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Working Paper

Estimating income responses to tax changes: a dynamic panel data approach

CESifo Working Paper, No. 2121

Provided in Cooperation with:
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Suggested Citation: Holmlund, Bertil; Söderström, Martin (2007) : Estimating income responses to tax changes: a dynamic panel data approach, CESifo Working Paper, No. 2121, Center for Economic Studies and ifo Institute (CESifo), Munich

This Version is available at:
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ESTIMATING INCOME RESPONSES TO TAX CHANGES: A DYNAMIC PANEL DATA APPROACH

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CESIFO WORKING PAPER NO. 2121
CATEGORY 1: PUBLIC FINANCE
OCTOBER 2007

An electronic version of the paper may be downloaded
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CESifo *Working Paper No. 2121*

ESTIMATING INCOME RESPONSES TO TAX CHANGES: A DYNAMIC PANEL DATA APPROACH

Abstract

Recent research on the behavioral effects of income taxes has to a large extent focused on the elasticity of taxable income with respect to the net-of-tax rate, i.e., one minus the marginal tax rate. We offer new evidence on this matter by making use of a large panel of Swedish tax payers over the period 1991-2002. Changes in statutory tax rates as well as discretionary changes in tax bracket thresholds provide exogenous variations in tax rates that can be used to identify income responses. We estimate dynamic income models which allow us to distinguish between short-run and long-run effects in a straightforward fashion. The estimates of the long-run elasticity of income with respect to the net-of-tax rate typically hover in a range between 0.20 and 0.30. The short-run elasticities are in general smaller but less precisely estimated. We use the estimates to simulate the fiscal consequences of a tax reform that reduces the top marginal tax rate by five percentage points. Such a reform turns out to have negligible effects on tax revenues and may even yield a fiscal surplus.

JEL Code: H24, H31, J22.

Keywords: marginal tax rates, progressive taxes, earned income, tax reform.

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This draft: September 29, 2007
We are grateful for valuable comments from Per Engström, Anders Kristoffersson, Håkan Selin, seminar participants at IZA (Bonn) and participants at the Nordic Summer Institute in Empirical Labor Economics (Helsinki). Financial support from FAS (Swedish Council for Working Life and Social Research) is gratefully acknowledged.

1. Introduction

Research on the behavioral effects of labor taxation has largely focused on the impact on hours of work and labor force participation. More recently, a literature has emerged that focuses on the impact on taxable income and other measures of income. One reason for this new direction is that taxes may affect individual behavior along a number of margins in addition to the effects on hours of work and participation, such as work effort and job mobility. By examining the impact on income, one could arguably capture a wider set of responses than those studied in traditional labor supply studies. The new literature is mainly based on U.S. data and has so far not converged to a consensus view regarding the quantitative magnitudes of the behavioral responses. Studies of income responses to changes in tax rates have rarely focused on European experiences.

The present paper makes several contributions to the empirical literature on income responses to marginal tax changes. First, we highlight the distinction between short-run and long-run responses by estimating dynamic models using panel data. Previous research has in general been vague as to whether the estimated elasticities of interest have pertained to the short run or the long run. In fact, the modeling approaches commonly used have not been adequate for distinguishing between short-run and long-run responses. Second, we examine behavioral differences between men and women, an issue where most of the previous literature has been silent. Third, our study provides the first comprehensive empirical analysis of the impact of Swedish tax changes subsequent to the major reforms in 1990-91. These changes have been targeted at high-income earners and involved tax hikes as well as tax cuts.

We make use of a large panel data set that comprises information for 12 years, namely 1991-2002. We identify the effects of income tax changes on income by exploiting two main sources of exogenous variations in the tax rules. First, changes in the statutory tax rates have occurred in 1995 as well as in 1999. Second, the “kinks” of the progressive tax schedule have been subject to discretionary changes which induce exogenous changes in marginal tax rates for a given level of income.

The broad features of the Swedish tax system have remained largely intact since the early 1990s, when the “tax reform of the century” was introduced. This major reform involved substantial simplifications and base broadening of the tax system. One key element was the introduction of a two-tiered marginal tax schedule for earned income. The idea was that most

income earners should pay only the proportional municipality tax (hovering around 30 percent). For incomes above a certain threshold, a state tax kicked in at the marginal rate of 20 percent. The state tax was raised to 25 percent in 1995. From 1999 and onwards, the state tax has comprised two levels, viz. 20 and 25 percent.

A noteworthy element of the Swedish tax system is its treatment of the individual, rather than the family, as the basic tax unit. The tax schedule for earned income pertains to individual income and is independent of spousal income. Another notable element is the so-called dual income tax system, i.e., the fact that earned income and capital income are subject to different tax treatments: earned income is subject to progressive taxes whereas income from capital is taxed at the flat rate of 30 percent.

The conventional approach to the estimation of income responses to tax changes has involved regressing changes in log income on changes in the log of the net-of-tax rate, where the net-of-tax rate is defined as one minus the marginal tax rate. This regression framework in first differences is typically, implicitly or explicitly, derived from a relationship between the *levels* of income and marginal tax rate. However, the "difference specification" in the regression models implicitly assumes immediate adjustment to changes in tax policy. If the adjustment is gradual rather than immediate, the model is misspecified.

