Hourly wage rate and taxable labor income responsiveness to changes in marginal tax rates

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Abstract

Recently, a voluminous literature estimating the taxable income elasticity has emerged as an important field in empirical public economics. However, to a large extent it is still unknown how the hourly wage rate, an important component of taxable income, reacts to changes in marginal tax rates. In this study we use a rich panel data set and a sequence of tax reforms that took place in Sweden during the 1980s to estimate the elasticity of the hourly wage rate as well as the taxable labor income elasticity with respect to the net-of-tax rate. We also estimate elasticities with respect to the non-labor income in a way that is novel in the literature. While carefully accounting for the endogeneity of marginal tax rates we find a statistically significant response in wage rates both among married men and women. The estimates of the hourly wage rate elasticity with respect to the net-of-tax rate fall in the range of 0.14–0.16 for males and 0.41–0.57 for females, whereas the corresponding taxable labor income elasticity estimates hover between 0.19–0.21 for males and 0.96–1.44 for women. Moreover, for men we find that the taxable labor income elasticity with respect to non-labor income is statistically significant; the point estimate being −0.07. This implies that the compensated taxable labor income elasticity is about 5 percentage points higher than the uncompensated one. In general, we consider the estimates for males to be more certain and robust than the estimates for females.

Keywords: Income taxation, Hourly wage rates, Work effort, Taxable income

1. Introduction

Historically, the study of the behavioral response to changes in marginal tax rates has been centered on the labor supply choice. However, the standard labor supply model, where the individual chooses hours of work given an exogenous wage rate, abstracts from the possibility that the individual is able to affect her own wage rate. Indeed, it is not far-fetched to consider situations when a lower tax rate may induce the individual to change job, take on more difficult and compensated tasks, put in more effort into wage bargaining, alter form of compensation or simply work more intensely. Even though such changes in work effort and tax avoidance to a large extent are unobservable to the econometrician, behavioral changes along this margin are nevertheless likely to show up in altered hourly wage rates.

Reasoning along these lines has been one of the rationales of a growing body of research measuring the elasticity of taxable income with respect to the net-of-tax rate (one minus the marginal tax rate) with Lindsey (1987) and Feldstein (1995) as seminal contributions. However, it is still unknown if, or to what extent, individuals influence their hourly wage rates in response to tax changes. Recent research on U.S. data (Gruber and Saez, 2002; Kopczuk, 2005 and Giertz, 2007) indicates that much of the taxable income response lies in deduction behavior.

Here we address the issue of hourly wage rate responsiveness by employing a rich survey and register data set created from the 1981 and 1991 waves of the Swedish Level of Living Survey. In particular, we have access to a survey variable on the individual’s hourly wage rate on a longitudinal basis. Between 1981 and 1991 top marginal tax rates were cut by 34 percentage points in Sweden in a piecemeal fashion. This sequence of tax reforms created substantial individual exogenous variation in marginal tax changes depending on tax bracket in 1981. In this paper we exploit this exogenous variation, together with the rich panel data material, to test whether hourly wage rates are sensitive or not to changes in marginal tax rates.

While carefully accounting for the endogeneity of marginal tax rates as well as other factors that determine wage rates we do find a statistically significant response both among married men and...
women: The estimates of the hourly wage rate elasticity with respect to the net-of-tax rate fall in the range of 0.14–0.16 for males and 0.41–0.57 for females. Seen from the perspective that wage rates often have been assumed to be exogenous in labor supply models these estimates must be thought of as surprisingly large.

In line with previous literature, we have also estimated the elasticity of taxable labor income with respect to the net-of-tax rate. For married men we obtain estimates of the (uncompensated) taxable labor income elasticity ranging between 0.19 and 0.21. For women the corresponding estimates hover between 0.96 and 1.44. Taxable labor income is defined as the earnings net of costs of earning the income. One should note, however, that the elasticity estimates for males in general are more precise and more robust than the estimates for females.

We improve upon existing studies in one additional crucial respect: we specify virtual incomes and set out to estimate the taxable labor income elasticity with respect to the non-labor income. For males we find a statistically significant non-labor income elasticity with expected sign: \(-0.07\). The corresponding estimates for females are not significantly different from zero. Armed with these elasticities we are able to compute compensated elasticities. For males, an uncompensated elasticity of 0.19 corresponds to a compensated taxable labor income elasticity of 0.24. Interestingly, our finding of significant income effects conflicts with a frequently cited result in Gruber and Saez (2002). Using a different methodology, they did not find significant income effects on U.S. data from the 1980s.

Our paper also adds to a growing literature that examines tax responsiveness on Swedish data. From different methodological perspectives Gelber (2008), Hansson (2007), Holmlund and Söderström (2007), Ljunge and Ragan (2006) and Selén (2005) all exploit large register data sets and study how mostly earned income reacts to changes in net-of-tax rates. However, none of these papers utilizes the Swedish Level of Living Survey and none of these makes a separate analysis for hourly wage rates.

The paper is structured as follows. In the next section we briefly describe the income tax changes that occurred between 1981 and 1991 in Sweden; a more thorough description is given in Appendix A. In Section 3 we discuss a number of methodological issues. These involve our treatment of income effects, our model framework and instrumentation procedure. Section 4 contains a description of the data source. The estimation results are presented and discussed in Section 5. Section 6 concludes.


In 1981 top marginal taxes were near a historical high; taxpayers in the highest bracket were subject to a marginal tax rate of 85%. As can be seen from Fig. 1, which depicts the evolution of top marginal tax rates during the relevant time period, there was a steady decline in top marginal tax rates between 1981 and 1991. The most dramatic cut occurred in conjunction with the profound tax reform of 1991, sometimes called ‘the tax reform of the century’ (Agell et al., 1998), when top marginal taxes fell by 15 percentage points. However, if one considers the whole period 1981–1991 marginal taxes were reduced by 34 percentage points for those who were in the top bracket in 1981.

Fig. 2 illustrates average marginal tax rates for 1981 and 1991 by decile in our estimation sample, where income deciles have been defined based on taxable labor income as of 1986. Marginal tax rates have been computed while taking both the statutory income tax schedule and means-dependent housing allowances into account. Apparently, income tax progressivity has been considerably reduced between the two years. The largest decrease in marginal tax rates was in the 10th decile, whereas the tax changes were noticeably more modest in the two bottom deciles. There were also considerable reductions in marginal tax rates in the middle of the income distribution. The main reason is that the 1981 statutory tax schedule caused marginal tax rates to be high even at moderate income levels.

3. Methodological considerations

3.1. Taxable income model

In what follows, we briefly describe the canonical taxable income model as presented in Gruber and Saez (2002) to get a framework for interpreting the taxable income elasticities. The wage rate responses cannot be interpreted within that model. Therefore, in Section 3.2 we also discuss a model where the individual can vary both work effort and hours worked.

Following Gruber and Saez (2002) we consider a model of utility maximization where the individual chooses her optimal amounts of consumption, \(C\), and taxable income \(z\), subject to the budget constraint \(C = (1 - \tau)z + R\), where \(\tau\) is the marginal tax rate on a linear segment of the income tax schedule and \(R\) is virtual income. In a

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3 The timing of the 1991 Swedish tax reform coincided with the most severe macroeconomic downturn since the 1930s, and the recession has rendered appraisals of the reform more difficult. In June 1990, the unemployment rate was 1.1%, while it in the same month of 1993 was 9.0% (SCB, 2005). Our interpretation is that the soaring unemployment rates pose a minor problem to our study that uses data from 1981 and 1991. First, on an annual basis the unemployment rate was 3.0% in 1991, which can be compared with 2.5 for 1981. Second, the biggest increase in unemployment was among younger individuals. Since our sample contains individuals aged 22–54 in 1981 and 32–64 in 1991 our sample was less affected by the macroeconomic crisis.
Swedish institutional context it is natural to interpret \( z \) as taxable labor income.\(^4\) Optimization yields optimal taxable income supply functions of the form \( z = z(1-\tau), R \). The uncompensated taxable income elasticity with respect to the net-of-tax rate, \( (1-\tau) \), can then be decomposed according to the Slutsky relationship

\[
\xi^u = \xi^c + \xi^g (1-\tau) \frac{z}{R} 
\]

(1)

where \( \xi^c \) is the compensated taxable income elasticity with respect to \( (1-\tau) \) and \( \xi^g \) is the elasticity with respect to the virtual income. Despite the well-known fact that \( \xi^c \) is the central parameter needed for welfare evaluation (see e.g. Feldstein, 1999), the previous literature has so far not set out to specify \( R \) and to estimate \( \xi^g \). A large amount of works (Feldstein, 1995; Auten and Carroll, 1999 and others) implicitly assumes that \( \xi^g = 0 \). On the other hand, Gruber and Saez (2002) derive an empirical equation that includes an approximation of the term \( (dR/d\tau) / z(1-\tau) \) as a way to control for the income effect of a tax change. The approximation made by Gruber and Saez is, however, only valid for small tax changes and is a rather poor approximation of larger ones.

