telegdy (eds.): *The Hungarian Labour Market 2013*, Research Centre for Economic and Regional Studies of the Hungarian Academy of Sciences and Hungarian Employment Foundation.

Benedek, Dóra, Péter Elek and Péter András Szabó (2009): HKFSZIM: A computer program modelling the tax and transfer system. (In Hungarian. Original title: HKFSZIM – Adó- és támogatási rendszert modellező számítógépes program. Kézirat.) Manuscript, Hungarian Ministry of Finance.

Benedek, Dóra, Gábor Kátay and Áron Kiss (2013): Analysing the impact of tax reforms with microsimulation models. Forthcoming in: Péter Benczúr, Károly Fazekas and Álmos Telegdy (eds.): *The Hungarian Labour Market 2013*, Research Centre for Economic and Regional Studies of the Hungarian Academy of Sciences and Hungarian Employment Foundation.

Blundell, Richard, Alan Duncan, Julian McCrae and Costas Meghir (2000): The labour market impact of the Working Families' Tax Credit. *Fiscal Studies* 21 (1), 75-104.

Bourguignon, Francois and Amadeo Spadaro (2005): Microsimulation as a tool for evaluating redistribution policies. *Journal of Economic Inequality* 4 (1), 77-106.

Cameron, Grant and Ross Ezzeddin (2000): Assessing the direct and indirect effects of social policy: integrating input-output and tax microsimulation models at Statistics Canada. In Lavinia Mitton, Holly Sutherland, and Melvyn Weeks (eds.): *Microsimulation modelling for policy analysis: Challenges and innovations,* Cambridge University Press, 42-65.

Chetty, Raj, Adam Guren, Day Manoli and Andrea Weber (2013): Does Indivisible Labour Explain the Difference between Micro and Macro Elasticities? A Meta-Analysis of Extensive Margin Elasticities. *NBER Macroeconomics Annual* 27(1), 1–56.

Creedy, John and Alan Duncan (2002): Behavioural microsimulation with labour supply responses. *Journal of Economic Surveys* 16 (1), 1-39.

Davies, James B. (2009): Combining Microsimulation with CGE and Macro Modelling for Distributional Analysis in Developing and Transition Countries. *International Journal of Microsimulation*, 49-65.

Feldstein, Martin (2000): The transformation of public economics research: 1970-2000, *Journal of Public Economics*, 86 (3), 319-326.

Fuest, Clemens, Andreas Peichl, and Thilo Schaefer (2008): Is a flat tax reform feasible in a grown-up democracy of Western Europe? A simulation study for Germany. *International Tax and Public Finance* 15, 620-636.

Galuščák, Kamil, and Gábor Kátay (2017). Labour Force Participation and Tax-Benefit Systems: A Cross-Country Comparative Perspective. Updated version of Banque de France Working Paper 536 (2015), available at https://kataygabor.files.wordpress.com/2017/11/galuscak-katay.pdf

Gravelle, Jane G. (2015). Dynamic Scoring, *Journal of Policy Analysis and Management*, 34(4), 970-977.

Gruber, Jonathan, and Emmanuel Saez (2002): The Elasticity of Taxable Income: Evidence and, Implications. *Journal of Public Economics,* Vol. 84, No. 1, 1–32.

Harris, Edward and Shannon Mok (2015): How CBO Estimates the Effects of the Affordable Care Act on the Labour Market, Working Paper 2015-09, Congressional Budget Office.

Horváth, Michal, Matús Senaj, Zuzana Siebertová, Norbert Svarda and Jana Valachyová (2017), Evaluating the Aggregate Effects of Tax and Benefit Reforms, Council for Budget Responsibility of Slovakia, mimeo.

Immervoll, Herwig, Henrik Jacobsen Kleven, Claus Thustrup Kreiner and Emmanuel Saez (2007): Welfare reform in European countries: A microsimulation analysis. *The Economic Journal* 117, 1-44.

Jongen, Egbert L.W., Henk-Wim de Boer and Peter Dekker (2014): MICSIM: A behavioural microsimulation model for the analysis of tax-=benefit reform in the Netherlands. CPB Background Document, 2014 November.

Kátay, Gábor (ed.) (2009): Az alacsony aktivitás és foglalkoztatottság okai és következményei Magyarországon (Causes and consequences of low activity and employment in Hungary, in Hungarian only). MNB Occasional Papers 79.