Our approach also posits a relationship between income and tax rate levels but allows for lagged adjustment. This leads to an "error correction" specification which encompasses the conventional regression model as a special case and yields estimates of short-run as well as long-run responses. A dynamic specification can be rationalized from several considerations. First, there may be lags in the diffusion of information about changes in tax policy. Second, individual behavior may exhibit "habit persistence", an idea that has a long tradition in studies of consumer demand. The hypothesis is that the individual gauges his consumption (or labor supply) against some benchmark that in part depends on her own behavior in the past.[1] Third, there may be costs associated with changes in hours worked.[2] For example, a change in working time may require a switch to a new employer. Fourth, to the extent that tax changes affect human capital investment, the earnings response will not be immediate.

[1] See Johnson and Pencavel (1984) for an empirical implementation of this idea in a study of labor supply.
[2] Formal models of dynamic labor supply with explicit costs of adjustment appear rarely in the literature. The paper by Nadiri and Roach (1974) is one of the exceptions.

Our estimates of the long-run income elasticity with respect to the net-of-tax rate typically range between 0.20 and 0.30. The estimates of the short-run elasticities are generally much smaller but are less well determined. The estimates for men are more robust than those for women. The estimates are used to simulate the implications for government revenues of a tax reform that reduces the top marginal tax rate by five percentage points. Such a reform turns out to have negligible effects on tax revenues and may even yield a fiscal surplus. An important reason for this outcome is the presence of interactions between income taxes and other taxes, such as payroll taxes. A cut in the top marginal tax rate brings about higher incomes which in turn are associated with higher tax revenues from income as well as payroll taxes.

The paper proceeds by providing a brief overview of previous research. Section 3 describes the Swedish tax system and the data are described in section 4. The empirical analysis is presented in section 5 and section 6 concludes.

2. Previous Research

2.1 Theoretical Issues

Recent research on income responses to tax changes has several forerunners. One strand consists of the large literature on labor supply which focuses on how taxes affect hours of work and labor force participation. This literature builds on the canonical model of labor supply, where wage rates are taken as given and individual choices are dictated by preferences and budget restrictions (see Blundell and MaCurdy, 1999, for a survey of this research). A smaller and more recent literature has examined how wage rates respond to changes in the tax system in imperfectly competitive labor markets. In this literature, hours of work are determined by the worker (as in the canonical model) or through some bargaining mechanism, whereas wages may be set by firms (as in efficiency wage models) or through individual or collective bargaining (as in search models or trade union models).

The recent focus on how taxes affect income is motivated by the view that taxes may have a multitude of effects on individual behavior in addition to the traditional labor supply responses. This view emphasizes that traditional estimates of the labor supply responsiveness to tax rates may substantially underestimate the overall effect, the reason being that individual adjustments along other margins are ignored. Taxes may affect work effort, what type of jobs that are accepted, and incentives for geographical and occupational mobility. This line of

argument has been articulated by Martin Feldstein in a series of papers; see Feldstein (1995a, 1995b, 1999). A normative conclusion that follows from this perspective is that tax distortions are more serious, the higher the elasticity of taxable income is with respect to changes in tax rates. Indeed, Feldstein (1999) shows that the elasticity can be used to compute the deadweight loss from income taxes.

The literature on how wages are affected by the tax system in imperfect labor markets has paid particular attention to the role of higher tax progressivity, i.e., the impact of a rise in the marginal tax rate relative to the average tax rate. A common result in a variety of models is that higher tax progressivity leads to wage moderation, which in turn will bring about a fall in equilibrium unemployment. The intuition for this result is perhaps most easily seen in a bargaining model, where a higher marginal tax rate raises the cost of wage increases and leads the parties in the bargain to opt for lower wages. Although the result is reasonably robust across a variety of models and specific assumptions, it is not completely robust.[3] So in the end and as usual, empirical work is needed to establish how taxes affect wages, hours and labor income. By and large, the empirical literature tends to confirm that increased tax progressivity is conducive to wage moderation, but there are also some conflicting results.[4]

The normative implications of estimated elasticities of income with respect to tax rates will generally depend on what is assumed about labor market imperfections. High elasticities reflect potentially large tax distortions from the perspective of the traditional model. In a bargaining model, by contrast, a rise in the marginal tax rate that leads to wage moderation and to a decline in overall income may conceivably be welfare improving via the associated increase in employment. Indeed, there is typically an optimal degree of tax progressivity in models of imperfect labor markets; see Holmlund and Kolm (1995) and Sorensen (1999) for elaborations of this idea.

The recent literature on income responses to tax rates has typically been framed within the context of the canonical model, where income responses are viewed as the outcome of individual labor supply choices rather than individual or collective bargaining. We make no

[3] Contributions to the theoretical literature on taxes in imperfectly competitive labor markets include Hoel (1990), Koskela and Vilmunen (1996), Lockwood and Manning (1993), Pissarides (1998), Hansen (1999), Sorensen (1999), Fuest and Huber (2000) and Sandemann Rasmussen (2002). Bovenberg (2003) provides a comprehensive treatment.

[4] Contributions to the empirical literature include Lockwood and Manning (1993), Holmlund and Kolm (1995), Wulfsberg (1997) and Slok et al (2000).

attempt in this paper to identify the precise income-generating effects at work. In all likelihood, actual incomes are influenced partly by individual choice and partly by bargaining mechanisms.

2.2 Empirical Research on Income Responses to Tax Changes

The empirical literature on the responses of taxable income to changes in tax rates was pioneered by Lindsey (1987) and Feldstein (1995a, 1995b). The key parameter of interest in their studies as well as in the subsequent literature was the elasticity of taxable income with respect to the net-of-tax rate, i.e., one minus the marginal tax rate. This elasticity – ETI for short – was found to be remarkably high in these early studies which exploited data from U.S. tax reforms in the 1980s. Lindsey reported ETIs in a range between 1.6 and 1.8, whereas Feldstein's estimates ranged from 1.0 to 3 depending on the income definition used.