In this paper we specify virtual incomes by adopting a standard procedure in the labor supply literature. Let \( (1-\tau) \) and \( R \) be the net-of-tax rate and virtual income for an individual located on the \( i \)th segment of the tax schedule. The budget constraints have been calculated while taking the actual values of the parameters that determine the budget constraint as given. These parameters include unearned income (positive or negative), the number of children in the household and geographical location.\(^5\) Here we only consider individuals who are placed at locations where the income tax function is differentiable.\(^6\) In contrast to earlier taxable income studies on Swedish data (Holmlund and Söderström, 2007; Ljunge and Ragan, 2006; Selén, 2005 and Hansson, 2007) we have not only taken the statutory income tax schedule into account in the tax calculations, but also the marginal effects from means-tested housing allowances. Suppose that the budget constraint consists of \( N \) segments and let \( \tau_i \) be the upper kink point in terms of the \( i \)th segment. We then define virtual income of the first segment, \( R_1 \), as

\[
R_1 = \text{capital income (net of tax)} + \text{imputed income from owner occupied housing (net of tax)} + \text{child allowance} + \text{housing allowance (at zero hours of work)} + \text{disposable income of the spouse}
\]

Virtual incomes for upper segments, \( i = (2,N) \), can be written as

\[
R_i = R_{i-1} + [(1-\tau_{i-1}) - (1-\tau_i)] \frac{z_{i-1}}{R_{i-1}} \quad (c.f. \text{ Blomquist, 1988}).
\]

Since individuals differ with respect to their non-labor income \( R_n \), individuals that are located on the same segment of the income tax schedule will in general have different virtual incomes.

3.2. Why do hourly wage rates vary over time?

There are at least three reasons why individual hourly wage rates vary over time: (i) because an individual’s effort in a broad sense changes, (ii) because a larger or smaller part of the compensation is taken in the form of fringe benefits instead of regular cash pay or (iii) because of general equilibrium effects when either the supply or demand for labor shifts. These shifts in demand and supply curves might be caused by changes in the income tax system, pay roll taxes or other factors unrelated to taxes, such as changes in technology or shifts in the demand for goods.

The first set of changes can be divided into at least four types of behavioral changes, more effort on present job, switching to a better paid job that requires more effort, a geographical move to a better paid job and investments in human capital. In the next section we lump together these four types of adaption to the tax system and study how an individual chooses effort defined in a very broad sense.

Part of the compensation for work comes in other forms than wages. In Sweden the most important such compensation would probably be occupational pensions. In the US company paid health insurance would be a major fringe benefit. How large the part of total compensation that comes in the form of wages is probably influenced by tax laws as well as tax rates. Since these laws change over time the division of total payment between fringe benefits and wages will probably also vary over time. It also implies that the wage response to a change in the marginal tax can differ over time, if the rules governing how fringe benefits are taxed have changed. This is essentially the point made in Slemrod and Kopczuk (2002) when discussing the elasticity of taxable income. The parameters estimated in the taxable income literature are in general reduced form parameters where the parameters reflect both underlying preferences as well as other properties of the tax system than those described by the marginal tax rates.\(^7\)

The third set of changes can be of several kinds. In an economy where the wage rate is market determined the change in taxes might lead to a shift in the aggregate supply seen as a function of the wage rate for a standard unit of work, and a movement along the demand curve with a decrease in the market wage if aggregate hours have increased and an increase if aggregate hours have decreased. If wages are largely determined by union contracts, the “market” wage might still be affected by the change in taxes. Changes in the payroll tax will likewise shift the demand curve and the equilibrium wage for a standard unit of work. Moreover, these general equilibrium effects might affect different segments of the labor market differently. It is therefore possible that the general equilibrium effects of a tax reform affects relative pre-tax wages.

As in most of the taxable income literature our focus is not on the general equilibrium effects but on individual behavior. The goal is to estimate the behavioral effects of tax changes, i.e. how an individual reacts to changes in the net-of-tax rate and in the virtual income, while controlling for general equilibrium effects.\(^8\) Since, the general equilibrium effects might affect different segments of the labor market differently we in our analysis divide our sample into ten segments, allowing the general equilibrium effects to be different across these groups. The details of this are explained below.

The market responses to changes in the tax system might be different for different wage groups as they belong to different segments of the labor market. The same applies for exogenous productivity growth. Here we assume that the wage for an individual \( i \) in group \( j \) at time \( t \) is given by

\[
W_{igt} = \omega(F_{igt}, \gamma_{igt}) A_{ij}(\text{taxsystem}, \text{technology}) e^{c_{it}}
\]

(3)

\(^4\) In fact, this is also most appropriate from a theoretical point of view. The proposition that the taxable income elasticity captures all behavioral responses necessary to evaluate the deadweight loss of income taxation has been developed in static models where unearned income has been taken as given. See e.g. Chetty (2009) for a more general model.

\(^5\) See Appendix A for a detailed description of the tax and transfer system.

\(^6\) In our estimation sample, 3 men and 2 women were located at kink points in 1981. Since the marginal tax rates are not defined for these, we have deleted these few observations in the empirical analysis.

\(^7\) See also Blomquist (1988) and Heim and Meyer (2004) for discussions of how parameters in behavioral relations sometimes is a mixture of preference parameters and parameters of the budget constraint.

\(^8\) Hence, we do not attempt to establish the incidence of taxation as such an analysis would in general also require estimates of labor demand. Kubik (2004) is a study with a different focus than ours. On U.S. data, Kubik attempts to establish the incidence of personal income taxation. One of his findings is that wage effects are important when assessing the distributional consequences of tax reform.
where $E$ is effort level, $\gamma$ a vector of individual characteristics and $\epsilon$ a random term. The function $A_j$ is meant to give the equilibrium wage rate for a standard unit of labor of type $j$. It depends on the intersection of demand and supply curves of labor seen as a function of the wage rate for a standard unit of labor of type $j$. We assume that this function varies between groups.

Taking logs and differencing between time $t$ and $t - k$ we obtain:

$$\ln(W_{it}/W_{it-k}) = \ln\left[\omega E_i/\omega_{it-k}\right] = \ln\left[\alpha_i(E_i, \gamma_i) / \alpha_i(E_{it-k}, \gamma_{it-k})\right] + \ln\left[A_i/A_{it-k}\right] + (\epsilon_{it} - \epsilon_{it-k})$$

(4)

The term $\ln(A_i/A_{it-k})$ controls for the general equilibrium effects on the wage for group $j$ of the labor market. However, our focus in this paper are on the parameters of $\ln \{E_i, \gamma_i\}$. In the next section we give a model for the behavior generating this wage function. One should keep in mind that since the wage rate is an important component of taxable income the above results are valid also for taxable income.