Kátay, Gábor and Zoltán Wolf (2004): Investment behaviour, user cost and monetary policy transmission: The case of Hungary. MNB Working Paper 2004/12, Central Bank of Hungary.

Kiss, Áron and Pálma Mosberger (2015): The elasticity of taxable income of high-earners: Evidence from Hungary. *Empirical Economics*, 48 (2), 883-908.

Köllő, János (2009): On the sidelines: Uneducated unemployed in the post-socialist economy (In Hungarian. Original title: A pálya szélén. Iskolázatlan munkanélküliek a posztszocialista gazdaságban). Osiris, Budapest.

Köllő, János and Beáta Nacsa (2005): Flexibility and Security in the Labour Market. Hungary's Experience. ILO Flexecurity Paper 2004/2, Budapest, International Labour Office Subregional Office for Central and Eastern Europe.

Lattarulo, Patrizia, Renato Paniccià, Nicola Sciclone (2003): Un approccio integrato micro e macro all' analisi dei redditi delle familie toscane (The household income distribution in Tuscany: a combined micro and macro approach). IRPET Working Paper 21.2003.

Magnani, Riccardo and Jean Mercenier (2009): On linking microsimulation and computable general equilibrium models using exact aggregation of heterogeneous discrete-choice making agents. *Economic Modelling* 26, 560-570.

Meghir, Costas and David Phillips (2010): Labour Supply and Taxes. In: J. Mirrlees, S. Adam, T. Besley, R. Blundell, S. Bond, R. Chote, M. Gammie, P. Johnson, G. Myles and J. Poterba (eds.), *Dimensions of Tax Design: the Mirrlees Review,* Oxford University Press, 202-274.

Peichl, Andreas (2009): The benefits and problems of linking micro and macro models: Evidence from a flat tax analysis. *Journal of Applied Economics* 12 (2), 301-329.

Plumb, Michael (2001): Empirical tax modelling: an applied general-equilibrium model for the UK incorporating micro-unit household data and imperfect competition. D.Phil. thesis, Nuffield College, University of Oxford.

Saez, Emmanuel, Joel Slemrod, and Seth H. Giertz (2012): The Elasticity of Taxable Income with Respect to Marginal Tax Rates: A Critical Review. *Journal of Economic Literature,* Vol. 50, No. 1, pp. 3–50.

Slemrod, Joel (1985): A general equilibrium model of taxation that uses micro-unit data: with an application to the impact of instituting a flat-rate income tax. In John Piggott and John Whalley (eds.), *New developments in applied general equilibrium analysis*, Cambridge University Press, 221-252.

Szabó-Morvai, Ágnes (2013): Who Benefits from Child Benefits? The Labour Supply Effects of Maternal Cash Benefit. Chapter of PhD Thesis, Central European University.

Tongeren, Frank W. van (1995): Microsimulation modelling of the corporate firm: exploring micro-macro economic relations. Berlin and New York: Springer.

Van Soest, Arthur (1995): Structural models of family labour supply: a discrete choice approach. *Journal of Human Resources*, 63-88.

Williamson, Paul, Asghar Zaidi and Ann Harding (2009): New Frontiers in Microsimulation Modelling: Introduction. In: Willamson, Paul, Asghar Zaidi and Ann Harding (eds.): *New Frontiers in Microsimulation Modelling*, 31-49, Ashgate.

APPENDIX

Extensive margin results

Table A1: Conditional marginal effects at the extensive margin

		Structural	Reduced-form[17]
Full sample (15–74)	net wage	0.34 [0.007]	0.28 [0.006]
	transfer	-0.12 [0.002]	-0.09 [0.002]
Prime age (25–54)	net wage	0.25 [0.004]	0.15 [0.003]
	transfer	-0.08 [0.001]	-0.05 [0.001]
- elementary school or less	net wage	0.34 [0.006]	0.27 [0.005]
	transfer	-0.11 [0.002]	-0.09 [0.002]
- secondary education	net wage	0.23 [0.004]	0.15 [0.003]
	transfer	-0.08 [0.001]	-0.05 [0.001]
- tertiary education	net wage	0.16 [0.004]	0.08 [0.002]
	transfer	-0.04 [0.001]	-0.03 [0.001]
- single men	net wage	0.11 [0.004]	0.11 [0.002]
	transfer	-0.04 [0.001]	-0.03 [0.001]
- single women	net wage	0.29 [0.007]	0.19 [0.004]
	transfer	-0.11 [0.002]	-0.07 [0.001]
- married men	net wage	0.14 [0.003]	0.09 [0.002]
	transfer	-0.04 [0.001]	-0.03 [0.001]
- married women	net wage	0.43 [0.007]	0.24 [0.005]
	transfer	-0.15 [0.002]	-0.09 [0.002]

Source: Galuščák and Kátay (2017)

[17] This column corresponds to the gains-to-work methodology employed in Benczúr *et al.* (2014), Galuščák and Kátay (2017), Horváth *et al.* (2017); being further developed in Benczúr and Kátay (2017).