The subsequent literature has addressed a number of pitfalls that plagued the seminal papers and also highlighted the sensitivity of the estimates to alternative specifications and data. A crucial issue has been to separate the impact of tax policy from other factors that may have affected the evolution of incomes. In the US, cuts in marginal tax rates among high-income earners occurred concomitantly with rising income inequality, a development that easily can produce large ETI estimates even absent much impact from tax policy. The contributors following Lindsey's and Feldstein's papers have typically arrived at much smaller ETIs than their predecessors. There is, however, substantial variation in the reported estimates.

The post-Feldstein contributions to the U.S. literature include papers by Auten and Carroll (1999), Samartino and Weiner (1997), Gruber and Saez (2002), Kopczuk (2005), Saez (2003), Moffitt and Wilhelm (2000) and Giertz (2006). Giertz (2004) provides a recent survey of this literature. These studies typically adopt instrumental variables estimation of "difference specifications", i.e., they regress changes in income on changes in the net-of-tax share while treating the tax variable as endogenous. A very brief summary of the results reads as follows: (i) ETI is typically positive, although not always so; (ii) ETI is typically well below unity, although not always so; (iii) the "preferred estimates" are typically located in a range between 0.2 and 0.5.

Three studies have examined the effects of the Swedish tax reform 1990-91, viz. Hansson (2007), Ljunge and Ragan (2005) and Selén (2002). These studies adhere to the conventional

difference specification and report estimates of ETI in a range between 0.2 and 0.4. Selén also briefly looks at the tax reforms during the 1990s and reports estimates of ETI close to zero. A study on Norwegian data by Aarbu and Thoresen (2001) present ETI estimates close to zero, hovering between -0.6 and 0.2.

Despite a good deal of research, there is thus considerable dispersion of the estimates. The reasons for the differences are not well understood. The definition of income seems to matter, but it is not clear exactly how and why. The results are sensitive to sample selection rules, but exactly how remains unclear. And the strategies employed to control for exogenous income trends seem to affect the results.

3. The Swedish Tax System

A major tax reform took place in Sweden in 1990 and 1991 (see Agell et al, 1996, for details). The reform involved broadening of the tax bases and cuts of the statutory marginal income tax rates. An important ingredient was the introduction of a dual income tax, where earned income and income from capital were taxed according to different schedules. The new proportional capital income tax, levied on dividends, interest income and capital gains, was set to 30 percent and has remained at this level. The tax on earned income consists of two parts, one "local" and one national. The local income tax – determined by the local and regional governments – is proportional to income (above a basic deduction) but varies across localities. In 1991, the national average of the local income tax rates stood at 31 percent. On top of the local income tax, a national (state) tax kicked in at a rate of 20 percent for earned taxable incomes above 170,000 SEK, which corresponded to the 75th percentile of the distribution of taxable incomes.[5] By 1991, the income tax schedule pertaining to earned income thus involved two brackets with (average) marginal rates of 31 and 51 percent.

Although the main features of the new tax system have remained intact over the following years, several changes have taken place. One important change took place in 1995 when the national tax rate was raised to 25 percent. This system was modified 1999 when two brackets – 20 and 25 percent – for the national tax was introduced. This basic structure remains in place as of 2007. By 1999, the top rate kicked in at the 95th percentile of the distribution of

[5] Based on register data (LINDA) for individuals aged 20-59 with positive taxable income.

taxable incomes.[6] Table B1 in Appendix B describes in detail the evolution of tax bracket thresholds over the period 1991-2002.

We use mainly two sources of exogenous variations in tax policies that should enable identification of behavioral responses. A first source is the changes in the statutory national tax rate: the increase from 20 to 25 percent in 1995 and the introduction in 1999 of a two-bracket system. The 1999 reform implied that some individuals actually experienced cuts in the marginal tax rate since the threshold for the 25 percent rate was increased. A second source is the discretionary changes in the income thresholds which determine when the national tax kicks in; tax payers close to the threshold may be exposed to changes in the marginal tax rate through these bracket adjustments.

One might also wish to consider a few other ingredients of the tax system, such as changes in the proportional local tax rates. However, the local tax rates have changed very little over the studied period; the averages have hovered between 30 and 31 percent. Actual individual local tax rates are affected by mobility decisions and should be treated as endogenous.

Taxable income is obtained after various deductions from gross income. First, there are work-related deductions that may be requested by the tax payers and will be scrutinized by the tax authorities. Expenses caused by travel to work are the typical examples; such expenses are deductible if they exceed a certain amount. To arrive at taxable income, two further deductions are undertaken without any involvement by the tax payer. There is a "basic deduction" (grundavdrag) and there are social security fees that have been partly or wholly deductible. The basic deduction varies with the level of assessed income[7] up to a ceiling and takes a hump-shaped pattern, whereby the effective marginal tax rate is reduced at low incomes and increased over a range of incomes higher up in the distribution. Employee social security fees became increasingly important during the 1990s and had reached 7 percent of assessed income by the end of the decade. These fees are proportional up to a ceiling beyond which the marginal rate is zero. They involve some actuarial elements, however, and should not be treated as entirely analogous to ordinary taxes.

[6] Based on register data (LINDA) for individuals aged 20-59 with positive taxable income.
[7] Assessed income is gross income minus work-related deductions. More information on income definitions are given below.