### 3.3. Empirical model for hourly wage rates

Consider a simple extension of the standard neo-classic static labor supply model, where the individual also has the option to choose the optimal amount of work effort. Let $E$ denote work effort (interpreted broadly so as to accommodate all the types of adaption listed under point (i) above). Individuals maximise utility according to the well-behaved utility function $U = U(C, E, H)$, where $m$ from the individual's point of view is a constant. In what follows, we normalize $m$ to be one. Given that the individual is located on a linear segment of the income tax function the budget constraint can be expressed as $C = (1 - \tau)\alpha(E, \gamma) \times H + M$, where $\tau$ is the marginal tax rate, $C$ is consumption, $H$ is hours of work and $M$ is virtual income. After optimisation we obtain optimal hourly wage rate functions of the form $W = \alpha(E(1 - \tau), M, \gamma; \gamma)$. In this paper we will impose the following functional form assumption for $\alpha(E(1 - \tau), M, \gamma; \gamma)$:

$$\ln(\alpha_i) = \alpha_i t + \alpha_2 \ln(1 - \tau)_{it} + \alpha_3 \ln M_{it} + \alpha_4 t \gamma_i + \alpha_5 \gamma_i$$

where, again, $i$ indexes individuals and $t$ time. As seen above, a time effect is assumed to work linearly both independently and through the vector of individual characteristics $\gamma$, which are supposed to be time-invariant.

Before proceeding we make the observation that the virtual income term $M_{it}$ is unobservable in the context of a model where the individual chooses both work effort and hours of work. However, for a given amount of effort the budget constraint is observable in the $(C, H)$-plane. Here, we will approximate $M_{it}$ from the $(C, H)$-plane while treating the effort level as fixed. The computation of the virtual income term $M_{it}$ for this model will therefore coincide with the computation of $R$ for the taxable income supply model described in Section 3.1. Taking first differences of Eq. (5) between time $t$ and $t - k$ we obtain

$$\ln(\alpha_i) / \ln(\alpha_{it-k}) = \alpha_1 k + \alpha_2 \ln((1 - \tau)_{it} / (1 - \tau)_{it-k}) + \alpha_3 \ln(M_{it} / M_{it-k}) + \alpha_4 k \gamma_i$$

(6)

Combining Eq. (6) with the terms in Eq. (4) that are outside the control of the individual we obtain:

$$\ln(W_{it}/W_{it-k}) = \alpha_1 k + \alpha_2 \ln((1 - \tau)_{it} / (1 - \tau)_{it-k}) + \alpha_4 \ln(M_{it} / M_{it-k})$$

$$+ \alpha_5 k \gamma_i + \ln(A_i / A_{it-k}) + (\epsilon_{it} - \epsilon_{it-k})$$

(7)

The $\gamma_i$-vector might contain both observed and unobserved characteristics. To account for observed characteristics that interact with the time trend we include quadratics in years of schooling, years of work experience, age and the number of children. In similarity with e.g. Auten and Carroll (1999), Sillamaa and Veall (2001), Aarbu and Thoresen (2001), Hansson (2007) and others, we let the set of individual characteristics be measured in the base period.

We also need to control for time-invariant individual unobserved factors (like innate ability) that interact with the time trend as well as the general equilibrium effects as given by $\ln(A_i/A_{it-k})$ in Eq. (7). In principle, if we were able to find a good proxy variable for the unobserved heterogeneity at the individual level this would account for wage growth factors both at the individual level and at the group level.

Wooldridge (2002, p. 63–67) suggests that the dependent variable from an earlier period can be used as a proxy for unobserved heterogeneity. Basically, we adopt this procedure here. Since we do not have access to lagged hourly wage rates for a sufficient number of observations in our sample we use the log of lagged taxable labor income as a proxy variable in the hourly wage rate regressions. To lessen the influence from transitory shocks in income, we use the log of a three year average of taxable labor income in 1975, 1976 and 1977. To avoid any correlation between $(\epsilon_{it} - \epsilon_{it-k})$ and the proxy variable we utilize income variables from 4 to 6 years before the base year 1981.

In addition, we allow for the possibility that the unobserved heterogeneity affects wage growth differently depending on which segment of the labor market the individual belongs to. That is, the general equilibrium effects $\ln(A_i/A_{it-k})$ can be different for different $j$. We therefore divide the entire sample (men and women pooled) into 10 groups and let the $j$th group of the labor market be defined by the jth decile, where deciles are based on the income measure that is constructed from the 1975–77 income variables. Along these lines, to some of the regressions we add a 10-piece spline function in our logged averaged lagged income variable. The knots of the spline are defined by the deciles. As we use observations from 1981 and 1991 our estimating equation then becomes

$$\ln(W_{it}/W_{it-k}) = \gamma_0 + \gamma_1 \ln \left(\frac{([1 - \tau]_{1981})}{([1 - \tau]_{1981})}\right)$$

$$+ \gamma_2 \ln \left(\frac{M_{it}/M_{it-k}}{M_{it}/M_{it-k}}\right) + \gamma_3 X_{it}$$

(8)

$$+ f(\ln TL_{it}) + (\epsilon_{it} - \epsilon_{it-k})$$

where $X_{it}$ is a vector of control variables and $f(\ln TL_{it})$ is a function of the log of average lagged taxable labor income. We will also run similar regressions with the change in the log of taxable labor income, $\ln(\frac{TL_{it}}{TL_{it-k}})$ as the dependent variable. The log–log specification has earlier been used by a majority of authors in the taxable income literature, e.g. Auten and Carroll (1999), Gruber and Saez (2002) and Kopczuk (2005).

### 3.4. Endogenous regressors

The most apparent methodological challenge involved in estimating Eq. (8) is that the location of the individual on the income tax schedule is a function of the dependent variable. Thus, movements in the contemporaneous error term do not only affect the wage rate or taxable labor income variable, but the net-of-tax rate and virtual income regressors as well. What are then needed are valid instruments for $\ln(1 - \tau)_{1981} / (1 - \tau)_{1981}$ and $\ln(M_{it}/M_{it-k})$.  

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9 The variable is constructed in the following way: $\ln TL_{it} = \ln(\sum_{k=75}^{\infty} TL_{it} / r)$ where $TL_i$ is taxable labor income and $r$ is the number of years for which $TL_i > 0$.

10 A 10-piece spline in income has earlier been added to the right-hand side of regression equations in e.g. Gruber and Saez (2002) and Kopczuk (2005). Our motivation is somewhat different though.
Previous literature analyzing taxable income responsiveness with panel data has almost exclusively, in some way or another, used instruments that are functions of first period income. It has become a common practice (Auten and Carroll, 1999, Gruber and Saez, 2002, Kopczuk, 2005 and others) to construct instruments by computing ‘synthetic marginal tax rates’ based on taxable income in the first period.\(^\text{11}\) Let \(Z_\text{it}\) refer to taxable income, \(\tau_\text{it}\) to the marginal tax rate and \(p\) to an index that is either a wage, income or a consumer price index. Then the standard instrument for \(\ln \left(\frac{1 - \tau_\text{it}(pZ_\text{it})}{1 - \tau_\text{it-1}(pZ_\text{it-1})}\right)\) is \(\ln \left(\frac{1 - \tau_\text{it}(pZ_\text{it})}{1 - \tau_\text{it-1}(pZ_\text{it-1})}\right),\) where \(\tau_\text{it}(pZ_\text{it})\) is the marginal tax rate as a function of the tax law of period \(t\) and the taxable income in the base period, \(Z_\text{it-1}.\) It has been alleged that the change in the log of the synthetic marginal tax rates, \(\ln \left(\frac{1 - \tau_\text{it}(pZ_\text{it})}{1 - \tau_\text{it-1}(pZ_\text{it-1})}\right),\) only should reflect pure exogenous tax law changes and exclude behavioral ones.

However, as highlighted by Moffitt and Wilhelm (2000), it is in general unlikely that \(Z_\text{it-1}\) is correlated to the same degree with \(\epsilon_\text{it}\) as with \(\epsilon_\text{it}\) as \(\epsilon_\text{it-1}\) as well. Consequently, \(Z_\text{it-1}\) is probably correlated with \(\epsilon_\text{it} - \epsilon_\text{it-1}\). In the literature, this problem is frequently dealt with by including some function of \(Z_\text{it-1}\) into the regression equation as a proxy for the transitory element in \(\epsilon_\text{it}\) as well as trends in the income distribution.\(^\text{12}\) However, we have not seen any proof that this procedure actually solves the endogeneity problem.