Details of the general equilibrium model simulation

The production function of the representative firm exhibits constant elasticity of substitution (CES).[18] The profit-maximisation problem of firms can be formulated as:[19]

$$\max\left(\alpha K^{\beta}+(1-\alpha)L^{\beta}\right)^{\frac{1}{\beta}}(1-\tau_s)-w(1+\tau_W)L-\frac{r}{1-\tau_K}K.$$

Here, τ_s is the effective tax rate on sales (representing, in the baseline, the effects of the local business tax), w is the gross wage, τ_W is the rate of employer-side social security contributions (equivalent to a payroll tax), τ_K is the effective tax rate on capital and $\frac{r}{1-\tau_K}$ is the net user cost of capital.

The model is closed by the equation that determines the aggregate supply of capital. Capital is provided by an international capital market. Its supply is modelled in a reduced form: $\widehat{K}=\eta\hat{r}$, where η is the elasticity of capital supply *K* with respect to the after-tax rate of return *r* (and $\hat{x}$ denotes the percentage change of variable x).

It is easiest to present the comparative statics results if we log-linearize the model around the equilibrium. After deriving the first-order conditions and log-linearization, we arrive at the following four equations:

$$\hat{k}=\frac{1}{\alpha\bar{k}^{\beta}}\left(\frac{1}{1-\alpha}\right)^{\frac{\beta}{1-\beta}}\frac{1}{1-\beta}\left(\frac{\bar{w}(1+\overline{\tau_W})}{1-\overline{\tau_s}}\right)^{\frac{\beta}{1-\beta}}\left(\hat{w}+(\widehat{1+\tau_W})-(\widehat{1-\tau_s})\right)$$

$$\hat{k}=\frac{1}{\alpha\bar{k}^{\beta}}\left(\frac{1}{\alpha}\right)^{\frac{\beta}{1-\beta}}\frac{1}{1-\beta}\left(\frac{\bar{r}}{(1-\overline{\tau_K})(1-\overline{\tau_s})}\right)^{\frac{\beta}{1-\beta}}\left(\hat{r}-(\widehat{1-\tau_K})-(\widehat{1-\tau_s})\right)+\left(\frac{1}{\alpha}\right)^{\frac{1}{1-\beta}}\hat{k}$$

$$\hat{k}=\widehat{K}-\hat{L}$$

$$\widehat{K}=\eta\hat{r}$$

Here, k is the capital-labour ratio and $\bar{x}$ denotes the ex-ante equilibrium value of variable x. The first equation ensures that wages are equal to the marginal product of labour, while the second equation ensures that the return on capital is equal to its marginal product. The labour supply shock $\hat{L}$ is the result of microsimulation (reflecting both the exogenous labour supply response to the policy shock and the endogenous response to the change in wages).[20] A balanced budget restriction is not imposed (see a discussion of this point in Section 2.4).

[18] Previous estimations of factor demand and the substitutability between labour and capital rejected that the Cobb-Douglas production function can be used. See Kátay and Wolf (2004) for an estimation of the demand for capital.

[19] We write the firm's problem in net terms, so it does not contain the value-added tax (VAT). The VAT is, however, included in the net wage entering the labour supply decision.

[20] VAT and labour taxes directly affect labour supply.

Calibration of the macro model part

The parameters of the model are calibrated based on previous estimations and simple statistics taken from national accounts.

