Fiscal Implications of Personal Tax Adjustments in the Czech Republic

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Abstract

We investigate the fiscal implications of the changes in personal income tax implemented in the Czech Republic in January 2006. In addition to evaluating the direct effect of this tax reform, our analysis takes into account its *employment effect* on the government budget due to individuals entering or leaving employment. We first estimate the probability of working (labor supply) as a function of the effective net wage and then simulate the impact of the changes in paid taxes and received benefits on employment. We find that a 10 percent rise in the net wage increases the probability of working by 0.55 and 0.18 percentage points for women and men respectively. These estimates suggest that the employment effect is unlikely to substantially alleviate the fall in net budget revenues. We predict that, for the sub-population of prime age employees, net government revenues decline by roughly 8 billion Czech korunas (CZK) as a consequence of the implemented income tax cuts. The employment effect counteracts the decline by only CZK 0.4 billion. The stimulating effect of the tax reform on employment is reduced by the current benefit system: the incentive to work due to the higher after-tax wage is partially offset by the fall in social benefits once people start working.

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Nontechnical Summary

The paper focuses on two key issues: the evaluation of the response of labor supply to the reforms of the personal income tax system that took place in the Czech Republic in 2005 and came into effect in January 2006 and the impact of these reforms on the government budget. The 2006 reform we consider consists of cutting the tax rates for the lowest two tax brackets by 3 and 1 percentage point respectively, and extending the lowest tax bracket. Using the Czech household income survey data of 2002—the most recent data available for this purpose—we first estimate the wage semi-elasticity of labor supply. With these estimates in hand we then predict how much employment responds to lower income taxes (i.e., higher net wages). In the overall assessment of the fiscal implications of the tax reform we take into account both the direct effect and the effect of the change in the labor supply. We find that the overall fiscal impact of the tax cuts for the sub-population corresponding to our sample is rather small: a decline of about CZK 8 billion in net tax revenues. This is not surprising, as the implemented changes are only moderate.

Our estimates of labor supply support the common evidence that women are more sensitive to wages than men: The estimated mean wage semi-elasticity of labor supply is 0.055 and 0.018 for women and men respectively. In other words, a 10 percent rise in the effective net wage would increase the employment rate among men by 0.18 percentage points and the employment rate among women by 0.55 percentage points. We also find that the effect decreases with income and education. For the low educated, whose income falls into the lowest tax bracket, the impact of the 10 percent increase in the effective net wage is a 0.27 and 0.72 percentage point increase in the employment rate for men and women respectively. The corresponding numbers for the highly educated with income in the highest bracket are 0.05 and 0.20. This finding implies that reforms that aim to increase an individual's economic activity should primarily target low-skilled people with the lowest wages.

Using our estimates of the wage semi-elasticity of labor supply we calculate the likely impact of the tax modifications on the government budget. We predict that the tax cuts will induce about $2,400$ individuals (net) to enter employment, resulting in a CZK 0.4 billion increase in net tax revenues. Our results reveal that the positive effect of increased labor supply, what we call the *employment effect*, is too small to outweigh the drop in income tax revenues due to the lower taxes.

Based on the estimate of the employment effect, we predict the impact of the 2006 reform on the government budget for the sub-population considered. The method we apply calculates the overall fiscal effect as the sum of the fall in tax revenues due to lower taxes, the fall in expenditure on social benefits, and the increase in tax revenues via higher labor supply. It turns out that the first two effects are substantially stronger and the last only negligible. We expect that the total PIT revenues will fall by CZK 11.6 billion due to the changes in the two lowest income tax brackets, while expenditures on social benefits will presumably fall by CZK 3 billion due to the increase in after tax earnings, leaving the direct impact on the budget at CZK 8.6 billion. We predict the employment effect to counteract the decline by only CZK 0.4 billion, leaving the overall effect of the tax reform on the budget at about CZK 8 billion. The stimulating effect of the tax reform on employment is reduced by the current benefit system: the incentive to work due to the higher after-tax wage is partially offset by the fall in social benefits once people start working.

1. Introduction

Conventional wisdom suggests that lower taxes motivate people to work more, but is silent on how strong this effect is quantitatively. We complement common sense with quantitative evidence on the wage sensitivity of labor supply in the Czech Republic and predict the effect of the recent personal income tax changes on labor supply and the government budget.

The paper focuses on two key issues: the evaluation of the response of labor supply to the reforms of the personal income tax system and their impact on government budget. Using the Czech household income survey data of 2002—the most recent data available for this purpose—we first estimate the wage semi-elasticity of labor supply. With these estimates in hand we then predict how much employment responds to lower income taxes (i.e., higher net wages). The reform we consider consists of cutting the tax rates for the lowest two tax brackets by 3 and 1 percentage point respectively, and extending the lowest tax bracket. The method we apply calculates the overall fiscal effect as the sum of the fall in tax revenues due to lower taxes, the fall in expenditure on social benefits, and the increase in tax revenues via higher labor supply. It turns out that the first two effects are substantially stronger and the latter only negligible. We find that the overall fiscal impact of the tax cuts for the sub-population corresponding to our sample is rather small: a decline of about CZK 8 billion in net tax revenues. This is not surprising, as the implemented changes are only moderate. The stimulating effect of the tax reform on employment is reduced by the current benefit system: the incentive to work due to the higher after-tax wage is partially offset by the fall in social benefits once people start working.

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Using our estimates of the wage semi-elasticity of labor supply we calculate the likely impact of the tax modifications on the government budget. Our results suggest that the positive effect of increased labor supply, what we call the *employment effect*, is too small to outweigh the drop in income tax revenues due to the lower taxes. We predict that under the 2006 reform the net tax revenues for our estimation sample are about CZK 8 billion lower compared to the 2005 tax system. We predict that the tax cuts will induce about $2,400$ individuals (net) to enter employment, resulting in a CZK 0.4 billion increase in net tax revenues. Our results reveal that the positive effect of increased labor supply, what we call the employment effect, is too small to outweigh the drop in income tax revenues due to the lower taxes.

Our calculations are subject to the following limitations. First, we restrict our analysis and therefore also our predictions to individuals between 25 and 54 years of age who are not self-employed, students, on maternity leave or fully disabled.[1] We exclude these groups to keep the sample homogeneous for the estimation of the labor supply. It follows that we focus only on the effect of the tax cuts on our subgroup, and not the overall effect on the whole population. The personal income tax revenues from the

[1] The exact specification of our estimation sample and the justification of its choice is described in section 5 below and section A.1.1 of the separate appendix.

sub-population corresponding to our estimation sample make up 48 percent of total Czech public sector PIT revenues.

Second, by labor supply we mean the decision to work, i.e., we focus only on labor force participation. Although changes in hours worked are possible as a consequence of the tax cuts, the institutional restrictions on the choice of hours and the well-established finding that hours (intensive margin) are less sensitive to wages than the decision to work (extensive margin), suggest that the additional effect is of much smaller magnitude.

Third, we classify both inactive and long-term unemployed individuals as not supplying labor, assuming that long-term unemployment is voluntary. In other words, we assume that unemployment benefits and other social transfers increase individuals' reservation wages and make them reject job offers with wages that are too low. Thus, the employment effect is calculated here from the labor-supply estimates, assuming there are no constraints on labor demand, i.e., as if there were always some job offers with low wages available, and it is the increase in the net wage that makes people accept them when they would not have done otherwise. The disregard of the demand side could bias our estimate of the employment effect downwards. However, at least part of the demand restrictions are captured in the estimation through the presence of the measure of regional unemployment in the estimated probability of working.

Fourth, apart from the direct effect on the labor market we assume away general equilibrium effects in our projections of the fiscal implications.[2] Finally, our analysis focuses on the short run. We do not consider any effects that lower taxation of labor may have on immigration, capital formation or the choice of education.

The paper is organized as follows. The next section summarizes the theoretical framework for the estimation of labor supply. Section 3 presents the econometric methodology that we use to estimate the probability of working. Next, in section 4, we briefly describe the tax and benefit systems (the baseline) and the tax reform (2006 legislation) that we analyze. This is followed by a brief description of our dataset and the construction of the key variables. The results from the labor supply estimation are summarized in section 6. In section 7 we use the labor supply estimates to predict the fiscal implications of the reform. Section 8 concludes.

2. Theoretical Framework

2.1 Evaluation of Tax Reform

We calculate the fiscal implications of the tax reform in two ways. As a baseline we apply the *ceteris paribus* approach, which assumes away any behavioral response of people. This method, while informative as a starting point, is in principle just an accounting exercise vulnerable to the Lucas critique. For that reason we take our analysis one step further by accounting for the response of employment to changes in taxes. In particular, these changes may induce some non-employed individuals to start working, or some workers to leave employment. The transition to employment generates more taxpayers and less benefit-receivers, while the exit from employment leads to the opposite. We call this indirect impact of the tax reform—through the behavioral response—the *employment effect*. The fiscal impact of the employment effect is given, on the revenue side, by the difference between the taxes paid by the new workers who enter employment, and the taxes previously paid by the individuals who stop working. The impact on

[2] For example, lower taxes and higher disposable income will probably have a positive effect on household consumption and saving, which in turn might in principle affect the interest rate. At the same time, the interest rate might also be affected by the higher budget deficit.

the expenditure side is determined by the difference between the additional benefits paid to those who leave employment, and the reduction in the benefits for those who start working. When evaluating the total fiscal implications of the reform we therefore calculate the tax revenues and benefit payments based on the new, post-reform distribution of individuals between employment and non-employment.

How do the proposed reforms affect the income circumstances of individuals—the benefits they receive and the net wages they earn if working? The policy measures directly change the amount of benefits an individual will obtain (if eligible). The impact of the tax reform on net wages is, however, ambiguous and depends on employers' behavior. Standard models of labor supply and labor demand predict that—if labor supply is perfectly inelastic—any increase in income tax is paid by employees. Symmetrically, a reduction in the tax rate may be absorbed by employers and result in no change in the net wage.[3] In what follows, we assume that the proposed reduction in taxes is fully acquired by the employees. Our estimate of the fiscal impact of the employment effect therefore provides an upper bound for all the other cases when only part of the tax change is translated into net wages.

As the reform consists in lowering taxes, the expected employment effect is positive—higher net wages increase the opportunity costs of not working and induce people to seek employment. However, as will be described in more detail later, the increase in the net wages of the low-income workers who also receive benefits may under the tax reform and the current benefit structure shift these individuals and their households outside the benefit eligibility criteria, thus producing a disincentive to work.

2.2 Theory

The theoretical framework of our analysis is as follows.[4] An individual maximizes her utility subject to the budget constraint:

$$\begin{aligned} \max_{\{c,h\}} \quad & u(c,h) \\ \text{s.t.} \quad & c \leq w\,h + T(w\,h,\, D, y) + y, \\ & 0 \leq h \leq H, \end{aligned}$$

where u is a utility function which depends positively on the amount of consumption c and negatively on the amount of hours the individual works h. Assuming away the possibility to borrow, the individual's consumption is constrained to be less than the sum of her gross earnings $w\,h$, net transfers from the government $T(\cdot)$, and her other non-labor income y. The function $T(w\,h,\, D, y)$ defines the transfers she receives from the government minus the taxes she pays, depending on her gross earnings $w\,h$, other non-labor income y, and the demographic characteristics of the family D. The function $T(\cdot)$ thus reflects the given tax and benefit system.