In this study we propose a new kind of instrument for the change in the log net-of-tax rate that is not a function of base year income. Our instrument will be of the form \(\ln \left(\frac{1 - \tau_\text{it}(pZ_\text{it})}{1 - \tau_\text{it}(pZ_\text{it})}\right)\) where \(Z_\text{it}\) denotes imputed taxable labor income for period \(t\). As explained above, in our study we use a 10-year difference, more specifically we set \(t = 1991\) and \(t - 10 = 1981.\) To obtain \(Z_\text{it}\) we have regressed both \(Z_\text{1991}\) and \(Z_\text{1981}\) on a fourth order polynomial in \(Z_\text{1086}\) - a set of socio-demographic control variables and a full set of interaction variables between \(Z_\text{1086}\) and the socio-demographic control variables.\(^\text{13}\) The vector of individual characteristics includes years of schooling in 1981, squared years of schooling, years of work experience in 1981, squared years of work experience, squared age in 1981, number of children in the household 1981 and squared number of children in the household. Since the virtual income also depends on the location on the income tax schedule \(\ln (M_\text{it} / M_\text{it} - 1)\) is instrumented in the same vein.

The key feature of our instrument is that it is a function of taxable labor income in 1986, i.e. the year in the middle of the year difference. An intuitive appeal of the instrument is that, even in the presence of substantial first-order auto-correlation in \(\epsilon_\text{it}\) a transitory shock in \(\epsilon_\text{t-1} / \epsilon_\text{t}\) will only have a negligible impact on \(\epsilon_\text{t} / \epsilon_\text{t}\) (\(\epsilon_\text{t-1}\)). However, there is also a more theoretical argument in favor of using the income variable from the middle year of the year difference. As we show in Appendix C, an instrument that is a function of \(\epsilon_\text{t-1} / \epsilon_\text{t}\) where period \(t - 1\) is the ‘middle year’, will be uncorrelated with \(\epsilon_\text{t} - \epsilon_\text{t}\) given reasonable assumptions about the structure of the error term.


\[\text{4. Data}\]

The data come from the 1981 and 1991 waves of the Swedish Level of Living Survey, designed to be representative of the Swedish population. The questionnaires for these two years resemble each other to a high degree. We have also had access to register data on the individuals (and their spouses) participating in the survey, provided by the tax registers of Statistics Sweden. The survey variables are exclusively available for the years when the Swedish Level of Living survey was conducted, whereas the register data also are available for surrounding years. The survey and register variables have been utilized in the calculation of budget constraints. During the time period of study the individual, and not the household, was the taxable unit with respect to taxation of labor incomes.\(^\text{14}\)

We restrict the sample to those who were married or cohabiting both in 1981 and 1991. This is because spousal income is a central part of the virtual income measure. In addition, we only include individuals of working age. Since no married individuals in the data were younger than 22 in 1981 our data set consists of individuals who were aged 22–54 in 1981 (and 32–64 in 1991). We exclude those who were self-employed either in 1981 or 1991 or in both years since hourly wage rates are obtained for employees only. Exclusions have also been made due to missing values for some of the variables included in the regressions and the variables needed to calculate the

\[\text{11}\] Other strategies to instrumenting that rely on first period income are e.g. Feldstein (1995) who groups taxpayers by their pre-reform marginal tax rates in difference-in-difference estimations, an approach that has been extended to a regression framework by Moffitt and Wilhelm (2000). The sole exception that we know of is Carroll (1998) who obtains a tax instrument by using an average of taxable income between the two years of investigation. We comment on this instrument in Appendix C.

\[\text{12}\] Kopczuk (2005), who stacks many year-differences and construct instruments based on base year income constructs separate controls for the trend in the income distribution and the transitory component of the error term. He both constructs for functions of log income for the year before the base year and the difference between base year income and the income for the year preceding the base year.

\[\text{13}\] Men and women have been pooled in these two auxiliary regressions. The adjusted \(R^2\)-values are around 0.96 in the separate regressions for \(Z_\text{1981}\) and \(Z_\text{1991}\).

\[\text{14}\] Joint taxation of capital income was abolished in 1986. However, wealth was taxed on a joint family basis during the whole time period of study.
The hourly wage rate variable, which is the dependent variable in many of the regressions, is highly comparable between the two years. It is constructed from the survey question “What kind of wage agreement do you have? How much is your wage before tax for the hours you normally work?” and “How many hours do you normally work per week?” The hourly wage rate measure is then obtained by summing all types of compensation paid for normal work hours and dividing by stated normal hours of work. Note that our wage rate measure has not been obtained by dividing a taxable earnings measure with reported hours of work, which is the case in many other data sets. Hence, if the measurement errors in the wage rate are of the ‘classical’ type, i.e. uncorrelated with the true values of the wage rate and distributed with zero mean, the measurement errors will affect the efficiency, but not the consistency, of our estimates.

The taxable labor income variable, which is our second dependent variable, is taken from the tax registers. It is defined as the earnings net of costs of earning the income. These costs are mainly the tax deductible part of work related travel costs. Hence, our taxable labor income concept does not embrace the Swedish counterpart to ‘itemized deductions’ in the U.S. In essential respects, the definition of the taxable labor income concept is similar between the two years.

Figs. 3 and 4 depict the 1981 and 1991 levels of log real wages and log taxable labor income respectively by income decile. Visual inspection of the first graph suggests that the overall growth in real wages was quite low between the two years. The percentage growth of the Swedish wage and income distribution during the 1980s was very different from its U.S. counterpart. In the U.S. there was a sharp increase in income inequality during the same time period.

5. Estimation results

In this section we present the estimation results. Since we have found that the structure differs between men and women we report results for each gender separately. Throughout the 2SLS estimations, the first stage F-statistics of the excluded instruments are always high and not reported. Thus, the instruments are strongly correlated with the instrumented regressors.

Regression results for log hourly wage rates are reported in Table 1, whereas the results for log taxable labor income are described in Table 2. These tables have a common structure. The first four columns of each table display the results for married males; the last four columns display the results for married females. In the first column we have included a set of socio-demographic control variables, but no income controls. In the second column we have controlled linearly for the log of average lagged taxable labor income. The third column shows the results when instead a 10-piece spline in log average lagged taxable labor income is added to the regression. The fourth column, finally, reports the results when the occupational dummies are included. To ease exposition, we only report the key estimates—full results can be provided upon request.

5.1. Hourly wage rates

Columns (1)–(4) of Table 1 convey an interesting message: male log hourly wage rates exhibit a sharp response to log net-of-tax rates. The elasticity estimate is 0.14 when income controls are disregarded (column 1). When income controls are included the net-of-tax rate elasticity slightly increases. When the 10-piece linear spline function is added (column 3) the elasticity estimate is 0.16. Including a set of occupational dummies yields elasticity estimates around 0.14. It is worth emphasizing that all these elasticity estimates are significantly different from zero. Throughout columns (1)–(3) the p-values of the t-statistic are below 0.01, whereas the corresponding p-value in column (4) is 0.015.

15 In total, there are 675 (697) males (females) in the survey who were married both years, aged in the relevant interval, who were not self-employed any of the two years and who were without missing values on any of the variables needed to calculate the budget constraint and/or perform the regressions. 595 (538) observations of these had positive wage rates both years. In addition, 13 (16) observations were excluded for any of the following reasons: Since we take logs in the estimations those who had non-positive taxable labor income or non-positive (virtual) non-labor income any of the two years have been excluded. Finally, as pointed out above, a very small number of observations were excluded since they were located at kink points in 1981. Since our estimation procedure requires individuals to fulfill the inclusion criteria both in 1981 and 1991 the sample size is a bit smaller than what is common for labor supply studies conducted on this data source. E.g. Blomquist et al. (2001) include 864 prime aged married men from the 1981 wave of the survey and 680 married men from the 1991 wave.

16 See e.g. Slemrod (1998) and Aarbu and Thoresen (2001) for discussions of the importance in using a constant tax base between the two years. In Sweden, the wider taxable income concepts changed dramatically in 1991 as dual income taxation (i.e. separate taxation of capital and labor income) was introduced.
### Table 2
2SLS regression results for log taxable labor income.