In addition to the abovementioned ingredients of the tax system, there are some progressive features in the systems for housing allowances and child care fees. We have no information at our disposal regarding how these characteristics vary across individuals in our data set.

4. The Data

The data come from a longitudinal data base, LINDA, which is a 3.35 percent random sample of the Swedish population. LINDA is based on a combination of several registers, for example income tax registers and population censuses.[8] From this data base, all individuals aged 20 to 59 are extracted for 12 consecutive years, viz. from 1991 to 2002. We focus on the years following the major tax reform of 1990-91, thus avoiding the complications associated with the changes in capital income taxation that were part of that reform. This procedure gives us around 160,000 individuals per year, and in total around 1.9 million observations. An individual is on average observed 9.4 times, 113,904 individuals are observed all 12 years, and there are 204,276 unique individuals. When allowing for lags, the period of estimation will be 1993-2002.

In addition to rich information on incomes, the data include information on human capital attributes as well as some demographic characteristics (such as age, gender, education and marital status). We have added information on local labor market conditions, measured as the ratio between the number of vacancies and the number of unemployed.[9] Labor market conditions matter for bargaining outcomes and influence the risk of being quantity-constrained in labor supply decisions.

The fraction of tax payers affected by the national tax has hovered between 19 and 26 percent over the period 1991-2002. The top national rate of 25 percent has affected around 5 percent of the tax payers since its introduction in 1999. Although there have been no drastic changes in the statutory income tax rates, the changes that have occurred as well as “bracket switching” entail a non-trivial number of tax changes that can be taken as exogenous to

[8] For a description of LINDA, see Edin and Fredriksson (2000).

[9] We are grateful to Kerstin Johansson for giving us access to these data. The local labor market is based on the commuting patterns of individuals in 284 municipalities of Sweden, resulting in 100 local labor markets. The tightness measure is defined as the number of vacant jobs divided by the number of job seekers registered at the public employment offices. The number of job seekers is the sum of the stock of openly unemployed and the stock of participants in active labor market programs.

individual behavior. To illustrate, consider a measure of the change in the individual marginal tax rate, $\Delta\hat{\tau}_{it}$, of the form

$$\Delta\hat{\tau}_{it} = \tau\left[Y_{it-1}(1+g); z_t\right] - \tau\left(Y_{it-1}; z_{t-1}\right) \tag{1}$$

where subscript *i* refers to individual *i*, Y_{it-1} refers to taxable income as of year *t*-1, *g* is the general growth in incomes and z_t (as well as z_{t-1}) captures the tax code. The first term on the right-hand side is the predicted marginal tax rate pertaining to year *t* and the second term is the actual marginal tax rate in year *t*-1. Eq. (1) gives a measure of the change in the marginal tax rate that is independent of fluctuations in the individual income level. Over the period 1992-2002, there are around 90,000 observations where $\left|\Delta\hat{\tau}_{it}\right| \geq 0.05$ holds, i.e., where the marginal tax rate increases or decreases by at least 5 percentage points. All these changes take place in the upper half of the income distribution and two thirds of them occur in 1995 and 1999, i.e., the years when changes in the statutory tax rates kick in.[10] Over 70 percent of these changes pertain to men.

An analogous measure for changes in average tax rates reveals very little action in the data: tax policies have had almost negligible effects on average tax rates over the studied period. There are only some 20 observations where the (predicted) average tax rate increases or decreases by more than 5 percentage points and around 1,500 observations where the changes exceed 3 percentage points. Although some individuals are exposed to substantial changes in actual average tax rates, these changes are to an overwhelming degree driven by income shocks rather than by changes in tax policy. These observations suggest that it will be difficult to achieve credible identification of income responses to changes in average tax rates.

There are a number of income variables in the data. We focus on labor income and entrepreneurial income, with or without associated taxable transfer payments, and exclude income from capital and capital gains.[11] Most social transfers are taxed as labor income; this includes for example unemployment benefits and sickness benefits.

[10] The local tax rate is set at the national average in these calculations. The measure is thus not affected by changes in tax rates that are due to residential mobility.
[11] Entrepreneurial income captures self-employment income associated with unincorporated businesses. Owners of incorporated businesses receive their compensation in the form of wages and salaries.

We consider mainly three income concepts: (i) *earned income* (*YE*), which includes labor income and but excludes social transfers; *broad income* (*YB*), which includes taxable transfers in addition to earned income; and *assessed income* (*YA*), which equals broad income minus work-related deductions. We do not explicitly examine movements in *taxable income* (*YT*), the reason being that taxable income is essentially a nonlinear function of the other income variables. As mentioned, taxable income equals assessed income minus deductions that are determined by the tax authorities. The basic deduction depends on assessed income and the (partly deductible) social security fee is capped at a level that depends on broad income.[12]

Table 1 shows some descriptive statistics concerning the various income variables. Earned income exhibits much more variation than the other income variables, a fact that reflects that transfers are excluded from earned income but included in the other income measures. Transfers produce a sizeable level difference between broad income and earned income; the average difference between the two measures amounts to almost 10 percent (not shown in the table). The correlation matrix reveal a high degree of correlation between changes in broad income and assessed income but more modest correlations between earned income and the other income variables.

The fraction of people with positive earned income has hovered between 85 and 87 percent over the period 1993-2002. The fraction fell sharply (from 91 to 86 percent) over the period 1991-1993, when a deep recession hit the Swedish economy. The fraction with positive broad income has been around 95 percent over the period 1993-2002. The fraction of entrepreneurial income in earned income is 6 percent on average. Women accounts for 49 percent of the sample. See Table B2 in Appendix B for more information on the sample.