Assuming away the possibility to borrow, the individual's consumption is constrained to be less than the sum of her net wage, $w\,h + T(w\,h,\, D, y)$, and y, her non-labor income and all other household income from market sources (i.e., excluding any social transfers). The term $w\,h$ is her total earnings and function $T(\cdot)$ describes the tax and benefit system. The total amount an individual can therefore consume is her total earnings, her non-labor and other household income y, plus all the transfers she gets minus all the

[3] Although this may not seem realistic, as employees observe the tax change and how much they pay, this result may occur when firms reduce the planned increases in wages in response to the net wage increase due to the reduction in income tax.

[4] This is a standard model of static labor supply. The notation we use here is based on a simplified version of the model used in Eissa et al. [2004], extended to capture the household structure and to include non-labor and other household income. We omit the fixed costs of working in the presented theoretical framework, as they are not fundamental to the illustration of the basic idea of the model. However, our econometric methodology is flexible enough to be able to capture their effect as well.

taxes she pays, as given by $T(\cdot)$. The transfers and taxes depend on the level of her earnings, on the level of her non-labor and other household income y, and on the demographic characteristics of the family D.

The working hours are restricted to range from zero to some maximum amount H (e.g., 20 hours a day). Assuming non-satiation, the individual will consume all her available income. Consequently, the first budget constraint becomes an equality. The maximization problem can be solved in two stages: First, for the optimal number of hours conditional on working, and second, for the optimal decision whether to work or not. The solution to the first stage is given by the first order conditions. The optimal h^* given $0 < h < H$ solves the equation

$$(1-m)w = -\frac{\frac{\partial u(c,h)}{\partial h}}{\frac{\partial u(c,h)}{\partial c}},$$

where $m = \frac{\partial T(\,wh, D, y)}{\partial w\, h}$ is the effective marginal tax rate of working an additional hour, which includes both the direct marginal tax rate and the reduction in transfers or benefits due to the increased earnings. The solution to the second stage is given by comparing the utility under working and not working. The individual will work if

$$u(h^*, c^*) \geq u(0, c_0). \tag{2.1}$$

Optimal consumption when not working is given by $c_0 = T(0, D, y) + y$, namely the benefits the individual receives if not working plus non-labor and other household income. Optimal consumption if working is

$$c^* = w\, h^* + T(w\, h^*, D, y) + y = c_0 + (1 - \tilde{m}) w\, h^*,$$

where

$$\tilde{m} = \frac{T(0, D, y) - T(w\, h^*, D, y)}{w\, h^*}$$

is the *effective marginal tax rate of the transition from not working to working*.

The optimal number of hours worked h^{**} is therefore

$$\begin{aligned} h^{**} &= h^* && \text{if } u(h^*, c^*) \geq u(0, c_0), \\ h^{**} &= 0 && \text{otherwise.} \end{aligned}$$

h^{**} is a function of all the parameters of the model and defines the individual's labor supply.

The labor supply decision as described above consists of two parts. The first is when the individual decides whether to be on the labor market at all, i.e., whether to work or not. This is called the labor force participation decision, which is also referred to as the decision at the *extensive margin*. Second, an individual who decides to work chooses the optimal amount of hours she would like to spend working. The choice of hours (conditional on the decision to work) is referred to as the decision at the *intensive margin*. In our estimation, we focus on the extensive margin and model only the labor force participation decision. The proposed reforms may also induce changes in the hours of work of those already working, which in turn has further fiscal implications (in particular when individuals move between tax brackets). However, there are several reasons why we have decided to leave the intensive margin decision out of our analysis: First, there is a strand of research that criticizes the idea that people can completely freely choose the number of hours of work in their jobs. This research suggests that different jobs are characterized by different hours and wage combinations[5] and if people can—at all—choose their hours

[5] For example management consulting jobs pay high per hour wages but require working long hours while the opposite is true of some public sector occupations.

of work continuously[6] it is only in the long run, by their choice of occupation or type of job.[7] As the number of working hours in the data is clustered around 40 hours per week, it is likely that people cannot choose the exact number of hours they prefer to work. Second, the histogram of the hours of work suggests that the labor supply expressed by the hours equation is a highly non-linear function that cannot easily be approximated by a simple model of labor supply of hours. Third, the reported hours of work are believed to be frequently contaminated with measurement error. Juster and Stafford [1991] and Bound et al. [1989] document the extent and direction of the misreporting of hours of work, suggesting that most individuals over-report the hours they work. Fourth, and most importantly, it is well documented (see Heckman [1993]) that the wage semi-elasticity of labor supply at the intensive margin is very small, whereas it is much more pronounced at the extensive margin. This means that net wage levels have a much higher impact on our decision whether to work or not than on our choice of hours of work, given that we have already decided to work. We therefore do not estimate the full labor supply with the choice of hours but rather focus on the labor force participation decision, where the largest impact can be expected.

Based on the theoretical model presented above, we define an indicator function E describing whether an individual decides to work ($h^{**} = h^*$) or not ($h^{**} = 0$). E is therefore defined to equal one if equation (2.1) is satisfied and zero otherwise. The theory described above suggests that E is a function of all the parameters of the model: the net wage (the gross wage reduced by the effective marginal tax rate of the transformation from not working to working), non-labor income and other household income, household characteristics and potential other factors X:[8]

$$E = f\big((1 - \tilde{m})w, y, D, X, \dots\big). \tag{2.2}$$

It is the decision whether to work or not, described by (2.2), that we estimate in the empirical part of this paper to evaluate and predict the behavioral responses of individuals to the implemented tax changes. At the same time, as a by-product of our exercise, we provide one of the first estimates of the labor supply (defined as the employment decision) for the Czech data.

2.3 Stylized Facts about Labor Supply

There exists a substantial amount of both theoretical and empirical work on labor supply. Extensive surveys of the previous research include Killingsworth [1983] and Blundell and MaCurdy [1999]. Although the wage elasticities that have been estimated and documented in the literature span relatively broad intervals of values and are rather sensitive to the choice of the econometric method and the model specification (see for example Mroz [1987]), there seems to exist a consensus on at least two major facts: the wage semi-elasticity of labor supply is higher for women (in particular married and with children) than for men, and, as we mention above, the extensive margin wage semi-elasticity is much larger (at least for some groups) than the intensive margin wage semi-elasticity. Blundell and MaCurdy [1999] summarize in tables 1 and 2 the wage elasticities estimated in several empirical studies. The results span from 0 to 0.12 for men, while for women they range between 0.05 and 2. However, these are estimates of the wage elasticity of the full labor supply function (including choice of hours as well as the decision to work), and are therefore not directly comparable with our results.[9] Blau and Kahn [2005] estimate

[6] Although individuals can choose in principle to work part-time or full-time, only some occupations allow this choice and the per hour wages of the two types of work tend to differ as well, with part-timers typically being paid less in per hour terms than their full-time working counterparts.

[7] If individuals do choose from wage–hours combinations, two separate equations for hours and wage have to be simultaneously estimated. See for example Moffitt [1984].

[8] Assuming that utility is linear in c_0 leads the guaranteed income (the benefits when not working) to cancel out.

[9] The elasticity of the choice of hours estimation often imposes rather strict functional forms and restricts the intensive and extensive margins to be affected by the same factors in the same way, if fixed costs are not considered. In this sense, the labor force participation decision that we estimate here is more flexible.

the wage semi-elasticity of labor force participation of married women (evaluated at the mean of the explanatory variables) in the US to fall from roughly 0.33 in 1990 to roughly 0.22 in 2000. In contrast to our findings, the results of Blau and Kahn (and many other studies) are based on gross wages in the participation model and ignore the tax and benefit system.[10]

A comprehensive overview of the literature estimating the effects of taxes and benefits on labor supply can be found in Hausman [1985] and Moffitt [2002]. Again, it is emphasized that the effect is most pronounced at the extensive rather than the intensive margin of the labor supply decision.

There are only a few studies that discuss the likely effects of taxes and benefits on labor supply in the Czech Republic. For example, Galuscak and Pavel [2005] calculate the make-work-pay indicators (the average effective tax rate[11] and the replacement rate) and present their population distribution in 2002 using the same dataset as here. They argue that both low-income individuals and families experience work disincentives under the current tax and benefit scheme. In addition, the system is most demotivating for individuals with working spouses and for the unemployed who have a non-employed spouse. Other papers include Sirovatka and Zizlavsky [2003] and Jahoda [2004]. All these studies analyze the effect of taxes and benefits on labor supply only indirectly, through the make-work-pay indicators. Based on the values and distribution of these indicators, the intensity and the extent of work disincentives are conjectured. In contrast, we analyze the full labor supply model of the decision to work or not. Our estimates of the probability of being employed capture not only the effect of taxes and benefits through the effective net wage, but also other economic and demographic factors. In addition, the make-work-pay indicators typically use a fixed wage (e.g., 2/3 of the average wage in Galuscak and Pavel [2005]) as the expected wage a non-employed individual would earn if working, assuming away any individual heterogeneity among the non-employed. In contrast, we impute potential wages for the non-employed using the estimated wage determination equation. This allows us to capture the observed differences across non-workers.

3. Econometric Model of Labor Supply

We first estimate the labor supply decision as a function of the effective net wage and other factors as implied by our theoretical model. As mentioned above, we focus only on the extensive margin of the choice of hours, and therefore define the labor supply as a binary indicator E describing whether an individual works or not. We approximate the optimal amount of hours of work supplied h^{**}, derived in our theoretical model by the following econometric specification:

$$h_i^{**} = \alpha \log w_i + X_i'\beta + \varepsilon_i,$$

where w_i is her effective net wage, X_i is a vector of variables other than the wage that affect the decision to work and ε_i is an error term assumed to be independent across individuals and to be distributed $\varepsilon_i \sim N(0, \sigma_\varepsilon)$. We then estimate E_i, a binary indicator which equals one if an individual i works ($h_i^{**} > 0$) and zero otherwise. Given our assumption about the distribution of the error term, we estimate the decision to work, as described by E_i, by a standard probit model. The probit specification implies that the probability of being employed is

$$Prob(E_i = 1|w_i, X) = Prob(\alpha \log w_i + X_i'\beta + \varepsilon_i > 0) = \Phi(\alpha \log w_i + X_i'\beta),$$

[10] Although they consider taxes and benefits in the second half of their study, showing similar results to the gross wage estimates, they do not present the results for the participation equation.