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th></th>
<th></th>
<th></th>
<th>Females</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td>Uncompensated net-of-tax rate elasticity</td>
<td>0.207</td>
<td>0.205</td>
<td>0.210</td>
<td>0.194</td>
<td>0.964</td>
<td>1.049</td>
<td>1.442</td>
<td>1.386</td>
</tr>
<tr>
<td></td>
<td>(0.068)***</td>
<td>(0.064)***</td>
<td>(0.074)***</td>
<td>(0.070)***</td>
<td>(0.570)*</td>
<td>(0.598)*</td>
<td>(0.832)*</td>
<td>(0.837)*</td>
</tr>
<tr>
<td>Non-labor income elasticity</td>
<td>−0.067</td>
<td>−0.068</td>
<td>−0.069</td>
<td>−0.072</td>
<td>−0.041</td>
<td>−0.038</td>
<td>−0.042</td>
<td>−0.043</td>
</tr>
<tr>
<td></td>
<td>(0.034)**</td>
<td>(0.036)**</td>
<td>(0.036)***</td>
<td>(0.034)**</td>
<td>(0.060)</td>
<td>(0.061)</td>
<td>(0.069)</td>
<td>(0.069)</td>
</tr>
<tr>
<td>Implied compensated net-of-tax rate elasticity</td>
<td>0.252</td>
<td>0.251</td>
<td>0.257</td>
<td>0.243</td>
<td>0.982</td>
<td>1.065</td>
<td>1.460</td>
<td>1.404</td>
</tr>
<tr>
<td></td>
<td>(0.072)***</td>
<td>(0.070)***</td>
<td>(0.080)***</td>
<td>(0.077)***</td>
<td>(0.582)*</td>
<td>(0.609)*</td>
<td>(0.845)*</td>
<td>(0.850)*</td>
</tr>
<tr>
<td>Log average lagged taxable labor income</td>
<td>0.099</td>
<td>(0.109)</td>
<td></td>
<td></td>
<td>−0.144</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.052)***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-piece spline in log average lagged income</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Occupational dummies</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>586</td>
<td>586</td>
<td>586</td>
<td>586</td>
<td>522</td>
<td>522</td>
<td>522</td>
<td>522</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses. * denotes significance at 10%, ** significance at 5% and *** significance at 1%. All regressions include control variables for years of schooling in 1981, squared years of schooling, years of work experience in 1981, squared years of work experience, squared age in 1981, number of children in the household in 1981, squared number of children in the household and a constant. Standard errors and confidence intervals for the implied compensated net-of-tax rate elasticities have been obtained by the delta method.

Viewed from the perspective that wage rates have been taken as given in the standard static neo-classical labor supply model our elasticity estimates must be considered as large.\footnote{From a completely different point of departure Holmlund and Kolm (1995) have regressed changes in logged hourly wage rates, obtained by dividing earnings with a survey variable of number of hours worked for full time workers, on changes in a logged measure of tax progressivity and average tax rates. Their model framework, where a trade union and a firm bargain over wages and unemployment, predicts that tax progressivity should lead to wage moderation. Their regression results show that the coefficients for the tax progressivity measure, where the marginal tax rate of course is an essential element, generally are significant and with expected sign. As actually noted by Holmlund and Kolm (1995), this is also consistent with the interpretation that individuals might change their work effort in response to changes in tax progressivity.} However, we do not find any evidence that the log virtual income would affect the log hourly wage. The non-labor income elasticity estimates are always very close to zero and insignificantly different from zero.

Columns (5)–(8) of Table 1 show the corresponding estimates for married females. Interestingly, the wage rate elasticities are considerably higher for women than for men. However, they are also more sensitive to the inclusion of different set of control variables that account for wage growth factors that are outside the individual’s control. Without income controls the net-of-tax rate elasticity amounts to 0.42, but when the 10-piece spline function is added the net-of-tax rate elasticity increases to 0.57. Furthermore, when the occupational dummies are included the elasticity estimates decreases to 0.42. The net-of-tax rate elasticity estimates for women are always significantly different from zero at a level of 10%.

As for men, non-labor income elasticities are estimated to be small and not significantly different from zero.

#### 5.2. Taxable labor income

Table 2 reports the regression results when log taxable labor income is the dependent variable. For taxable labor income we in addition to the uncompensated elasticities also report the implied compensated elasticities. The latter have been obtained from the Slutsky-decomposition described in Eq. (1) in Section 3.1. The estimated uncompensated taxable labor income elasticity for males is always significantly different from zero at a level of 1%. It is noteworthy that the (uncompensated) net-of-tax rate elasticity estimates for males are quite insensitive to the inclusion of different set of controls. Throughout columns (1)–(3) the net-of-tax rate elasticity estimates can be rounded to 0.21, whereas the elasticity estimates amount to 0.19 in column (4) where the occupational dummies are added.

A remarkable feature of columns (1)–(4) of Table 2 is that the non-labor income elasticities are statistically significant. When the full set of control variables are included in the regression (column 4) the estimate of the elasticity with respect to the non-labor income is statistically significant from zero at a level of 5%. Moreover, they take on expected sign. Throughout columns (1)–(4) the non-labor income elasticity is estimated to be around −0.07. Since we did not find any significant income effects when estimating hourly wage rates a plausible interpretation is that the income effect works through the labor supply choice in terms of hours worked.

The estimates for males are comparable to those previously obtained on Swedish data by Hansson (2007). She estimates a net-of-tax rate elasticity of 0.29 for males. While using a family model, where spouses consider each other’s net-of-tax rates, Gelber (2008), also on Swedish data, estimates own net-of-tax rate elasticities to be 0.17 for males, which is by and large of the same magnitude as our estimates for married males.

An implication of our results is that the compensated taxable labor income elasticity is estimated to be larger than the uncompensated one. If we apply the simple formula in Eq. (1) and evaluate the term \((1 − τc) / R\) at the male sample mean values of \((1 − τ)\), \(z\) and \(R\) we obtain a compensated taxable labor income elasticity, \(\hat{ζ}^c\), of a magnitude of 0.24 when all the control variables are included (column 4).\footnote{For males we have that \((1 − τc) / R = 0.4747/209.006 / 146.262 = 0.6783. The mean values have been obtained by pooling the 1981 and 1991 male observations in the sample. Nominal values for \(z\) and \(R\) and have been inflated to the 1991 price level by the consumer price index. For females the corresponding value is \((1 − τc) / R = 0.5964 / 124.863 / 171.434 = 0.4344.} This indicates that the compensated taxable labor income elasticity for males is about 5 percentage points larger than the uncompensated one.

For females the taxable labor income elasticity with respect to the net-of-tax rate is estimated to be considerably larger than for males. However, the estimates are also more uncertain. The elasticity estimates hover between 0.96 and 1.44. Still, they are all significant at a level of 10%. Larger standard errors for females were expected for two reasons. First, since women on average are to be found in lower tax brackets the variation in the change in log net-of-tax rates is smaller for them.\footnote{See Appendix B for descriptive statistics.} Second, the size of the female sample is smaller.

For females the non-labor income elasticity estimates are of expected sign and around −0.045. However, these estimates are far
from being significantly distinct from zero. The compensated elasticities, evaluated at the female sample mean values of \((1 - \tau)\), \(z\) and \(R\), are approximately 2 percentage points larger than the uncompensated ones.

Labor supply studies previously conducted on the same data set, the Swedish Level of Living Survey, have obtained hours of work elasticities with respect to the net wage rate of a magnitude of 0.08–0.1 (e.g. Blomquist and Newey, 2002; Blomquist et al., 2001) for men and 0.3–0.75 for women (Blomquist and Hanson-Brusewitz, 1990; Liang, 2008). It is worth noting that the earlier obtained male and female labor supply elasticities and the hourly wage rate elasticities reported in Table 1 by and large add up to the taxable labor income elasticities shown in Table 2 both for males and females.