The income distribution has widened over the period. Table 2 shows the evolution of incomes by various percentiles. For earned income, the growth in nominal income has been 25 percent for the 10th percentile and 60 percent for the 99th percentile. Adjusted for inflation, these numbers correspond to roughly 5 and 40 percent real income growth. Aside from these divergent trends at the bottom and the top, there are modest increases in income inequality in

[12] In LINDA, these three measures correspond to (i) primärinkomst (CPRIM), (ii) sammanräknad förvärvsinkomst (CSFVI) and (iii) taxerad förvärvsinkomst. Taxable income corresponds to beskattningsbar förvärvsinkomst in LINDA.

Table 1. Income correlations and other statistics, 1991-2002.

	ln *YE*	ln *YB*	ln *YA*	ln *YT*
ln *YE*	1.000			
ln *YB*	0.727 [0.560]	1.000		
ln *YA*	0.725 [0.558]	0.998 [0.995]	1.000	
ln *YT*	0.711 [0.521]	0.980 [0.940]	0.982 [0.944]	1.000
Means	11.695 [0.048]	11.870 [0.065]	11.860 [0.065]	11.758 [0.067]
St dev	1.147 [0.821]	0.864 [0.525]	0.859 [0.523]	0.861 [0.512]
# observations	1 660 041	1 828 182	1 827 065	1 794 674

Notes: The total number of observations is 1 913 038. The last row report the number of observations with positive *YE*, *YB*, *YA* and *YT*, respectively. Numbers in brackets refer to first differences of log incomes. The age range is 20-59.

the major part of the distribution. These broad patterns hold for both men and women as well as for all four measures of income.

Previous research, largely based on U.S. data, has often tried to identify income responses to cuts in marginal tax rates by using data showing sharply widening income differentials. A difficulty that arises in this setting is to separate the effects of tax cuts from other determinants of increasing income dispersion. If the tax cuts are concentrated at the top, there is an obvious risk that the income responses will be overstated. The risk of overestimating the income responses should be smaller in the Swedish setting. The main statutory tax change has involved a tax hike rather than a tax cut for top incomes, something that would tend to underestimate rather than overestimate the income responses absent suitable controls for rising income differentials. We will, however, also control for trend changes in the income distribution.

Table 2. The evolution of income by percentiles, 1991-2002.

	p10	p25	p50	p75	p90	p95	p99
Taxable							
1991	10.77	11.33	11.75	12.06	12.33	12.54	12.98
2002	10.98	11.77	12.19	12.47	12.75	12.98	13.48
Change 1991-2002 (%)	23.4	55.3	55.3	50.7	55.2	55.3	64.9
Assessed							
1991	10.95	11.50	11.85	12.11	12.37	12.57	13.00
2002	11.18	11.89	12.25	12.52	12.80	13.01	13.50
Change 1991-2002 (%)	25.9	47.7	49.2	50.7	53.7	55.3	64.9
Broad							
1991	10.97	11.51	11.86	12.12	12.39	12.59	13.03
2002	11.19	11.90	12.26	12.53	12.81	13.03	13.51
Change 1991-2002 (%)	24.6	47.7	49.2	50.7	52.2	55.3	61.6
Earned							
1991	10.31	11.32	11.83	12.12	12.40	12.60	13.04
2002	10.53	11.68	12.25	12.54	12.82	13.04	13.51
Change 1991-2002 (%)	24.6	43.3	52.2	52.2	52.2	55.3	60.0

Note: The table shows nominal incomes (in natural logarithms) and income changes in percent. Over the period 1991-2002, the consumer price index increased by 20.0 percent.

5. Empirical Analysis

5.1 Empirical Strategy

The previous empirical literature in this area has typically employed panel data and regressed changes in log income on changes in the log of the net-of-tax rate. A few other covariates are usually also included. Our specification is a generalization of this benchmark formulation where the benchmark obtains as a special case. The basic model is specified as a dynamic income equation of the form

(2) $$y_{it} = \alpha + \beta_1 n_{it} + \beta_2 n_{it-1} + X_{it}\gamma_1 + X_{it-1}\gamma_2 + \rho y_{it-1} + \eta_i + \varepsilon_{it}$$

where y_{it} is log income pertaining to individual *i* in year *t* and $n_{it} \equiv \ln(1-\tau_{it})$ is the log of the net-of-tax rate, where τ_{it} is the marginal tax rate. X_{it} is a vector of other regressors, η_i is an

individual-specific fixed effect and ε_{it} is a mean zero random error term. The short-run effect of interest is captured by β_1 and the long-run effect is given by $(\beta_1+\beta_2)/(1-\rho)$, where the presumption is that $\rho \in (0,1)$ holds. Although there is often a presumption that the response is stronger in the long run than in the short run, the specification is not restrictive in that respect. The response may be stronger in the short run than in the long run for a variety of reasons. For example, if a tax hike increases tax avoidance, this may well be a "one-time effect" rather than a gradual adjustment. Adjustments driven by habit persistence or adjustment costs may entail more gradualness.