[11] This rate is identical to the effective marginal tax rate of the transition from not working to working that we calculate here.

where $\Phi(\cdot)$ is the cumulative density function of the standard normal distribution. As the model is non-linear, the impact of the right-hand side variables has to be expressed in terms of the marginal effects evaluated at different values of the independent variables. The calculation of the marginal effects is described in section 3 of the appendix.

The key independent variable in the model is the logarithm of the effective net wage w_i (after tax and any benefit reductions due to transition from non-employment to employment as described below) and α is the main parameter of interest. Other right-hand side variables include age, marital status, number of children of different ages, education, disability, household size, number of other economically active members of the household, other net monetary income of the household excluding any labor-related income of the analyzed individual and any social benefits, and regional unemployment. Section 1 of the appendix includes the definitions of the key variables and describes their construction. As the effects of the right-hand side variables are often very distinct for men when compared to women,[12] and the literature has documented substantial differences in the wage semi-elasticity of labor supply of men and women as well, we estimate the model separately by gender.

Estimation of labor supply requires decisions to be made concerning the definition of E. It is clear that the employed supply their labor ($E = 1$), while the inactive (people who are out of the labor force) do not ($E = 0$). The question that remains is how to treat the unemployed. The literature usually defines the labor force as the sum of individuals who either work or have a desire to work, i.e., the sum of the employed and the unemployed.[13] It follows that the labor supply in the form of labor force participation should be defined as those who are employed and unemployed. (Both groups supply their labor, with the latter not being able to work due to the constraint on the demand side, as no jobs are available for them.) This would suggest defining $E = 1$ for the unemployed as well. However, the labor supply decision of the unemployed is not straightforward. First, as described by the substantial job search literature, the decision of an unemployed person to accept or reject a job offer depends on her reservation wage. This framework tends to regard the unemployed and inactive as one group of non-employed, with the inactive characterized by a very large reservation wage. In addition, in particular in most of Europe, where unemployment benefits and their duration are high and the eligibility criteria for receiving them are not as strict, it is often believed that many (in particular the long-term) unemployed do not in effect supply their work and instead only rely on government support. In contrast to the first definition, this concept of the unemployed implies that they should be classified as $E = 0$. Previous research has taken different approaches to the way the unemployed are treated in the labor supply estimation; a frequent solution is to exclude the unemployed from the estimation sample altogether.

As changes in taxes and benefits influence the value of the effective net wage relative to the individual's reservation wage, we expect that the decisions of the unemployed to supply labor (to accept a greater or smaller number of job offers) will also be affected. Clearly, the effect of the proposed reforms on the economic activity of individuals consists primarily in motivating people to exit non-employment (both unemployment and inactivity) and start working. For this reason, *we choose first, to leave the unemployed in our analysis, and second, to regard them as not supplying labor,* i.e., classify them as $E = 0$.[14]

[12] For example, the presence of young children has a typically positive (but often insignificant) effect on the labor supply of men, while it has a highly significant and negative effect on the labor supply of women.

[13] The standard ILO definition of unemployment requires two other conditions to be met besides the expressed desire to work: availability to start working and active job search.

[14] For this reason, some of our coefficient estimates may not be directly comparable with the results of the labor supply literature that excludes the unemployed from the estimation. The reason is that some of the factors may affect the probability of employment not only through the impact on supply but also through the impact on the demand. The estimated coefficients may then reflect a mixture of the two.

We would like to emphasize here that, as we do not model the demand side of the labor market (and other markets), our model is a partial equilibrium model. It follows that our predictions assume that any increase in the labor supply will meet the demand, i.e., any individual that decides to start working (induced by the proposed reforms) will find a job. This assumption is based on the idea that unemployment (or at least long-term unemployment) is predominantly a labor supply rather than a labor demand problem. As the analysis here also assumes away any potential constraints on the demand side, we interpret our estimates of the behavioral response as an upper bound of the impact of the reforms on individuals' economic activity.

3.1 Constructing Wages

The key problem of the econometric specification above is that wages are not observed for those who do not work. We therefore specify and estimate the following wage equation to impute gross wages for non-workers:

$$\log ghw_i = Z_i'\delta + u_i, \tag{3.3}$$

where ghw_i is the gross hourly wage, Z_i is a vector of variables that determine individual i's wage and u_i is an error term assumed to be independent across individuals and distributed $u_i \sim N(0, \sigma_u)$. Equation (3.3) is estimated using the individuals in our sample who work and whose wage is observed.

As it is likely that workers systematically differ in their unobserved characteristics from non-workers and that the unobservable component of the decision to work is related to the unobservable component of the wage level,[15] equation (3.3) will be affected by sample selection and the standard OLS estimates will be biased. We therefore use the standard Heckman [1979] model to predict gross hourly wages for non-workers, taking into account the selection to employment. The wage and selection equations are estimated jointly by maximum likelihood. Again, the wage equation estimation and the wage imputation is done separately by gender. The detailed specification of the two equations of the Heckman model is described in detail in section 1 of the appendix.

For the Heckman model to be properly identified there has to be at least one right-hand side variable unique to each of the two equations (i.e., present in one of the equations and not in the other). These are the so called exclusion restrictions. We use the standard demographic factors such as marital status, children, further household characteristics, and other income as the variables affecting the probability of working but excluded from the wage equation. The estimation of the probit equation with the imputed wages further requires that there be variables affecting wages but not the probability of employment. Dummy variables for regions and the degree of urbanization of the residence are assumed to affect the wage levels but not the probability of working.[16]

The Heckman model is used to predict the gross hourly wages to non-workers and also to the employed whose wages were missing. The effective net wage used for the estimation of the probability of working was then constructed as follows. First we calculate for each individual her full-time equivalent gross monthly wage gmw based on the actual or predicted gross hourly wage.[17] The effective net wage that

[15] For example, individuals who are more likely to work may have on average higher wages.

[16] Both sets of exclusion restrictions have been tested by the simple procedure of including them one by one in the equation from which they are excluded and checking their significance with t statistics.

[17] We do this to keep the labor income (expressed in monthly terms) to the monthly social benefits, as well as to render all individuals more or less comparable. To construct the net monthly earnings of non-workers, we need to assume how many hours they would work. We also need this information to be able to determine which tax bracket they would fall into. Given that the vast majority of the working individuals in the sample work full-time (40 hours per week) and the part-time employment option in the Czech Republic still seems rather limited, we simply assume that should non-workers start working, they would work full-time.

enters (after logarithmic transformation) the probit estimation is then given by

$$w_i = (1 - \tilde{m}) \times gmw,$$

where $\tilde{m}$ is the effective marginal tax rate of the transition from non-employment to employment, defined as

$$\tilde{m} = 1 - \frac{nmw + (SB_{work} - SB_{nonwork})}{gmw}, \tag{3.4}$$

nmw denotes the monthly wage net of any taxes and social contributions, gmw is the gross monthly wage, SB_{work} are social benefits if working and $SB_{nonwork}$ social benefits if not working. As the social benefits are determined based on household composition and are often targeted for the household rather than being individual specific, we include the total household social transfers in SB_{work} and $SB_{nonwork}$.[18]

The structure of the benefit system implies that an individual's decision to work will also affect government transfers for the rest of the household. It is likely that this reduction will be part of the considerations of the individual's decision.

3.2 Predicting Probabilities

The implemented tax reform and changes to the system of social benefits have a direct impact on the effective net wage an individual receives if she starts working. We use the estimated model of the employment decision to predict the probability that a particular person would work under the current system in 2005, and compare it with our predicted probability that she will work under different values of the effective net wage as implied by the reform. The difference between these values then reflects the stimulating or de-motivating effects of the recent tax and benefit changes.

4. Current Czech Tax and Welfare System and Its Reform

This section briefly describes the system of personal income taxes and social benefits as of 2005, and the reform, which consisted mainly of reducing the tax rates in the lowest two brackets. For a more detailed summary of the system see section 2 of the appendix.

4.1 Personal Income Tax and Social Benefits in 2005—Baseline

Until 2005 net labor income was calculated by subtracting taxes and employee contributions to health and social insurance from gross income. Taxes were, in turn, computed using the tax base, defined as the sum of various income categories (e.g., wages and rental and entrepreneurial incomes) minus allowances for non-taxable items and deductibles. The personal tax scheme was stepwise; there were four tax brackets with corresponding tax rates: 15%, 20%, 25% and 32%. The part of income that falls into the lower bracket(s) was taxed at the corresponding lower tax rate(s); only the part that exceeds the lower bracket(s) was taxed at the higher tax rate(s).

[18] Using this standard definition of effective net wages is problematic in the case of highly de-motivating benefit systems, where for some individuals the effective marginal tax rate is actually greater than one. To be able to use these cases in our estimation, we censor the value of $\tilde{m}$ for these observations at the value of 0.99. We have also tried to use an alternative definition of $\tilde{m}$, where the change in the benefits is divided by the household size, which leads to tax values between 0 and 1. The results (available from the authors) for the marginal effects for men are robust to this specification, but the effect of wages on the employment of women almost doubles.

The complete scheme of social benefits was rather complicated. We use the summary of the Czech social system (in 2002) as provided by Galuscak and Pavel [2005], table 1, to calculate social benefits. These are defined as the sum of child benefits, housing benefits, social supplements and social assistance.

4.2 Tax Reform 2006

The Czech government implemented several modifications to the PIT scheme in 2005. These changes came into effect on January 1, 2006 and their key components can be summarized as:[19]

1. a decrease of the two lowest tax rates: from 15% to 12% and from 20% to 19%, and

2. an extension of the lowest tax bracket to be applicable to an average income of up to CZK $10,100$ per month (from the "baseline" value of CZK $9,100$ per month).

The new tax system thus lowers the PIT burden primarily for low- and middle-income employees. Consequently, the tax system becomes even more progressive. These changes in tax rates have an additional (indirect) effect: The amount of social benefits for some households will decrease as their net incomes rise (due to the lower PIT rates).

4.3 Effective Impacts of the Reforms: An Illustrative Figure

Figure 1 depicts the impact of the reform on an individual living in two types of households: a single-person household and a family-type household of two adults and two children. The impact is illustrated in terms of her after-tax labor income, per person social benefits, and her effective marginal tax rate of the transition from not working to working (as defined above) as a function of her own gross wage. The top panels refer to a single-member household, while the bottom panels show the same for a household with two adults and two children, assuming that the other partner earns gross a wage of CZK $15,600$ (the median wage in our estimation sample).