Ideally, we would like to re-estimate the hours of work elasticities with the estimation technique used in this paper on labor supply data from 1981 and 1991. However, as we do not have access to a measure of yearly work hours for 1981 and 1991, but only for 1980 and 1990 this, unfortunately, cannot be done in a good way.21 When we replace log taxable labor income for 1981 and 1991 with log yearly work hours for 1980 and 1990 in the baseline specification we obtain results that are consistent with the overall picture. However, these estimates tend to be imprecise and should be treated with caution.22

5.3. Alternative specifications

Remember that this is the first study in the taxable income literature that takes virtual income into account in estimation. Therefore, it is of interest to compare our baseline specifications with more ‘standard’ specifications that do not include virtual income as a regressor. Accordingly, in Table 3 we report output from regressions where we have omitted log virtual income but included the full set of control variables. When comparing Table 3 with columns (4) and (8) of Table 1 it is apparent that the wage rate elasticities are only slightly affected by the omission of log virtual income. Bearing in mind that the estimated non-labor income elasticities were very modest in size when the log hourly wage rate was the dependent variable, this was to be expected. Focusing instead on the taxable labor income regressions for married males we observe that the estimated net-of-tax rate elasticity is 0.24 when not controlling for log virtual income compared to 0.19 (column 4 of Table 2) in the baseline specification. The estimated elasticity for married females is virtually unaffected by the omission of log virtual income.

Apparently, when we constrain the virtual income elasticity to be zero we obtain approximately the same compensated net-of-tax rate elasticity as we obtain when we let the virtual income elasticity vary. In some sense, this is good news for the previous literature. For welfare evaluation, the compensated elasticity is the relevant measure (Feldstein, 1999). Still, in some applications we want to know what actually happens with the income supply and tax revenues when we alter certain tax parameters. In order to make such predictions in a correct way one would need accurate estimates both of the uncompensated taxable labor income elasticity and the non-labor income elasticity.

As discussed in Section 3.3, business-as-usual in the literature is to construct instruments based on first period income and to control for a function of first period income. When only one-year

21 The Swedish Level of Living Survey contains variables on yearly work hours for the year before the year of the interview. In the long tradition of labor supply estimation on this data source researchers have deflated the hourly wage rate variable for, say, 1981 to its value for 1980.

22 In the specification with the full set of control variables, we obtain an hours of work elasticity of 0.10 (robust standard error: 0.077) and a non-labor income elasticity of \(-0.06\) (0.029) for married males. For married females we obtain an hours of work elasticity of 0.28 (0.344) and a non-labor income elasticity of 0.02 (0.045).

### Table 3

<table>
<thead>
<tr>
<th></th>
<th>Log hourly wage rate</th>
<th>Log taxable labor income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Net-of-tax rate elasticity</td>
<td>0.139</td>
<td>0.422</td>
</tr>
<tr>
<td>Observations</td>
<td>586</td>
<td></td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses. * denotes significance at 10%, ** significance at 5% and *** significance at 1%. All regressions contain the same set of control variables that are included in the specifications reported in columns (4) and (8) in Tables 1 and 2.

difference is available (as in our study) the standard procedure is to control linearly for log base year income. When we run these more conventional regressions we obtain results that differ from the baseline scenario.23 For married males, the wage elasticity with respect to the net-of-tax rate is estimated to be 0.07. For married females, the corresponding estimate is 0.17. Hence, these point estimates are considerably lower than those obtained in the main regressions. The results diverge even more when log taxable labor income is the dependent variable. For males neither the net-of-tax rate elasticity nor the non-labor income elasticity are significantly different from zero. The former is estimated to be —0.02 and the latter —0.01. For females the estimate of the taxable labor income elasticity with respect to the net-of-tax rate is 0.28, whereas the non-labor income elasticity is 0.02.

It appears that in this setting the traditional approach to instrumenting generates some results that are counterintuitive, especially when estimating the taxable labor income elasticity for males. As outlined in Section 3.3, when first period income is used as an instrument (as opposed to our preferred approach), transitory shocks in income in the base period generally cause the instruments to be invalid. This problem becomes even more pronounced in our study since the number of years in the year difference is higher than in previous studies due to constraints on data availability.24

Finally, one might wonder what happens to the estimation results and the first stage F-statistics if one solely let the instrument be a function of 1986 year incomes and the reform in the income tax system. To this end, we have excluded the set of socio-demographic control variables from the imputation of incomes described in Section 3.4 so that we only predict incomes in 1981 and 1991 by using a fourth order polynomial in 1986 year incomes. This brings about an overall reduction in the first stage F-statistics. In the ‘full specification’, where all the control variables are included, the first stage F-statistic for the change in the log net-of-tax rate (log virtual income) falls from 61.5 (182.8) to 54.6 (60.2) for males. The corresponding first stage F-statistic for females drops from 9.7 (833.1) to 7.9 (638.8). For males, the uncompensated net-of-tax rate elasticities are somewhat higher than in the baseline regressions.

23 These regression results can be provided upon request. In this setup the instruments have been constructed in the following way: The location of the individual on the income tax schedule has been determined based on taxable labor income of 1981. The difference between the ‘simulated’ log net-of-tax rate and log virtual income are then exploited as instruments for the endogenous first-differenced variables.

24 It is probably for this reason that our results for taxable labor income also deviate from the results obtained in previous studies on Swedish data that have used instruments that are functions of first period income. For instance, Hanson (2007) uses panel data from 1989 and 1992. Saez et al. (2009) also point out that the mean reversion problem becomes more severe when lengthening the lag length.

25 Note that the first stage equations are identical for the log hourly wage rate and the log taxable labor income regressions since they only differ with respect to the dependent variable.
when the instrument is constructed in this way: 0.19 (and significant at 5%) for hourly wage rates and 0.23 (and significant at 1%) for taxable labor income. For females, however, the hourly wage rate elasticity is very imprecisely estimated to be $-0.07$, whereas the taxable labor income elasticity is $1.57$, but not significant. Throughout this section, we have seen that the elasticities have been more precisely estimated for males than for females. The non-robustness for females of excluding socio-demographic characteristics from the imputation procedure highlights the fact that we in general are more confident in the results for males than females.

6. Concluding discussion

Using Swedish panel data from 1981 and 1991, spanning a time period with large changes in the Swedish tax system, we study how hourly wage rates as well as taxable labor income react to changes in marginal tax rates and non-labor income. In particular, we would like to emphasize three contributions to the literature on the elasticity of taxable income.

First, previous literature has almost exclusively used instruments for the change in net-of-tax rates that are functions of first period income. In general this will create instruments that are invalid. To “solve” this endogeneity problem it is common practice to include some function of first period income as a regressor in the estimated function. However, we have not come across any reasonable explanation why this should solve the problem. Our data permit us to use a different strategy. We use exogenous individual characteristics as well as income from 1986, the year in the middle of the time period considered, to construct our instruments. The intuitive appeal of this way to construct instruments is that, even in the presence of substantial first-order auto-correlation in the transitory shocks, the shock in 1986 would show a very weak correlation with either the shock in 1981 or 1991. In addition, we show in the paper that instruments that are functions of the middle year generally are valid under some standard assumptions about the structure of the error term.

Second, a large part of the literature on the elasticity of taxable income has neglected the effect of non-labor income. This implies that one has not been able to estimate the compensated effect of the net-of-tax rate, even though it is well known that it is the compensated effect that is central to calculations of welfare losses. We use a method to calculate “virtual” non-labor income that is common practice in the labor supply literature, but which has not previously been adopted in the taxable income literature. For men we find a significant income effect when we estimate the taxable labor income elasticity; in our most preferred specification, when all the control variables are added, the elasticity of taxable labor income with respect to the non-labor income is $-0.07$. The compensated and uncompensated elasticities with respect to net-of tax rates are $0.19$ and $0.24$ respectively. For women the non-labor income effect is not significant. The compensated and uncompensated elasticities with respect to net-of-tax rates are $1.39$ and $1.40$ respectively. The results for females tend, however, to be less certain and robust than the results for males.

Third, as highlighted by Slemrod and Kopczuk (2002) and Kopczuk (2005) the elasticity of taxable income is a reduced form parameter and to some extent under government control. An implication of this is that it would be of value to know the anatomy of the behavioral response. A similar point is emphasized in the concluding section of Saez (2003). In this study, we have taken a step forward in this direction by focusing directly on how hourly wage rates respond to changes in marginal tax rates. Of course, a caveat is that we cannot discriminate between effort responses and shifts in the form of compensation from leniently taxed fringe benefits to fully taxed cash pay.