Our specification incorporates "mean reversion" in the sense that income changes in a period are related to the previous period's distance from long-run equilibrium. In other words, the model has an error correction specification which can be written as follows:

$$\text{(3)} \qquad \Delta y_{it} = \beta_1 \Delta n_{it} + \Delta X_{it}\gamma_1 + (\rho - 1)\left[y_{it-1} - \left(\frac{1}{1-\rho}\right)\left(\alpha + \bar{\beta} n_{it-1} + X_{it-1}\bar{\gamma} + \eta_i\right)\right] + \varepsilon_{it}$$

where $\bar{\beta} \equiv \beta_1 + \beta_2$ and $\bar{\gamma} \equiv \gamma_1 + \gamma_2$. The squared brackets include the error correction term which is zero in long-run equilibrium. Shocks to income are offset through lagged adjustment towards equilibrium provided that $\rho \in (0,1)$ holds.

The individual-specific fixed effects can be removed by first differencing. We obtain

$$\text{(4)} \qquad \Delta y_{it} = \beta_1 \Delta n_{it} + \beta_2 \Delta n_{it-1} + \Delta X_{it}\gamma_1 + \Delta X_{it-1}\gamma_2 + \rho \Delta y_{it-1} + \Delta \varepsilon_{it}$$

which is equivalent to

$$(4') \qquad \Delta y_{it} = \beta_1 \Delta^2 n_{it} + (\beta_1 + \beta_2)\Delta n_{it-1} + \Delta X_{it}\gamma_1 + \Delta X_{it-1}\gamma_2 + \rho \Delta y_{it-1} + \Delta \varepsilon_{it}$$

The remainder error term and the differenced lagged dependent variable is correlated (since the former contains ε_{it-1} and the latter y_{it-1}). Anderson and Hsiao (1981) suggested the use of either y_{it-2} or $\Delta y_{it-2} = y_{it-2} - y_{it-3}$ as instrument for Δy_{it-1}; such instruments are valid as long

as ε_{it} is not serially correlated. The use of y_{it-2} as instrument is known as the "level" form of the Anderson and Hsiao estimator, whereas the use of Δy_{it-2} is referred to as the "difference" estimator. An advantage of the level estimator is that we can exploit data available from year *t*=3 and onwards (since y_{it-2} is available from *t*=3), whereas the difference estimator is not available until *t*=4 (since Δy_{it-2} is first available at year *t*=4).[13] Since the validity of y_{it-2} as instrument is conditional on absence of serial correlation in the idiosyncratic error term, ε_{it}, it becomes important to test for serial correlation. We use the Arrelano-Bond tests of first- and second-order correlation in the differenced residuals. Absence of serial correlation in ε_{it} would imply negative first-order autocorrelation as well as zero second-order correlation in $\Delta\varepsilon_{it}$.

An endogeneity problem specific to the problem at hand concerns the net-of-tax rate. This variable is clearly endogenous when the tax system is progressive. In general, we can write the net-of-tax rate as a function $n_{it} = n(y_{it}; z_t)$, where z_t captures the tax code.[14] Analogously, $n_{it-1} = n(y_{it-1}; z_{t-1})$. It is obvious that n_{it} is endogenous because it depends on income in the current period. However, it is clear that n_{it-1} is also correlated with the error term in (4) since it contains lagged income. To deal with these issues we construct two instruments, in addition to y_{it-2}. These instruments are as follows:

(5a) $$n_{it}^{p} = n(y_{it-2}^{P,t}; z_t)$$

(5b) $$n_{it-1}^{p} = n(y_{it-2}^{P,t-1}; z_{t-1})$$

where $y_{it-2}^{P,t}$ and $y_{it-2}^{P,t-1}$ are predicted taxable incomes pertaining to period *t* and *t*-1, respectively. These predictions are based on observed taxable incomes in year *t*-2. We inflate y_{it-2} by the growth of median income between year *t*-2 and *t* (as well as between *t*-2 and *t*-1).[15] The model is thus exactly identified.

[13] Arellano (1989) reports that the estimator that uses instruments in levels has much smaller variances than the difference estimator.

[14] In the regressions, y_{it} stands for log income. With some abuse of notation, we let y_{it} represent the level of income when discussing instruments.

[15] The national averages of the 284 local tax rates are applied when constructing the instruments since the actual local tax rate is endogenous to mobility decisions. For 2000-2002 we add the national average of the "church

Our data comprise 12 years, i.e., 1991 through 2002. We employ the Anderson-Hsiao level estimator in order to maximize the number of time periods and thus end up with 10 years covering the period 1993-2002.

Comparisons with Conventional Specifications

How is our approach related to the specifications used in previous work? A conventional specification involves regressing the change in income against the change in the net-of-tax rate and lagged *levels* of other covariates, i.e.,

$$\Delta y_{it} = \beta \Delta n_{it} + X_{it-1}\gamma + v_{it} \tag{6}$$

This is the benchmark specification in Auten and Caroll (1999) and Gruber and Saez (2002) as well as several other studies. However, it is also commonly argued that it is important to control for first-period income and thus include the lagged income level as an additional regressor, i.e.,

$$\Delta y_{it} = \beta \Delta n_{it} + \kappa y_{it-1} + X_{it-1}\gamma + v_{it} \tag{7}$$

The lagged income variable may appear in a linear fashion as in (7) and in Auten and Carroll (1999), or as a flexible spline function as in Gruber and Saez (2002). The inclusion of lagged income among the right-hand side variables is typically motivated by mean reversion arguments, i.e., the need to control for the possibility that large positive (negative) shocks to income in a particular year are offset by slow (fast) income growth in subsequent years.[16] The endogeneity of Δn_{it} is recognized and the typical procedure is to instrument by means of lagged income and the current tax system, i.e., an instrument of the form $n_{it}^{p} = n(y_{it-1}^{P,t}; z_t)$ is used. The conventional specification is "implicitly dynamic" since it uses lagged income as instrument.