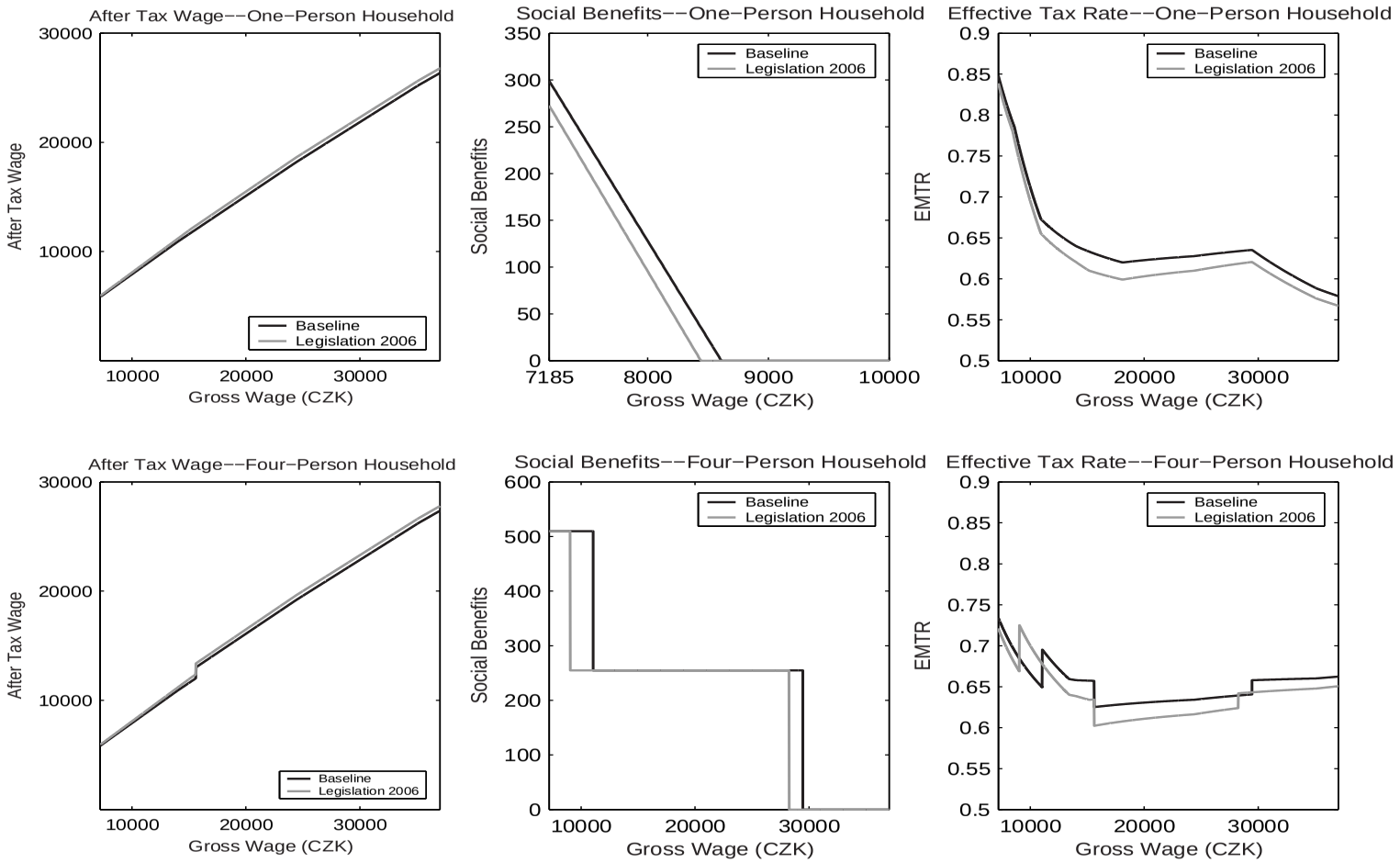
The figure provides some preliminary signals about the likely effects of the reform. The progressive PIT reform has relatively little effect: Net wages increase only moderately, and social benefits (per person or per household) for some individuals who work—as a consequence—decline.

The right-hand panels of figure 1 display the effective marginal tax rates of the transition from not working to working (computed using formula (3.4)) for individuals living in one- and four-member households. This rate reflects the actual incentives for a particular individual to work. It captures the degree to which her potential gross wage is taxed, not only due to the taxes but also due to the reduction in the per person social benefits as a consequence of starting to work. The figures show that—for both the baseline situation and the progressive tax reform—there is little incentive (in particular for a single person) to work when the potential gross wage is very low.[20]

[19] The tax rates and tax brackets effective since January 1, 2006 are described in table 1 in the appendix.

[20] Here, we assume that the non-workers are unemployed and receive unemployment benefits. The monthly (after-tax) social benefits (excluding unemployment benefits) for a non-worker living in a single-person household are CZK $5,027.50$ for both the baseline of 2005 and the reform scenario of 2006. Social benefits (per adult) for an individual living in the four-person household displayed in figure 1 amount to CZK $1,545$ and $1,249$ for the baseline and the reform alternative respectively.

Figure 1: After-Tax Wage, Social Benefits and Effective Marginal Tax Rates—One- and Four-Member Households



Notes: For the four-member household we assume that the other partner earns a gross monthly wage of CZK $15,600$. The household has two kids aged 3 and 8 years. The after-tax wage excludes social benefits. Social benefits are calculated per adult. The Effective Tax Rate (EMTR) is the effective marginal tax rate of the transition from not working to working as defined in the text. The horizontal scale starts at the 2005 minimum wage, CZK $7,185$.

5. Data Description and Summary Statistics

The data come from the Czech Statistical Office's Czech Household Income Survey, Mikrocensus 2002. The survey was conducted between February 28 and March 25, 2003 and covers in total $19,003$ individuals in $7,973$ households. It contains data on the income, economic and demographic characteristics of the respondents.

For our estimation, we select only individuals who are 25–54 years old. Students, the self-employed, women (and men) on maternity leave, and the fully disabled are excluded. In all these cases, the labor supply decision is more complex than the theoretical and econometric models which are used here can capture, and each would require a separate study. In addition, the specific social benefits targeted at these groups changed between 2002 and 2006, and the extrapolation of their behavior would require strict assumptions. On the other hand, it is these people whose labor supply is more sensitive to wages compared to an average individual. Consequently, the overall employment effect of the tax cuts on the whole population is expected to be (disproportionately) higher should these groups also be taken into account.

As for the self-employed, it is not clear how to understand and identify the concept of a non-working self-employed person in the data. In particular, it is not observable whether the non-worker would work in dependent employment or be self-employed if she started to work. Their inclusion would lead to a more subtle decision model of three alternatives: dependent work, self-employment, no work.

As explained above, the unemployed are kept in the sample and classified as not supplying labor. Given these restrictions, the estimation sample consists of $6,381$ individuals, $3,094$ men and $3,287$ women, living in $4,340$ households.

Ideally, the labor supply indicator in our model should reflect the current employment status of the individual. Unfortunately, the only labor force status variable available in the dataset is dominant economic activity during the past year, and it is this variable that we use to construct our indicator. This is a potential problem, leading, for example, to under-representation of short-run non-workers and over-representation of long-term non-workers. Fortunately, for most people in the dataset, the prevailing economic activity stays the same during the whole year. For example, the vast majority of the unemployed respondents, 82 percent, have not been employed at any time during the year. (This is graphically displayed in figure 1 in the appendix.) In addition, as our analysis focuses on labor supply, it is the long-term non-employed, who do not supply their labor but might change their behavior in response to the proposed reforms, that we are really interested in.

5.1 Descriptive Statistics

The proportion of the unemployed in the whole sample is comparable for men and women: 4.4 percent and 5.2 percent respectively. In contrast the participation rate is somewhat higher for men: it amounts to 98 percent for men and 93.6 percent for women, implying inactivity rates of 2 percent and 6.4 percent for men and women respectively.

Table 1 summarizes the basic characteristics of the most relevant variables. The average gross monthly wage (in 2002) in our estimation sample is about CZK $13,960$. The average age is slightly less than 40 years. About half the respondents have complete secondary education or higher. A typical household has about three members. About 67 percent of the individuals in our sample are married. The children variable refers to the number of children present in the household rather than the individual's own children. Children can be linked to their parents in the dataset only for household heads and their spouses. As we

Table 1: Estimation Sample Summary Statistics

Variable	Mean	Min.	Max.
Gross Wage	13958.5	5700	44084.2
Age	39.9	25	54
Higher Education	0.52	0	1
Married	0.67	0	1
Kids $<$ 2 years	0.06	0	2
Kids 3–5 years	0.09	0	2
Kids 6–9 years	0.17	0	3
Kids 10–15 years	0.35	0	3
# of Household Members	3.11	1	8
Unemployed	0.046	0	1
Inactive	0.042	0	1
Regional Unemployment	0.090	0.025	0.214
N		6381	

are using all individuals in the household to maintain a bigger sample size, we are limited to the use of the information about the presence of children in the household. However, this may be relevant information, because child care may be provided by other members of the household as well, and therefore affect their labor supply.

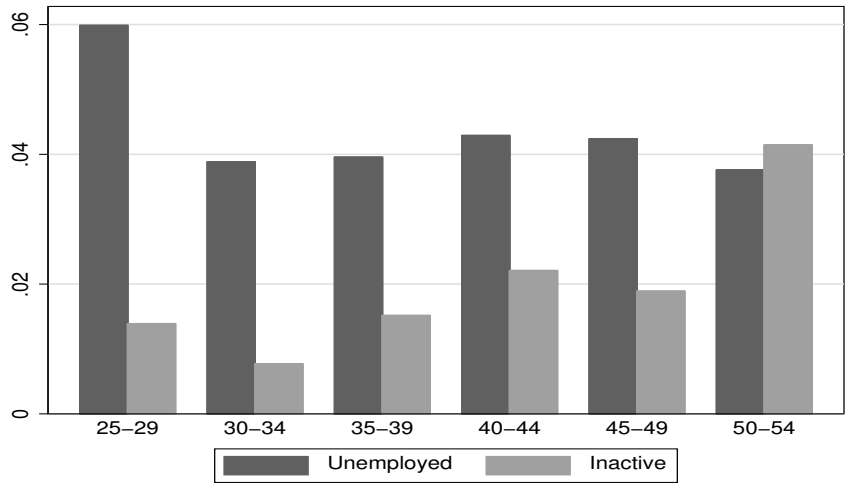
The effective marginal tax rate of the transition from non-employment to employment was constructed using formula (3.4). Total household social benefits were calculated for each individual for two possible states: working and not working, depending on her net after-tax wage, either actual or implied by the Heckman estimation. We used the summary of the Czech social benefit system (in 2002) as provided by Galuscak and Pavel [2005], table 1, to calculate social benefits. These are defined as the sum of child benefits, housing benefits, social supplements and social assistance.

Next, we focus on the distribution of the labor force status (employment, unemployment and inactivity) across different demographic groups to characterize the key labor supply patterns in our sample. Figures 2–4 display unemployment and inactivity rates by age, gender and education. The main findings are quite intuitive. The unemployment rates by age range between 3.8 percent and 6 percent for men and 1.8 percent and 8.2 percent for women. Unemployment is higher for younger individuals. Women's inactivity rates tend to be higher than men's. Both unemployment and inactivity rates are considerably lower for more highly educated individuals.