The effect of changes in non-labor income on changes in the wage rate is not significant. However, we have found a marked response in hourly wage rates to changes in the net-of-tax rate: the most preferred elasticity estimate is $0.14$ for males and $0.42$ (but more uncertain) for females. These results suggest that wage responsiveness to tax changes is just as important as hours of work responses, or perhaps even more important. Furthermore, as explained above, the hourly wage rate elasticities obtained here are consistent with our own estimated taxable labor income elasticities and earlier estimated hours of work elasticities.

Appendix A. The Swedish tax and transfer system in 1981 and 1991

A.1. The statutory income tax schedule

A global income tax system was in place in Sweden in 1981, i.e. earned income and unearned income (capital income) were taxed according to the same income tax schedule, a schedule that is illustrated in Table A.1. The statutory ‘federal’ tax schedule was in general highly progressive and contained 22 brackets. However, a special tax reduction caused the marginal tax rate to actually decrease over some intervals. There were also two caps for the marginal tax rate. Below SEK 192,000 SEK the marginal tax rate (“federal” marginal tax rate + local tax rate) was not allowed to exceed 0.8.26 And above 192,000 the maximum limit was 0.85.

<table>
<thead>
<tr>
<th>Table A.1</th>
<th>Statutory income tax schedule in 1981.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessed income</td>
<td>Marginal tax rate</td>
</tr>
<tr>
<td>0–4600</td>
<td>0</td>
</tr>
<tr>
<td>6400–25,600</td>
<td>0.3155</td>
</tr>
<tr>
<td>25,600–32,000</td>
<td>0.3355</td>
</tr>
<tr>
<td>32,000–38,400</td>
<td>0.3455</td>
</tr>
<tr>
<td>38,400–40,000</td>
<td>0.3755</td>
</tr>
<tr>
<td>40,000–44,800</td>
<td>0.2755</td>
</tr>
<tr>
<td>44,800–44,900</td>
<td>0.3055</td>
</tr>
<tr>
<td>44,900–51,200</td>
<td>0.4055</td>
</tr>
<tr>
<td>51,200–57,600</td>
<td>0.4355</td>
</tr>
<tr>
<td>57,600–60,000</td>
<td>0.4955</td>
</tr>
<tr>
<td>60,000–64,000</td>
<td>0.5155</td>
</tr>
</tbody>
</table>

Marginal tax rates are reported for an individual with an average local tax rate $(= 0.2955)$.

The global income tax system was abandoned in 1991. In the new dual income tax system capital income was taxed at a proportional rate of 0.3, whereas earned income was still taxed according to a progressive income tax schedule. If a deficit in capital income would emerge, the taxpayer could deduct a fraction of the deficit from the tax on earned income.27 The number of brackets was seven in 1991—a considerably lower amount of segments than in 1981. As can be viewed in Table A.2, in the highest income tax bracket the marginal tax rate was $0.5112$ for an individual with an average local tax rate. The regressive elements of the tax schedule were due to the phase-out region of the standard deduction. For assessed earnings below SEK 63,892 and above SEK 184,803 the standard deduction amounted to SEK 10,304.28 In the interval 63,892 and above SEK 184,803 it decreased at a rate of 0.25. However, between 101,888 and 184,803 it decreased at a rate of 0.1.

---

26 Throughout this appendix we use the nominal values for both years. The 1981 income values can be deflated to the 1991 price level by a factor 272.2/112.1 by the consumer price index.
27 The tax reduction amounted to 30% of the deficit given that the deficit was lower than $100,000$ SEK. Above that limit only 21% of the deficit could be deducted. The tax reduction was, however, not allowed to exceed the tax payment on earned income.
28 There was also a standard deduction, which was 4000 SEK for taxpayers earning more than 40,000 SEK.
A.2. Housing allowance

An important feature of the system for housing allowances in Sweden was that the allowance was dependent on household income, which created an additional marginal effect for the individual. In both 1981 and 1991, the allowance entailed two components. First, the maximal amount of housing allowance was calculated as a function of the qualifying housing costs and family composition. Second, the maximal allowance was reduced according to a set of reduction rates that were determined by qualifying income and household composition.

The annual maximal housing allowance in 1981 can be written as

$$MH_{81} = \text{number of children} \times 1860 \text{ SEK} + (\text{qualifying housing cost SEK} - 500 \text{ SEK}) \times 0.8$$

The qualifying housing costs were not allowed to exceed certain levels, where the maximum levels were determined by household composition. The housing cost limits for 1981 are reported in Table A.3.

Table A.3

<table>
<thead>
<tr>
<th>Number of children</th>
<th>Housing cost limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>750 (S), 850 (M)</td>
</tr>
<tr>
<td>1–2</td>
<td>1250</td>
</tr>
<tr>
<td>3–4</td>
<td>1500</td>
</tr>
<tr>
<td>More than 4</td>
<td>1800</td>
</tr>
</tbody>
</table>

(S) denotes singles and (M) married.

In the 1991 system the corresponding maximal housing allowance, for households with children, can be written

$$MH_{91} = 1000 \text{ SEK} + \text{qualifying housing cost SEK}$$

Furthermore, the qualifying housing cost is determined by the number of children. Table A.4 reports the lower, middle and upper limits for qualifying housing costs in 1991. The transfer covers 75% of the costs between the lower and middle limit and 50% of the cost between the middle and upper limit. For two-person or single households without children the maximal transfer was equal to 30% of the costs between 1600 SEK and 3500 SEK.

Table A.4

<table>
<thead>
<tr>
<th>Number of children</th>
<th>Lower</th>
<th>Middle</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1800</td>
<td>2400</td>
<td>3500</td>
</tr>
<tr>
<td>2</td>
<td>1500</td>
<td>2800</td>
<td>4000</td>
</tr>
<tr>
<td>More than 2</td>
<td>1200</td>
<td>3200</td>
<td>4500</td>
</tr>
</tbody>
</table>

In both 1981 and 1991 the qualifying income, which determines the reduction rate, is based on total income of the household and wealth exceeding a certain amount. If the present year household income was in the neighbourhood of the household income two years earlier, the allowance was based on the latter. In this interval, there was no additional marginal effect from the housing allowance system. But for larger changes, the amount of the transfer was dependent on the income acquisition in the present year. The maximal allowance was reduced according to Table A.5 for 1981 and Table A.6 for 1991. At some point the entire allowance was taxed away. After that point the marginal effect from housing allowances was zero.

Table A.5

<table>
<thead>
<tr>
<th>Aggregated total income 1981</th>
<th>Rate of reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{79} &lt; a$</td>
<td>0</td>
</tr>
<tr>
<td>$(a + 50,000) - (a + 20,000)$</td>
<td>0.15</td>
</tr>
<tr>
<td>$(a + 20,000)$</td>
<td>0.24</td>
</tr>
<tr>
<td>$Y_{89} &lt; a$</td>
<td>0</td>
</tr>
<tr>
<td>$(a - 50,000) - (a - 20,000)$</td>
<td>0.15</td>
</tr>
<tr>
<td>$(a - 20,000)$</td>
<td>0.24</td>
</tr>
<tr>
<td>$Y_{89} + b$</td>
<td>0</td>
</tr>
<tr>
<td>$(Y_{89} + 5000) - (Y_{89} + 2000)$</td>
<td>0.15</td>
</tr>
<tr>
<td>$(Y_{89} + 20,000)$</td>
<td>0.24</td>
</tr>
</tbody>
</table>

$Y_{79}$ is aggregated total income in 1979. $a$ equals 29,000 SEK for single and two-person households without children, 38,000 SEK for spouses with children and 30,000 for singles with at least one child. $b$ is equal to 59,000 for all.