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fee" (kyrkoavgiften) to the national average of the local tax rate so as to get a consistently defined instrument over the whole period. During 1991-1999, the church tax is included in the local tax rate. When the church was separated from the state in 2000, this tax was converted to a fee for members of the church. The church fee has amounted to slightly less than one percent of taxable income. Close to 80 percent of the population are members of the Swedish church.

[16] Blomquist and Selin (2007) motivate the inclusion of lagged income by arguing that it serves as a proxy for unobserved heterogeneity that interacts with time.

We see at least two potential problems with this conventional approach. First, it fails to make a clear distinction between short-run and long-run effects. A common view seems to be that the parameter on Δn_{it} should capture long-run effects, at least if the time differencing encompasses several years. This interpretation is problematic since the inclusion of lagged income implies a feedback effect that should be accounted for when computing the long-run response. A second issue concerns the econometric methodology. The validity of y_{it-1} as an instrument requires that there is no first-order autocorrelation in v_{it}. This condition seems to have been largely ignored in the previous literature; in fact, we are unaware of any previous study in this area that presents autocorrelation tests.[17] For reasons discussed above, lagged income is plausibly correlated with the error term and thus needs to be instrumented.

To what extent can the conventional difference model be nested as a special case of our dynamic specification? Specification (7) is not nested within (4) since it includes y_{it-1} rather than Δy_{it-1}. Specification (6) can however be nested within (4) after suitable modifications. By imposing $\beta_2 = \rho = 0$ in (4), we obtain a specification that is identical to (6) except for the treatment of the non-tax covariates included in the *X*-vector. A slight generalization of the treatment of the *X*-variables makes it possible to get reasonably congruent specifications. Note that $\Psi \equiv \Delta X_{it}\gamma_1 + \Delta X_{it-1}\gamma_2$ in (4) obtains as a special case of $\Psi^* \equiv X_{it}\gamma_1 + X_{it-1}\lambda - X_{it-2}\gamma_2$ when $\lambda = \gamma_2 - \gamma_1$. The specification in (6) is then obtained if $\gamma_1 = \gamma_2 = 0$. In order to avoid possible endogeneity of some covariates, we exclude potentially endogenous *t*-dated covariates. In particular, variables representing education and marital status appear only as lagged levels, i.e., as X_{it-1} and X_{it-2}.

In summary, the conventional specification can be nested a special case of our general dynamic model. The key restrictions are $\beta_2 = \rho = 0$. Moreover, it is important to test for serial correlation when estimating the conventional model as well as our general dynamic model.

[17] Moffitt and Wilhelm (2000) do however discuss the likelihood of correlation between the error term and lagged income. Some of the previous studies have used two-wave panels which have precluded tests of autocorrelation of the differenced error term.

5.2 Empirical Results

We focus on statutory marginal tax rates. These are the tax rates that apply to taxable income and consist of the local tax rate plus the national tax. A broader concept, which arguably may be thought of as representing the effective marginal tax rate, recognizes income-dependent basic deductions and social security fees. A well-informed agent, behaving according to the canonical labor supply model, would care about effective tax rates rather than the statutory ones. But the rules concerning deductions and fees are complex and it is not clear that they are well understood by the tax payers. The statutory rules, however, are simple since they involve only two or three brackets. It may well be the case that the statutory rules come closer than the effective rates to what agents perceive as relevant for their decisions. Ultimately, this is an empirical issue. The major changes in the tax system over the studied period are associated with changes in statutory rates and bracket adjustments. By Occam's razor we opt for the simpler alternative and focus on results based on statutory tax rates. Some results for effective tax rates are shown in Appendix A.

The tax reforms we study have been relevant for individuals well above median earnings. Recall that only 20-25 percent of the tax payers have been affected by the national tax and only around 5 percent by the top bracket in place since 1999. There is no obvious criterion, however, for choosing the appropriate limit for sample inclusion. Although the changes in the marginal tax rates have been most pronounced among people with relatively high incomes, an exclusive focus on these groups would weaken identification. And inclusion of all income levels would imply an implausible degree of homogeneity in behavior across the distribution.[18] We have settled for a rule that includes individuals with above-median income in the beginning of the studied period. A cutoff rule that depends on income in the first available year (1991) minimizes the risk of choosing a sample based on endogenous outcomes. However, income is volatile and sample inclusion based on only one year's income will miss individuals who have experienced temporary income cuts in that year. We have therefore computed average taxable income for each individual over the years 1991-94 (for those with positive incomes in each of those four years) and include in our sample only those with above-median average incomes. Recall that there is no major tax change before 1995.

[18] There is some evidence from U.S. studies that high-income earners exhibit stronger responsiveness to tax changes; see Gruber and Saez (2002).

The robustness checks that we have undertaken, and which will be presented below, do not indicate that the results are very sensitive to the choice of cutoff point. [19]

Results for the gender-pooled sample are set out in Table 3. The estimates correspond to eq. (2), estimated as first differences as given by eq. ($4'$). In addition to the tax variables, we include as covariates age squared, local labor market tightness and dummies for marital status, education and year.[20] We also include controls for changes in the income distribution that are unrelated to tax policy. These controls are produced by interacting log taxable income in 1991 with polynomial trends.[21]

Table 3. Estimation results, gender-pooled sample.