Figure 5 and table 2 summarize the cross-section distribution of gross and net monthly wages in 2002.[21] Not surprisingly, the distribution of the net wage is substantially more concentrated than the distribution of the gross wage: 90 percent of net wages are between CZK $5,700$ and $20,281$; for gross wages this range is between CZK $6,922$ and $26,793$. Second, the distribution of the gross wage is considerably skewed: The median gross wage CZK $12,649$ is significantly lower than the mean gross wage CZK $13,958$.

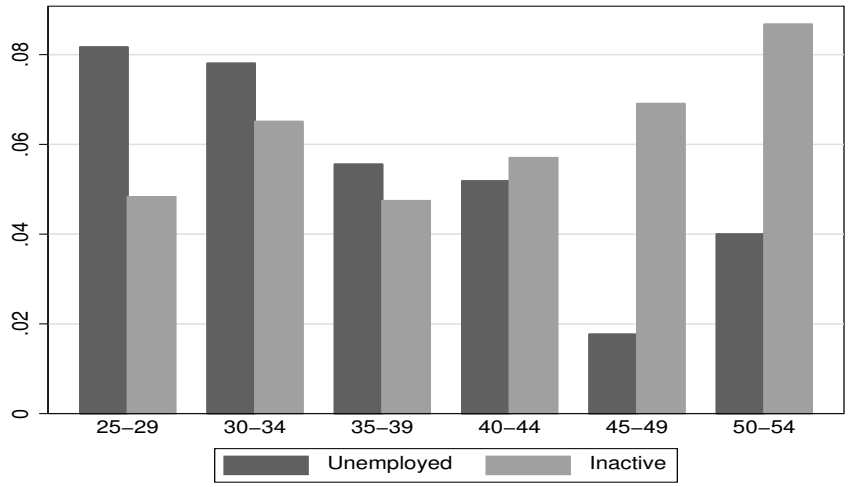
[21] Wages for non-workers in figure 5 and table 2 were augmented using the Heckman regression as described above. Gross wages below the 2002 minimum wage (CZK $5,700$) were imputed to equal to CZK $5,700$.

Figure 2: Unemployment and Inactivity by Age—Men



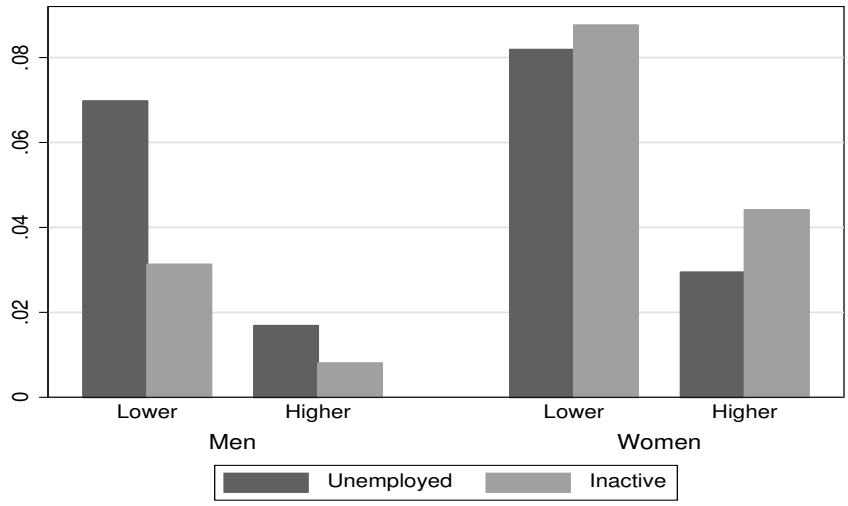
Notes: The unemployment rate is calculated as the share of the unemployed in the economically active. The inactivity rate is the ratio of the economically inactive to the total population.

Figure 3: Unemployment and Inactivity by Age—Women



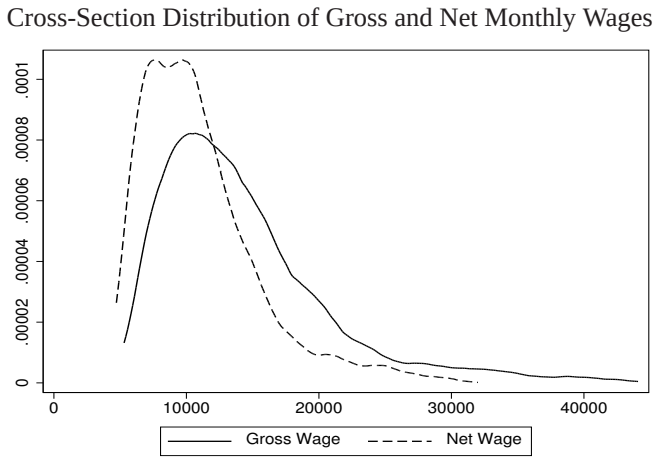
Notes: The unemployment rate is calculated as the share of the unemployed in the economically active. The inactivity rate is the ratio of the economically inactive to the total population.

Figure 4: Unemployment and Inactivity by Education and Gender



Notes: The unemployment rate is calculated as the share of the unemployed in the economically active. The inactivity rate is the ratio of the economically inactive to the total population. Higher education: Complete secondary education or higher.

Figure 5: Wage Inequality



Notes: The figure shows kernel density estimates (with the Epanechnikov kernel and automatic width selection).

Table 2: Cross-Section Distribution of Monthly Wages—Estimation Sample (2002, CZK)

Quantile	Gross Wage	Net Wage
1%	5700.00	4745.95
5%	6922.35	5700.48
10%	7727.12	6302.44
25%	9568.48	7727.18
50%	12648.50	10075.82
75%	16461.15	12942.82
90%	21522.50	16536.78
95%	26793.07	20281.10
99%	36738.34	26435.41
Mean	13958.47	10954.13

6. Estimation of Labor Supply

The results from the maximum likelihood estimation of the wage equation using the Heckman selection model are available in section 4 of the appendix. The estimates of the wage equation are in line with our prior expectations and with the evidence from the literature for other countries: Wages increase with age and education. The degree of urbanization of the residence also increases wages, as does living in Prague (the Czech capital), which is the base category for the dummy variables indicating the region. Disability significantly decreases the wage level. The results are fairly similar for men and women, though female wages seem to be more sensitive to many of these factors. The selection equation shows more substantial differences between men and women. In particular, the effect of young children is negative and large for women, while it is not significant for men.

Table 3: Probit Estimation Results—Men

Variable	Coefficient	(Std. Err.)
Log Net Wage	0.186**	(0.054)
Age	0.100†	(0.051)
Age^2	-0.132*	(0.065)
Non-Social Income	0.287**	(0.071)
Married	0.661**	(0.099)
Higher Education	0.307**	(0.094)
Kids $<$ 2 years	0.208	(0.167)
Kids 3–5 years	0.065	(0.142)
Kids 6–9 years	0.075	(0.115)
Kids 10–15 years	0.118	(0.098)
No. Hh Members	-0.154**	(0.056)
Other Ec Act in Hh	0.081	(0.084)
Regional Unemployment	-0.050**	(0.008)
Partly Disabled	-0.945**	(0.165)
Intercept	-1.752†	(1.058)
N	3094	
Log-likelihood	-562.187	

Continued on next page...

... table 3 continued

Variable	Coefficient	(Std. Err.)
$\chi^2_{(14)}$	331.116	

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

Table 4: Probit Estimation Results—Women

Variable	Coefficient	(Std. Err.)
Log Net Wage	0.384**	(0.033)
Age	0.096*	(0.044)
Age^2	-0.124*	(0.056)
Non-Social Income	-0.060†	(0.036)
Married	0.218**	(0.079)
Higher Education	0.140†	(0.071)
Kids $<$ 2 years	-0.227	(0.194)
Kids 3–5 years	-0.472**	(0.114)
Kids 6–9 years	-0.368**	(0.080)
Kids 10–15 years	-0.061	(0.071)
No. Hh Members	-0.002	(0.052)
Other Ec Act in Hh	0.096	(0.075)
Regional Unemployment	-0.030**	(0.007)
Partly Disabled	-1.219**	(0.160)
Intercept	-3.479**	(0.864)
N	3287	
Log-likelihood	-909.881	
$\chi^2_{(14)}$	493.26	

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

The wage equation estimated in the first stage was used to impute the wages of non-workers and of those in our sample who have wages missing. We then use the observed and imputed gross hourly wages to construct the effective net full-time equivalent monthly wages, as described in the previous section. The effective net wage is the key variable in the estimation of the labor supply decision. The results from the probit model of the probability of working are presented in tables 3 and 4. The sign and significance of the coefficients of most of the variables correspond to what has been found elsewhere in the literature: The net wage has a significant and positive effect on the probability of employment. Age enhances labor supply, while disability reduces it. In regions with higher unemployment, the probability of working is lower. Children have no effect on whether men work, but they reduce the probability of employment of women, although the effect diminishes as the children get older.[22] Married people are more likely to work than single ones, but the effect is more substantial for men than for women. The positive effect of

[22] The reason why there is no effect of children younger than two years on labor supply is that individuals on maternity leave are excluded from the sample.

Table 5: Marginal Effects by Tax Bracket and Education—Men

Tax Bracket		Education		
Gross Wage (CZK)	Marginal Tax Rate	Below Upper Sec	Upper Sec And Above	All
$< 9\,100$	15%	0.027^{**}	0.012^{*}	0.021^{*}
9 100–18 200	20%	0.018^{**}	0.008^{*}	0.011^{*}
18 200–27 600	25%	0.016^{**}	0.005^{*}	0.006^{*}
$> 27\,600$	32%	0.018^{**}	0.005^{*}	0.006
All	15–32 %	0.026^{**}	0.010^{*}	0.018^{*}

Significance levels : † : 10% $*$: 5% $**$: 1%

other income (excluding social benefits) on male employment has a less clear interpretation, as does the negative effect of household size.[23] We interpret this to be a consequence of the impact of the eligibility criteria for social benefits and of the very high marginal tax rate on the wage. As other income reduces the entitlement to benefits when not working, it also reduces their disincentives, i.e., it increases the incentives to work.[24] Household size on the other hand increases the minimum living standard of the family and therefore also the benefits eligibility if not working.

The insignificant effect of education on women's probability of working is less surprising, as here we already condition on wages, which are that is highly correlated with education. It seems that it is through wages that the effect of education on employment is most pronounced. However, the effect of education on men's decision to work is still high and significant.

Although the coefficients from the probit model are informative about the fit of the model[25] and the basic direction and significance of the impact of the individual factors, their size does not have a direct interpretation. Marginal effects have to be calculated to get information about the magnitudes. As the model is non-linear, the size of the effects varies with different values of the variables.

Marginal effects can be evaluated at mean values or for some typical representative individuals. Alternatively, which is the approach we take here, marginal effects can be evaluated at each point of the dataset, for each individual. The magnitudes can then be summarized for particular intervals of the values of factors by averaging the marginal effects over these intervals, i.e., over the group of people with values of the variables that belong to these intervals. As the primary focus of our analysis is on the effect of wages, we present only the marginal effects of wages on the probability of working.