Table A.6

<table>
<thead>
<tr>
<th>Aggregated total income 1991</th>
<th>Rate of reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{91} &lt; a$</td>
<td>0</td>
</tr>
<tr>
<td>$(a + 50,000)$</td>
<td>B</td>
</tr>
<tr>
<td>$Y_{91} - a$</td>
<td>0</td>
</tr>
<tr>
<td>$(a - 15,000) - (a - 5000)$</td>
<td>0.24</td>
</tr>
<tr>
<td>$(a - 5000)$</td>
<td>B</td>
</tr>
<tr>
<td>$(Y_{91} - 15,000) - (Y_{91} + 5000)$</td>
<td>0</td>
</tr>
<tr>
<td>$(Y_{91} + 50,000)$</td>
<td>B</td>
</tr>
</tbody>
</table>

$Y_{91}$ is aggregated total income in 1989. $a$ is 81,000 SEK for households with children and 66,000 SEK for households without children. $b$ is 0.2 for households with children and 0.1 for households without children.

A.3. Taxation of housing

In 1981, an implicit income from owner-occupied housing was taxed together with other sources of income according to the income tax schedule in Table A.1. In 1991, owner-occupied homes were...
separately taxed at a rate of 0.012 of the assessed value of the house. Both in 1981 and 1991, the assessed value was an undervaluation of the market value. When computing the imputed income from owner-occupied housing, which equals the market value multiplied with the nominal interest rate, we have therefore corrected for this by using so-called purchase-price coefficients. It has been possible to derive the assessed value from register data for both years.

### A.4. Child allowance

Households with children received a fixed amount, 3000 SEK, per year and child in 1981. The 1991 child allowance system implied a basic transfer of 9000 SEK per year and child. Moreover, for three or more children the household was provided additional transfers.33

**Appendix B. Descriptive statistics**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ log hourly wage rate</td>
<td>0.105</td>
<td>0.249</td>
<td>-0.962</td>
<td>1.128</td>
</tr>
<tr>
<td>Δ log taxable labor income(TLI)</td>
<td>0.160</td>
<td>0.287</td>
<td>-2.743</td>
<td>1.599</td>
</tr>
<tr>
<td>Δ log net-of-tax rate</td>
<td>0.392</td>
<td>0.392</td>
<td>-0.420</td>
<td>5.123</td>
</tr>
<tr>
<td>Δ log net-of-tax rate instrument</td>
<td>0.366</td>
<td>0.315</td>
<td>-0.506</td>
<td>1.385</td>
</tr>
<tr>
<td>Δ log virtual income</td>
<td>0.823</td>
<td>0.483</td>
<td>-1.625</td>
<td>4.021</td>
</tr>
<tr>
<td>Δ log virtual income instrument</td>
<td>0.831</td>
<td>0.497</td>
<td>-1.868</td>
<td>3.489</td>
</tr>
<tr>
<td>Log average lagged TLI</td>
<td>10.917</td>
<td>0.506</td>
<td>7.163</td>
<td>12.374</td>
</tr>
<tr>
<td>Business executives</td>
<td>0.084</td>
<td>0.277</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Senior officials</td>
<td>0.052</td>
<td>0.289</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Employed in farming</td>
<td>0.010</td>
<td>0.101</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Military</td>
<td>0.067</td>
<td>0.249</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Clerical employees</td>
<td>0.184</td>
<td>0.388</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Minor officials</td>
<td>0.101</td>
<td>0.301</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Woodmen</td>
<td>0.027</td>
<td>0.163</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Metalworkers</td>
<td>0.106</td>
<td>0.308</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Other industrial workers</td>
<td>0.072</td>
<td>0.258</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Construction workers</td>
<td>0.077</td>
<td>0.266</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Wholesale and retail</td>
<td>0.022</td>
<td>0.147</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Other privately employed workers</td>
<td>0.043</td>
<td>0.202</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Local government employees</td>
<td>0.067</td>
<td>0.249</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>State level employees</td>
<td>0.049</td>
<td>0.217</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Years of schooling in 1981</td>
<td>11.346</td>
<td>3.746</td>
<td>6.000</td>
<td>25.000</td>
</tr>
<tr>
<td>Years of work experience in 1981</td>
<td>18.710</td>
<td>9.187</td>
<td>1.000</td>
<td>40.000</td>
</tr>
<tr>
<td>Age in 1981</td>
<td>38.056</td>
<td>7.720</td>
<td>22.000</td>
<td>54.000</td>
</tr>
<tr>
<td>Number of children in 1981</td>
<td>1.510</td>
<td>1.025</td>
<td>0.000</td>
<td>5.000</td>
</tr>
</tbody>
</table>

Following Blomquist (1979) years of work experience has been defined as “AGE-8-years of schooling”. The number of observations is 586.

**Appendix C. Conditions for instrument validity**

While using the same notation as in the main text, assume that \( m = (t - k) / 2 \) is an integer. We now study the joint distribution of \( ε_{it-m} \) and \( (ε_{it} - ε_{it-k}) \) under some standard assumptions. Suppose that \( ε_{it} \) follows a first-order autoregressive process: \( ε_{it} = βε_{it-1} + \nu_{it} \), where \( |β| < 1 \) and \( \nu_{it} \sim (0, σ^2) \). Given this assumption \( ε_{it-m} \) and \( (ε_{it} - ε_{it-k}) \) will also be normally distributed. Moreover, they will have a joint bivariate normal distribution. (See, Theorem 3.5.1 in Hogg et al., 2005.) The covariance between \( ε_{it-m} \) and \( (ε_{it} - ε_{it-k}) \) can be expressed as

\[
E[ε_{it-m}(ε_{it} - ε_{it-k})] = E(ε_{it-m}ε_{it}) - E(ε_{it-m}ε_{it-k})
\]

\[
= E(ε_{it-m}(ρ^mε_{it-m} + \rho^m \nu_{t-m-k})) - E\left(ρ^mε_{it-m} \nu_{t-m-k}\right)
\]

\[
= ρ^mσ^2 - ρ^mσ^2 = 0
\]

(C.1)

Hence, independent of the value of \( ρ \), \( ε_{it-m} \) and \( (ε_{it} - ε_{it-k}) \) will be uncorrelated. Since \( ε_{it-m} \) and \( (ε_{it} - ε_{it-k}) \) are bivariate normal the zero correlation implies stochastic independence. (See Theorem 3.5.2 in Hogg et al., 2005.) This, in turn, implies that functions of \( ε_{it-m} \) will be stochastically independent of \( (ε_{it} - ε_{it-k}) \). In our setting we have \( t = 1991 \), \( t-k = 1981 \) and \( t-m = t - 5 = 1986 \). We thus have that \( ε_{1989} \) and \( (ε_{1991} - ε_{1986}) \) are stochastically independent. It follows that \( (ε_{1989} - ε_{1989}) \) and functions of \( ε_{1989} \), such as our instrument, also will be stochastically independent. Hence, under the assumptions considered the instruments we use are valid. The time series process considered above is well known and commonly used. However, the argument above also goes through under the weaker assumption that the times series of \( ε_{it} \) is covariance stationary and Gaussian.

The trick used above is to construct the instrument in such a way that we in the end have a sum of covariance terms such that there for each covariance term \( E(ε_{it}, ε_{i,t+r}) \), the two random terms being \( r \) periods apart, is a cancelling term \(-E(ε_{i,t} + ρε_{i,t+r})\) also with the two random terms \( r \) periods apart. Another instrument that generates error terms with this property is obtained by summing all the incomes between \( t \) and \( t-k \) (or take the average). We then obtain

\[
E[ε_{i,t-m}(ε_{i,t} + \ldots + ε_{i-k} + \ldots + ε_{i})] = E(ε_{i,t}ε_{i,t}) + \ldots + E(ε_{i-k} + ε_{i}) + E(ε_{i-k} - ε_{i-t}) - E(ε_{i-k} + ε_{i})
\]

We see that for each positive covariance term, where the two random terms are \( r \) periods apart, there is a corresponding covariance term with a negative sign. Hence, all the terms cancel.

It is interesting to note that Carroll (1998) suggested an instrument that is a function of the average income. As shown above the instrument 33 For 3 children the additional transfer was 4500 SEK, for 4 children 13,500 SEK, for 5 children 18,000 SEK, for 6 children 40,500 SEK and 7 children 54,000 SEK.
he suggested is valid, under the assumption that the times series of εt is covariance stationary and Gaussian. His motivation was, however, a bit different than the one given here. He argued that the average income would be a good proxy for the permanent income.

References