1) Taxes on capital (corporate income tax and other, less significant, corporate taxes) and consumption (VAT and other, less significant, consumer taxes) are calculated as effective tax burdens on aggregates taken from national accounts. The initial (2008) effective tax rate on capital is $\tau_K = 0.073$, while the initial effective tax rate on sales (calculated as total tax revenue divided by GDP) is $\tau_s = 0.0174$. The effective tax rate on consumption is $\tau_{VAT} = 0.182$.
2) The elasticity of substitution between capital and labour in the production function is chosen based on estimations of Kátay and Wolf (2004): $\beta = (\sigma - 1)/\sigma = (0.8 - 1)/0.8 = -0.25$.
3) The net user cost of capital is computed as described in Kátay and Wolf (2004). Its average value for the period 2005-2008 is 0.155.
4) The capital income share is calibrated based on averages from national accounts:
$$\left[\frac{r}{(1-\tau_K)(1-\tau_s)}K\right] / \, Y = 0.35.$$
Using the production function and the net user cost, the capital income share pins down also the value of *k*, the capital labour ratio.
5) Parameter α is obtained by rearranging the first order condition of profit maximisation with respect to capital:
$$\alpha\left(\alpha K^{\beta} + (1-\alpha)L^{\beta}\right)^{\frac{1}{\beta}-1} K^{\beta-1}(1-\tau_s) = \frac{r}{(1-\tau_K)}$$
$$\Rightarrow \alpha = \left(\frac{\frac{r}{(1-\tau_K)(1-\tau_s)}K}{Y}\right)^{1-\beta} \left(\frac{r}{(1-\tau_K)(1-\tau_s)}\right)^{\beta} = 0.429$$
6) One can choose the units such that *L=1*, thus *K=k* and the first order condition of profit maximization with respect to labour determines the wage w.
7) It is left to calibrate η, the elasticity of capital supply with respect to the after-tax return on capital. The two extreme cases are perfect capital mobility ($\eta = \infty$) and perfectly inelastic supply of capital ($\eta = 0$). The former is a reasonable assumption in the long run, supported either by a small open economy assumption (the rental rate is set by the world rate) or a closed economy Ramsey model (the rental rate is determined by the rate of time preference); while the latter is probably a good description of the very short run. While the model can be run with any of these values, the results shown below are based on a quite elastic capital supply ($\eta = 15$).

Main policy parameters in the simulation scenarios

Table A2: Parameters of hypothetical tax scenarios from Table 1

	Baseline (2008)	Across-the-board tax cut	Flat tax	Two rates, no ETC	One rate, with ETC
Lowest PIT rate	18%	17%	20.1%	0%	26.2%
Upper limit of the lowest PIT rate	1 700 000	1 700 000	-	828 000	-
Middle PIT rate	36%	35%	-	-	-
Upper limit of the middle PIT rate	7 137 000	7 137 000	-	-	-
Upper PIT rate	40%	39%	-	32%	-
Rate of ETC	18%	17%	-	-	23%
Maximal amount of ETC (per month)	11 340	11 730	-	-	18 078
Start of ETC phase-out	1 250 000	1 250 000	-	-	1 700 000
ECT phase-out rate	9%	9%	-	-	19%

Table A3: Parameters of actual tax scenarios from Table 3

	2008	2010[a]	2013
Lowest PIT rate	18%	21.59%	16%
Upper limit of the lowest PIT rate	1 700 000	3 937 008	-
Middle PIT rate	36%	-	-
Upper limit of the middle PIT rate	7 137 000	-	-
Upper PIT rate	40%	40.64%	-
Rate of ETC	18%	21.59%	-
Maximal amount of ETC, monthly	11 340	15 100	-
Start of ETC phase-out	1 250 000	2 510 236	-
ECT phase-out rate	9%	15.24%	-
Child tax credit (monthly, 1st and 2nd child)	0	0	-
Child tax credit (monthly, 3rd, 4th... child)	4 000	4 000	-
Child tax credit (monthly per child, 1 or two children)	-	-	10 000
Child tax credit (monthly per child, 3 or more children)	-	-	33 000
Employer contribution rate	32%	27%	27%
Employee contribution rate (below contribution ceiling)	15.5%	17%	18.5%
Effective tax rate on consumption	18.2%	19.4%	23.3%[b]
Effective tax rate on corporate income	7.3%	7.3%	6.2%[b]
Effective tax rate on sales (e.g., local business tax)	1.74%	1.65%	2.28%[b]
Maximum length of unemployment benefits (months)	12	12	3

Notes: [a] In 2010 (unlike in 2008 or 2013) the PIT code was based on a 'super-gross' income definition. Parameters here are translated into gross terms. [b] Effective tax rates on consumption, corporate income and sales include expert estimates of the central bank of Hungary based on legislation passed until August 2012. The effective tax rate on corporate income includes only that part of sectoral 'crisis taxes' that are to be made permanent according to official government policy.

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