As the wage enters the probit equation in logarithm, the marginal effect MFX $= \alpha\phi(\alpha \log w_i + X_i\beta)$, where $\phi(\cdot)$ is the probability density function of the standard normal distribution, can be directly interpreted as the wage semi-elasticity of the decision to work: A 1% percent rise in the net wage increases the probability of working by $0.01 \times$ MFX (or the proportion the of employed $P_E\%$ from $P_E\%$ to $P_E +$ MFX$\%$). Tables 5 and 6 summarize the average marginal effects for men and women overall and by tax brackets and education.

[23] These factors are not significant for women.

[24] The positive effect of other income may also reflect savings from previous work, which—if labor supply is persistent over time—results in the positive correlation. As we have only cross-sectional data at hand, we are unable to disentangle the two effects.

[25] The fit of our probits can also be assessed from the χ^2 statistics in tables 3 and 4 and pseudo R^2s, which are 0.23 and 0.21 for men and women respectively.

Table 6: Marginal Effects by Tax Bracket and Education—Women

Tax Bracket		Education		
Gross Wage (CZK)	Marginal Tax Rate	Below Upper Sec	Upper Sec And Above	All
$< 9\,100$	15%	0.072^{**}	0.053^{**}	0.064^{**}
9 100–18 200	20%	0.042^{**}	0.032^{**}	0.035^{**}
18 200–27 600	25%	0.032^{**}	0.024^{**}	0.024^{**}
$> 27\,600$	32%	0.025^{**}	0.020^{**}	0.020
All	15–32 %	0.067^{**}	0.043^{**}	0.055^{**}

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

The average marginal effect of the net wage on the probability of employment of women is higher than that of men. The results show that on average, a 10 percent rise in the effective net wage will increase the probability of working by 0.0018 (increase the employment rate by 0.18 percentage points) for men, and by 0.0055 (increase the employment rate by 0.55 percentage points) for women. The size of the effect declines with education and wage level. The wage semi-elasticity of low educated individuals, whose gross wage corresponds to the two lowest tax brackets (the two targeted by the progressive tax reform) is 0.027 and 0.018 for men and 0.072 and 0.042 for women.

Qualitatively, our estimates are consistent with the previous findings in the literature. The wage-elasticity of labor supply of women is higher than that of men, and the sensitivity of labor supply to wages decreases with education and income bracket. However, in terms of size, our results are at the lower end of the range of estimates documented in other papers. As mentioned earlier, focusing only on the decision to work, and incorporating both the tax and benefit system, prevents a direct comparison of our study with most of the previous work. In addition, our definition of the effective marginal tax rate of transition to working, which accounts for any fall in benefits a household experiences if the given individual starts working, may further contribute to the relatively small effects we find here.

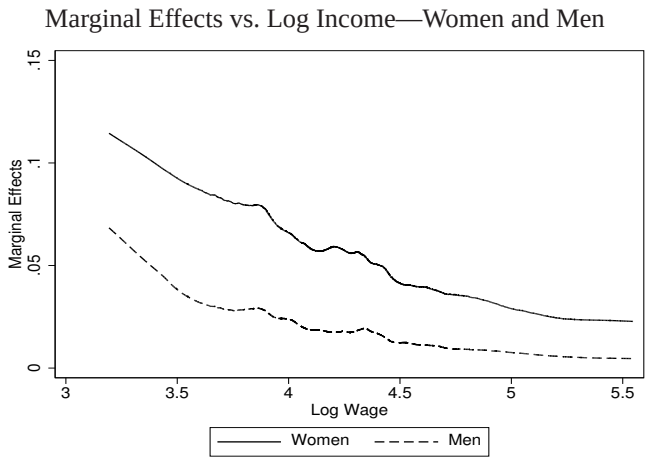
Figure 6 presents the smoothed marginal effects of men and women as a function of the logarithm of the effective net wage. It emphasizes the two features already discussed above: first, women are more sensitive to wages than men in their decision to work, and second, the wage sensitivity of labor supply substantially decreases with wage level for both men and women.

The results from the estimation of the wage semi-elasticity of the labor supply decision—whether or not to work —are already informative as to the effectiveness of the proposed reforms, prior to the formal evaluation of their fiscal implications. As for the changes in the tax rates, the higher wage sensitivity of low income individuals suggests that the tax reduction should be mostly targeted at the lowest tax brackets.[26]

At the same time, the increased incentives from lower taxes in the lowest bracket proposed by the progressive tax reform will (under the current benefit system) be counteracted by the fall in social benefit entitlements (the "in work" benefits) due to higher net wages. This plan includes a reduction in taxes that will lower the effective marginal tax rate of the transition from non-employment to employment $\tilde{m}$, but the existing eligibility rules for receiving benefits will raise it to some extent.

[26] This idea is also supported by the simple fact that the employment probability of high income individuals is almost one, i.e., they almost all already work and no tax reform can therefore induce them to increase their labor force participation any further.

Figure 6: Women Are More Flexible



Notes: The figure compares the smoothed marginal effect with respect to wages. The dependent variables are smoothed marginal effects from the probit estimation. The smoothing was done using the locally weighted regression with bandwidth 638 observations.

Table 7: Summary of the Consolidated Public Sector Budget (CZK billions)

	2002	2005	2006*
Income			
Personal Income Tax (PIT)	114.4	142.4	137.2
Health and Social Insurance (HSI)	335.0	416.1	437.7
PIT+HSI	449.4	558.5	574.9
Expenditure			
Social Benefits (excluding pensions)	91.6	96.1	99.1
PIT+HSI–SB	357.8	462.4	475.8

Notes: *: Expectation of the Czech Ministry of Finance, September 2006 (State budget proposal documentation, Books E and K).

To conclude, the tax changes proposed by the progressive tax option will have some effects on employment, as they target wage-sensitive individuals to a greater extent. However, the eligibility rules of the current benefit system will counteract the impact of the tax decreases in the low brackets.

Our results, however, also suggest that as the estimated net wage effects are relatively small, the behavioral response even among low income individuals will be relatively limited. The employment effect (the active scenario) is thus likely to have only a minor impact on the total fiscal implications of the reform.

7. Fiscal Implications

Table 7 summarizes the revenue and expenditure sides of the Czech consolidated public sector budget in 2002 (the year in which our data were collected) and 2005 (the last year for which actual data are available) and the expectations for 2006. The revenues from personal income taxes (PIT) reached roughly

Table 8: Fiscal Implications of Income Tax Reforms—Estimation Sample (CZK Billions, 2006)

	Baseline	Legislation 2006
Passive Scenario		
Personal Income Tax (PIT)	66.47	54.90
Health and Social Insurance (HSI)	315.84	315.84
PIT+HSI	382.31	370.74
Social Benefits	32.50	29.50
PIT+HSI–SB	349.81	341.24
Active Scenario		
Personal Income Tax (PIT)	–	54.94
Health and Social Insurance (HSI)	–	316.04
PIT+HSI	–	370.99
Social Benefits	–	29.37
PIT+HSI–SB	–	341.62

CZK 142 billion in 2005 and, according to the Czech Ministry of Finance, were expected to fall by almost CZK 5 billion in 2006 as a result of the tax cuts. The combined revenues from health and social insurance (HSI) were about CZK 416 billion in 2005 and are expected to be roughly CZK 30 billion higher in 2006.[27] On the expenditure side, the current (2005) social benefits (SB, excluding rents) total about CZK 96 billion and are expected to increase by about 3 percent in 2006. For our purposes the overall *net impact* of the current tax system on the budget is summarized by PIT+HSI–SB, which amounted to CZK 462 billion in 2005 and was expected to be CZK 476 billion in 2006.

Let us now consider how the tax reform will impact on government finances. We report two alternative settings: (i) the *passive scenario*, in which we assume there is no effect on labor supply, and (ii) the *active scenario*, which includes the employment effect (i.e., the labor supply response to the tax and benefit changes).

Table 8 reports the estimated *net impact* for the current (2005) tax system (denoted Legislation 2006) and the results for the recent reform. Note that in these calculations *we focus only on our estimation sample*, which consists of individuals between 25 and 54 years, excluding the self-employed and current students. It turns out that this sample covers about 48 percent of total personal income tax revenues. (The PIT revenues in our population-weighted estimation sample are CZK 66.5 billion, compared to the expected total PIT revenues of CZK 137.2 billion in 2006, reported in table 7.)

7.1 The Passive Scenario

As a benchmark we first focus on the *passive* scenario (assuming no effect of tax and benefit changes on employment), displayed in the top panel of table 8. The overall *net fiscal impact* will depend on the relative size of the effects on the revenue and expenditure sides. The revenue side PIT+HSI will be negatively affected and government expenditures will fall due to somewhat lower social benefits (as they decrease when net earnings rise).

[27] Note that a part of the HSI revenues is directly transferred to health insurance companies and does not enter the public sector budget.

The aggregate numbers displayed in table 8 are calculated using the gross wages in 2006, probabilities of employment and sampling weights. Suppose individual i, who in the current tax system works with probability $p_i^{baseline}$ (obtained from our probit estimation above), earns a full-time equivalent monthly gross wage w_i and pays personal income tax $t^{baseline}(w_i)$. Our dataset contains sampling weights v_i, which describe how many individuals in the population each person represents.[28] Denoting by N the number of individuals in our estimation sample, we calculate the total personal income taxes in the current tax system as

$$\text{PIT}^{baseline} = \sum_{i=1}^{N} v_i \, p_i^{baseline} \, t^{baseline}(w_i).$$

Similarly, total revenues from personal income taxes under the passive scenarios for the progressive tax reform are given by

$$\text{PIT}_{Pas}^{reform} = \sum_{i=1}^{N} v_i \, p_i^{baseline} \, t^{reform}(w_i).$$

The implications of the *active* settings, presented in the next sub-section, are computed based on the "new," post-reform probabilities of employment:

$$\text{PIT}_{Act}^{reform} = \sum_{i=1}^{N} v_i \, p_i^{reform} \, t^{reform}(w_i).$$

The probabilities of employment $p_i^{baseline}$ and p_i^{reform} depend on wages and the structure of the tax and benefits systems (among other things). We use analogous formulas to determine the appropriate sums for health and social insurance and social benefits.

We use the following procedure to make sure that the fiscal calculations apply to 2006 even though our data were collected in 2002. We first estimate the parameters of the labor supply (reported in tables 3 and 4) with the 2002 data. We assume that these parameters capture the structural characteristics of the model, which should not vary over time. Moving on to labor supply in 2006, we inflate wages with the expected growth of the wage deflator between 2002 and 2006 and other income with CPI growth. To calculate effective wages in 2006 we apply the tax and social benefits systems of 2005 for the baseline and 2006 for the "Legislation 2006" scenario. Finally, for the fiscal implications, we predict individuals' probability of working in 2006 under the two scenarios, and calculate their taxes and benefits.

Quantitatively, the progressive tax reform has the following effects. We expect that, for the sub-population corresponding to our estimation sample, the total PIT revenues will fall by CZK 11.6 billion due to the cuts in the two lowest income tax brackets. The expenditures on social benefits will presumably fall by CZK 3 billion. Under the PIT reform of 2006 the only impact on the expenditures side is through a decrease in social benefits due to higher incomes (caused in turn by lower taxes). The overall impact of this reform on the budget thus amounts to CZK 8.6 billion.

7.2 The Active Scenario Including the Employment Effect

Let us now extend our analysis to the active scenario, in which changes in taxes and benefits can affect labor supply behavior. Our estimates of the labor supply from section 6 imply that some individuals

[28] This means that the weights in our dataset sum to the total Czech population, $\sum_{i=1}^{\bar{N}} v_i \approx 10.2 \times 10^6$. The weights in our estimation sample sum to $\sum_{i=1}^{N} v_i \approx 3.5 \times 10^6$.

start working in response to an effective net wage increase due the proposed reforms. Individuals who enter employment start paying taxes and receiving less benefits, so income tax receipts will be higher and social benefits lower than under the passive scenario.

The bottom panel of table 8 summarizes the fiscal implications, which take into account the employment effect. The effect of the progressive tax reform is very similar to the passive scenario: the net fiscal impact is only about CZK 400 million lower. This is because the reform is found to have little effect on employment: The number of employed in the sub-population we focus on increases only slightly, from $3,158,900$ to $3,161,300$.[29] On the one hand most individuals see their (potential) wages increase due to lower income taxes. On the other hand, for some low-income individuals with children or non-workers in the household, this effect is diminished by the fall in actual or potential (if they start working) social benefits. Compared to the baseline, the PIT revenues and social benefits expenditures fall by CZK 11.5 and 3 billion respectively.

8. Conclusion

We estimate the fiscal implications of the income tax reform implemented in January 2006. In addition to quantifying the expected direct impact of the change in taxes and benefits on the government budget, we present an active scenario evaluation which takes into account the labor supply response and the employment effect. In order to do that, we first estimate the probability of working as a function of the effective net wage for each individual in our sample and simulate the impact of the changes in taxes and benefits on employment. The (fiscal) employment effect then consists of the additional taxes paid by the individuals who start working and the subsequent reduction in their benefits. We use micro data from Mikrocensus 2002 to conduct our estimation and focus on the sub-population of individuals between 25 and 54 years who are neither self-employed, nor students.

While our analysis is subject to numerous limitations, a number of conclusions emerge clearly and robustly. First, we provide one of the first estimates of the labor supply using the Czech data. For our purposes, we define the labor supply as the binary decision whether to work or not. We find that the mean marginal effect of a 10 percent rise in the effective net wage is 0.0018 for men and 0.0055 for women; this is equivalent to a 0.18 and 0.55 percentage increase in male and female employment respectively. The wage sensitivity of the probability of working decreases with wage and education. For low educated people, whose earnings fall into the lowest tax bracket, a 10 percent increase in the effective net wage leads to an increase in the employment rate for men and women by 0.27 and 0.72 percentage points respectively. The corresponding numbers for the highly educated with income in the highest bracket are 0.05 and 0.20.

Second, we take our labor supply estimates to investigate the fiscal impact of the reforms. We predict that, for the sub-population we consider, the progressive tax reform will result in a shortfall of about CZK 8 billion. The stimulating effect of this scheme amounts to only CZK 0.4 billion and is limited due to its interaction with the current social benefits system, which de-motivates lower earners from working.

[29] The sub-population results were obtained by applying the population weights to the results for our estimation sample.

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Appendix

A.1 Data Construction

Our data are taken from the Czech Household Income Survey, Mikrocensus 2002 (vyberove setreni o peneznich a naturalnich prijmech domacnosti), of the Czech Statistical Office (Cesky statisticky urad). The data were collected between February 28 and March 25, 2003 and cover in total $19,003$ individuals in $7,973$ households. The survey contains data on the income, economic and demographic characteristics of the respondents.

A.1.1 Estimation Sample

Here is how we choose our estimation sample:

- Individuals 25–54 years old
- Students and self-employed are excluded
- The unemployed are kept in the sample
- Women (and men) on maternity leave are excluded
- Fully disabled people are dropped (partly disabled are kept in the estimation sample)

This leaves us with an estimation sample of $6,381$ individuals, $3,094$ men and $3,287$ women, living in $4,340$ households.

A.1.2 Definitions of Key Variables

Constructing Wages for Non-workers

We first use the standard Heckman [1979] model to predict gross hourly wages for non-workers, taking into account the selection to employment. Before doing so we exclude outliers (i.e., the top and bottom 1% of the sample).[30]

The wage and selection equations are estimated jointly by maximum likelihood. Tables A.1 and A.2 report the estimates from the Heckman regression, which was used to augment the non-observed wages.

Table A.1: Heckman Estimation Results—Men

Variable	Coefficient	(Std. Err.)
Equation 1 : lwage		
age	0.017*	(0.008)
agesq	-0.019†	(0.010)
highEduc	0.261**	(0.014)
kraj2	-0.035	(0.031)
kraj3	-0.133**	(0.036)
kraj4	-0.131**	(0.036)
kraj5	-0.102*	(0.041)
kraj6	-0.162**	(0.053)
kraj7	-0.137**	(0.044)
kraj8	-0.120**	(0.040)
kraj9	-0.167**	(0.040)
kraj10	-0.136**	(0.036)
kraj11	-0.139**	(0.037)
kraj12	-0.186**	(0.044)
kraj13	-0.118**	(0.039)

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[30] To be more precise, we set the top and bottom percentiles, 147 observations in total, equal to missing values before running the Heckman regression and replace these missing values with fitted values afterward.

... table A.1 continued

Variable	Coefficient	(Std. Err.)
kraj14	-0.137**	(0.047)
vel	0.014**	(0.004)
nez_okr	0.005	(0.003)
disabledPart	-0.330**	(0.057)
Intercept	3.955**	(0.152)
Equation 2 : empl		
age	0.115*	(0.051)
agesq	-0.155*	(0.065)
married	0.733**	(0.098)
highEduc	0.498**	(0.094)
d_2	0.216	(0.161)
d3_5	-0.021	(0.139)
d6_9	0.020	(0.113)
d10_15	0.105	(0.094)
osob	-0.198**	(0.051)
othact	0.293**	(0.073)
othIncExNatIncM	0.000	(0.000)
natIncM	0.031**	(0.010)
kraj2	0.135	(0.247)
kraj3	-0.139	(0.261)
kraj4	-0.427†	(0.234)
kraj5	0.007	(0.291)
kraj6	0.030	(0.337)
kraj7	-0.106	(0.291)
kraj8	-0.211	(0.279)
kraj9	0.029	(0.269)
kraj10	-0.024	(0.272)
kraj11	0.097	(0.258)
kraj12	-0.485†	(0.257)
kraj13	-0.227	(0.258)
kraj14	-0.025	(0.299)
nez_okr	-0.060**	(0.019)
vel	0.020	(0.023)
disabledPart	-1.259**	(0.164)
Intercept	-0.175	(0.988)
Equation 3 : athrho		
Intercept	-0.436**	(0.130)
Equation 4 : lnsigma		
Intercept	-1.071**	(0.015)
N	3024	
Log-likelihood	-1510.756	
$\chi^2_{(19)}$	589.511	

Table A.2: Heckman Estimation Results—Women

Variable	Coefficient	(Std. Err.)
Equation 1 : lwage		
age	0.023**	(0.008)
agesq	-0.024*	(0.010)
highEduc	0.387**	(0.014)
kraj2	-0.029	(0.033)
kraj3	-0.110**	(0.036)
kraj4	-0.134**	(0.036)
kraj5	-0.059	(0.043)
kraj6	-0.110*	(0.056)

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... table A.2 continued

Variable	Coefficient	(Std. Err.)
kraj7	-0.142**	(0.044)
kraj8	-0.046	(0.042)
kraj9	-0.087*	(0.041)
kraj10	-0.187**	(0.038)
kraj11	-0.099*	(0.039)
kraj12	-0.105*	(0.045)
kraj13	-0.164**	(0.041)
kraj14	-0.148**	(0.049)
vel	0.026**	(0.004)
nez_okr	-0.006†	(0.003)
disabledPart	-0.565**	(0.057)
Intercept	3.365**	(0.163)
Equation 2 : empl		
age	0.117**	(0.038)
agesq	-0.144**	(0.047)
married	0.190**	(0.060)
highEduc	0.580**	(0.062)
d_2	-0.382*	(0.157)
d3_5	-0.315**	(0.086)
d6_9	-0.132*	(0.060)
d10_15	0.014	(0.052)
osob	-0.119**	(0.038)
othact	0.244**	(0.051)
othIncExNatIncM	-0.002*	(0.001)
natIncM	0.010†	(0.006)
kraj2	0.049	(0.147)
kraj3	-0.011	(0.160)
kraj4	-0.112	(0.164)
kraj5	0.319	(0.198)
kraj6	0.017	(0.223)
kraj7	0.048	(0.190)
kraj8	0.445†	(0.250)
kraj9	0.203	(0.184)
kraj10	-0.006	(0.177)
kraj11	-0.073	(0.160)
kraj12	0.110	(0.187)
kraj13	0.041	(0.174)
kraj14	-0.220	(0.198)
nez_okr	-0.029*	(0.014)
vel	0.034*	(0.016)
disabledPart	-1.656**	(0.152)
Intercept	-1.113	(0.721)
Equation 3 : athrho		
Intercept	1.565**	(0.113)
Equation 4 : lnsigma		
Intercept	-1.000**	(0.016)
N	3200	
Log-likelihood	-1763.524	
$\chi^2_{(19)}$	1356.596	

Wages are also predicted for the employed individuals who have missing wage information. However, these observations are (by construction) omitted from the estimation of the Heckman model.

Social Benefits

Social benefits for each observation were calculated for two possible states: working and not working, depending on the net wages implied by the gross wages from the Heckman estimation.

We used the summary of the Czech social system (in 2002) as provided by Galuscak and Pavel [2005], table 1, to calculate social benefits. These are defined as the sum of child benefits (pridavky na deti), housing benefits (prispevek na bydleni), social supplements (socialni priplatek), and social assistance (socialni davky).

Effective Net Wages

We construct the effective net wages that enter the probit as one of the dependent variables. The marginal effective tax rate, METR, is defined as

$$\tilde{m} = 1 - \frac{nw + (SB_{work} - SB_{nonwork})}{w},$$

where nw denotes the net wage, SB_{work} social benefits when working, $SB_{nonwork}$ social benefits when not working and w the gross wage. Thus the METR summarizes the effective rate of taxation, including the change in social benefits. Using the METR, we then calculate the net wage

$$w_{probit} = (1 - \tilde{m}) \times w$$

which (after taking log) we plug into the probit estimation.

Other, Non-Social Income

We include other, non-social income as an additional control variable in the probit estimation. Other income is measured as net monetary household income (cisty penezni prijem) minus social income (socialni prijmy) minus net working income. Net working income is in turn computed as 0.875×total gross income from main employment (hrube prijmy z hlavniho zamestnani) minus tax. The factor 0.875 reflects the employee contribution to health and social insurance.

Employment

The only unemployment variable the dataset contains is dominant economic activity (prevazujici ekonomicka aktivita) over the past year. Thus we unfortunately do not have a variable that indicates whether a given person is employed/unemployed at the moment when the survey is collected. Luckily, we think this is not a major problem since the vast majority of the unemployed respondents, 82%, have not been employed at any time during the year. This is graphically displayed in figure A.1.

Children

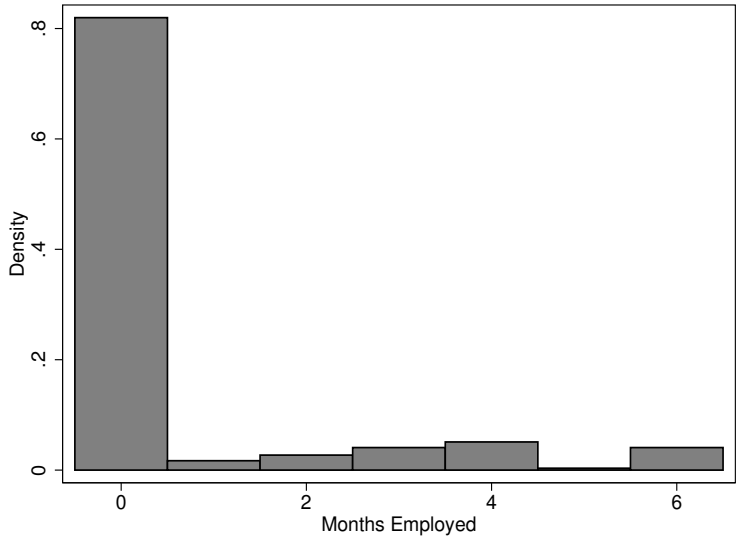
The children variable refers to the number of children present in the household rather than the individual's own children. Children can be linked to their parents in the dataset only for household heads and their spouses. As we are using all individuals in the household to maintain a bigger sample size, we are limited to the use of the information about the presence of children in the household. However, this may be relevant information as child care may be provided by other members of the household as well, and therefore affect their labor supply.

A.2 Current Czech Tax and Welfare System and Its Reform

A.2.1 Personal Income Tax and Social Benefits in 2005—"Baseline Scenario"

This section describes in detail the systems of personal income taxes and social benefits in the Czech Republic as of 2005.

Figure A.1: Months Employed for the Unemployed



PIT is paid on various types of household revenues, such as wages and rental and entrepreneurial incomes. Partial tax bases were obtained by matching particular revenues with corresponding expenditures [31] in each income category. The individual's total personal income tax base is calculated by summing the partial tax bases, subtracting the health and social contributions paid by the employee and applying the non-taxed items and deductibles. Depending on the size of this base the corresponding tax rate is applied. The non-taxed items include a fixed amount for each taxpayer, for the spouse if the partner's income does not exceed certain a level and special deductible items if the payer has a disability. Other deductibles include, for example, gifts to foundations, mortage interest payments, the payer's contribution to her pension funds or life insurance scheme and contributions to unions. The personal tax scheme is stepwise; there are four tax brackets with corresponding tax rates: 15%, 20%, 25% and 32%. Higher income is partly taxed at the lower tax rate(s) in the lower bracket(s); only the part that exceeds the lower bracket(s) is taxed at the higher tax rate(s).

The tax rates apply to the tax brackets depending on the tax base not the income. Taxpayers may thus use deductible items, such as mortgage interest payments and life insurance, to move from the higher tax brackets to the lower ones. In many cases, there was a substantial difference between the original gross income and the consequent tax base.

The social benefits scheme is rather complicated. An individual could qualify for several benefits depending on the financial situation of her household. The government provides several social benefits jointly labeled as *state social benefit support* including:

- child benefit (pridavek na deti)
- parent benefit (rodicovsky prispevek)
- social supplement (socialni priplatek)
- accommodation grant (prispevek na bydleni)
- birth grant (porodne)

[31] Small businessmen could as an option use instead of precise expenditures a lump sum expenditure between 20% and 50% of their revenues depending on the business sector (e.g., craftsmen or commercial traders could apply 25% and farmers 50% of their income as a lump sum expenditure).

- death allowance (pohrebne)
- several foster parent grants (davky pestounske pece)

In addition to these benefits, the public authorities also provide "social welfare benefits" depending on the financial situation of the claimant (e.g., her age, health, other circumstances). These benefits are determined case-by-case by the municipal authorities; there is usually no automatic legitimate claim for awarding them. The benefits can be categorized into five groups depending on their aim or target group:

1. Social welfare benefits for families and children: (davky socialni pece pro rodiny a deti)
   (a) child nutriment grant (prispevek na vyzivu ditete)
   (b) one-time financial or non-financial grants to parents of dependent children, to pregnant women and to dependent children (penezite a vecne davky rodicum nezaopatrenych deti, tehotnym zenam a nezaopatrenym detem)
   (c) marriage allowance for children from foster care (prispevek na uzavreni manzelstvi)
   (d) pre-foster care basic equipment allowance (prispevek na porizeni zakladniho vybeveni ditete pred jeho prevzetim do pestounske pece)
   (e) accommodation allowance for dependent orphaned child (prispevek na uhradu za uzivani bytu nezaopatreneho osireleho ditete)
   (f) allowance for pensioner's child recreation (prispevek na rekreaci deti duchodce)
2. Grant for a disabled person's care (prispevek pri peci o blizkou nebo jinou osobu)
3. Social welfare benefits for seniors:
   (a) one-time benefits:
      i. recreation and spa allowance (prispevek na rekreaci a lazenskou peci)
      ii. transportation costs allowance for recreation and spa senior visitors
      iii. exceptional expenditures allowances (financial or material)
      iv. phone line establishment or change
   (b) repeating benefits:
      i. joint feeding allowance (prispevek na spolecne stravovani)
      ii. increased living expenditures allowance for medical-technical tools (prispevek na zvysene zivotni naklady – ortopedicke, kompenzecni a jine pomucky)
      iii. phone line rental
4. Social welfare benefits for badly disabled citizens (25 different allowances)
5. Special circumstances benefits – financial and non-financial support.

In addition to these two social benefit schemes, sickness and unemployment benefits are provided. The sickness benefit system includes four different allowances: the sickness benefit itself, an equalizing allowance for pregnancy and motherhood, support for care for a sick family member and financial support in maternity.

The unemployment benefit is applied for a period of up to one year, depending on the age of the person, and depending on her previous income. The length of providing an unemployment benefit is 6 months for people younger than 50 years, 9 months for those between 50 and 55 and usually 12 months for those above 55. For the first three months, the unemployment benefit is 50% of the previous average monthly net income in the last employment, but not more than 2.5 times the subsistence level. For the remaining months, the unemployment benefit drops to 45% of the previous average monthly net income. For an unemployed person who cannot provide a previous working record and is older than 26 years, the base for the unemployment benefit calculation equals the person's subsistence level. The unemployment benefit is increased to 60% of the assessment base if the person retrains.

Table A.3: Current (2006) Tax Brackets and Rates

Annual tax base		Tax	from the base
from CZK	to CZK		exceeding
0	121,200	12%	0
121,201	218,400	14,544 CZK + 19%	121,200 CZK
218,401	331,200	33,012 CZK + 25%	218,400 CZK
331201	or more	61,212 CZK + 32%	331,200 CZK

Table A.4: Tax Abatements and (Previous) Non-taxable Items

Item	New tax abatements	Previous non-taxables
Taxpayer	7,200 CZK	38,040 CZK
Husband/wife	4,200 CZK	21,720 CZK
Partial disability	1,500 CZK	7,140 CZK
Disability	3,000 CZK	14,280 CZK
Full disability	9,600 CZK	50,040 CZK
Student	2,400 CZK	11,400 CZK

A.2.2 Reform changes to PIT—"Legislation 2006 Scenario"

The Czech government implemented several modifications to PIT during 2005. The main changes that we consider in this study are:

1. a decrease of the two lowest tax rates: from 15% to 12% and from 20% to 19%,
2. an extension of the lowest tax bracket to be applicable to an average income up to CZK $10,100$ per month instead of the previous CZK 9,100 per month,
3. the abolition of certain non-taxable items and their full replacement by a tax abatement,

The tax rates and tax brackets valid from January 1 2006 are depicted in table A.3. The tax measures attempt to lower the PIT burden primarily for low- and middle-income employees. At the same time, the PIT scheme becomes more progressive; decreasing only the lower tax rates and switching from non-taxable items to tax abatement have relatively disadvantaged higher income workers. For example, having non-taxable items helped the taxpayer to move her tax base into a lower tax bracket. Currently (2006), the taxpayer is more likely to stay in the higher tax brackets and can get some compensation only after the tax is calculated. The impact of the tax abatement depends on the marginal tax rate. The current setting of the tax abatement level on, for example, a taxpayer increased the tax obligation of payers from all tax brackets except the lowest one. Table A.4 summarizes the changes related to tax abatements.

The tax abatement on a taxpayer applies to all taxpayers; other items depend on certain conditions. For example, the tax abatement for a spouse is applicable only if she does not reach a certain level of income. This item is usually applied if one of the partners is unemployed or on maternity leave. The other three abatements depend on the taxpayer's health conditions and medical judgment; e.g., the partial disability and disability abatement items are relevant when the partial or full disability pensions are granted.

A.3 Calculation of Marginal Effects and Their Standard Errors

The marginal effects in tables 5 and 6 of the paper were calculated using standard formulas, see for example Baltagi [2002], as follows. Denote by X an $n \times k$ data matrix, β a $k \times 1$ parameter vector and x_i the ith row of X (x_i is $k \times 1$). The probability of employment can be calculated as:

$$P(E = 1|X) = \Phi(X\beta),$$

where is Φ is the normal cdf. The marginal effects with respect to x_i are

$$\mathrm{MFX}_{x_i} = \frac{\partial \Phi(x_i'\beta)}{\partial x_i} = \hat{\beta}\phi(x_i'\hat{\beta}).$$

Standard errors of the marginal effects can be obtained by the delta method from the (asymptotic) variance–covariance matrix

$$\mathrm{var}(\mathrm{MFX}_{x_i}) = \phi(x_i'\hat{\beta})^2 \left(I_k - x_i'\hat{\beta}\hat{\beta}x_i'\right) \mathrm{var}(\hat{\beta}) \left(I_k - x_i'\hat{\beta}\hat{\beta}x_i'\right)', \tag{A.1}$$

where I_k denotes the $k \times k$ identity matrix.

The t statistics in tables 4 and 5 of the paper do not account for the fact that wages were in the first stage generated by the Heckman model. The reason we do not use a bootstrap procedure to correct for this bias is that this is not computationally feasible given that we calculate the marginal effects for each observation in our dataset.