	(1)	(2)	(3)
	Assessed income	Broad income	Earned income
$\Delta^2 n_{it}$	-0.076 (1.49)	-0.073 (1.40)	0.193 (1.98)
Δn_{it-1}	0.139 (5.63)	0.150 (5.95)	0.149 (3.00)
Δy_{it-1}	0.497 (25.26)	0.524 (24.63)	0.325 (33.31)
Long-run elasticity	0.275 (5.18)	0.316 (5.34)	0.220 (2.98)
AR(1)	-34.73	-32.39	-44.37
AR(2)	1.67	0.89	-1.01
Obs.	621,185	621,560	585,576

Notes: The model is estimated in first differences (Anderson-Hsiao using lagged levels as instruments). The *t*-statistics in parentheses are robust to heteroskedasticity and arbitrary intra-individual correlation. Other variables are three education categories, marital status, local labor market tightness and year dummies. Lagged income and the two tax variables are treated as endogenous and instrumented as described in the text. Controls for trends in the income distribution by means of interactions between income 1991 and trend polynomials as described in the text. The Arellano-Bond statistics, AR(1) and AR(2) are asymptotically N(0,1) and test for first- and second-order serial correlation in the first-differenced residuals. The sample inclusion rule is based on average taxable income during 1991-94; observations above the median are included.

[19] The results for men are broadly similar if median income in 1991 is used as cutoff rule. The results for women differ, however: the estimated income responsiveness to tax changes is much smaller with the 1991 cutoff rule. The reasons for these differences are not clear but may reflect higher income volatility among women.

[20] The linear age effect is not identified. Education levels (three dummies) as well as marital status are included as lagged levels (one and two years). The data contain information on the number of children in the household but the definitions are not entirely consistent over the years. We have therefore excluded this variable from the regression models but the results are almost identical if the variable is included.

[21] We interact (in the level specification) log taxable income 1991 with three trend variables (linear, squared and cubic trends), thus allowing the trend evolution of income to differ depending on income in 1991.

Some general remarks are in order before discussing details. First, the instruments are strong as judged by very high *F*-values for inclusion of the instruments in the first stage. Second, the IV-estimates reported in the tables are very different from the OLS results (not reported). OLS yields negative and large coefficients on the net-of-tax rates, whereas IV generally yields positive estimates. These differences are as should be expected given a progressive tax system where the net-of-tax rate is decreasing in income. Third, it worth noting that the lagged dependent variables always enter with coefficients in the range between 0.2 and 0.5, significantly different from zero as well as significantly different from unity.

The point estimates of the long-run elasticities vary in a range between 0.22 and 0.32 depending on the definition of income. All these estimates are significantly different from zero. The tests for autocorrelation reveal negative first-order but no second-order autocorrelation in the differenced residuals. These patterns are consistent with zero autocorrelation in the residuals in levels.

The estimated short-run elasticities are not significantly different from zero for assessed and broad income. For earned income, the short-run and the long-run elasticities are not significantly different from each other (the *p*-value for equal elasticities is 0.46).

Separate results for men and women are shown in Table 4. The estimated long-run elasticities for assessed and broad income are very similar for men and women, whereas the elasticity for earned income is much higher for men than for women. In fact, the female long-run elasticity is not quite significant even after imposing a restriction, $\beta_2 = 0$, on the coefficients on the tax variables (column 7). (The restriction is not rejected.) For men there is some evidence of second-order autocorrelation in the differenced residual in two out the three cases. The estimates of the short-run impact vary substantially. For women, the estimated short-run impact is in fact negative. A negative short-run response may be consistent with some models of human capital accumulation where workers invest in education by reducing their working time. It would be farfetched, however, to propose such an interpretation without much stronger evidence.

Table 4. Estimation results by gender.

	Men			Women			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Assessed income	Broad income	Earned income	Assessed income	Broad income	Earned income	Earned income
$\Delta^2 n_{it}$	0.090 (1.51)	0.106 (1.74)	0.344 (3.07)	-0.365 (3.33)	-0.405 (3.58)	-0.035 (0.16)	0.108 (1.49)
Δn_{it-1}	0.146 (4.75)	0.161 (5.09)	0.209 (3.48)	0.116 (2.39)	0.115 (2.30)	0.060 (0.60)	0.108 (1.49)
Δy_{it-1}	0.460 (30.33)	0.481 (20.11)	0.340 (25.60)	0.572 (14.98)	0.618 (14.20)	0.309 (21.82)	0.309 (21.71)
Long-run elasticity	0.271 (4.42)	0.311 (4.65)	0.317 (3.43)	0.272 (2.22)	0.300 (2.09)	0.086 (0.60)	0.156 (1.48)
AR(1)	-29.45	-27.64	-32.84	-18.58	-17.01	-30.98	-32.22
AR(2)	2.96	2.12	-0.16	-1.64	-1.74	-1.08	-1.11
Obs.	427,873	428,084	404,045	193,312	193,476	181,531	181,531

Notes: In column (7), the restriction $\beta_2 = 0$ is imposed which implies that the parameters pertaining to $\Delta^2 n_{it}$ and Δn_{it-1} are equal. The *t*-value for the restriction is 0.71. See also notes to Table 3.

Robustness Checks

How sensitive are these results to the chosen cutoff rules for sample inclusion? We consider two alternative cutoff rules based on average taxable income over the period 1991-94. The lower cutoff – 125,000 SEK – corresponds to the 40th percentile of taxable income 1991-94; the higher cutoff – 150,000 SEK – is fairly close to the 60th percentile. The results are shown in Table 5 and indicate somewhat higher long-run elasticities for the higher cutoff case. The short-run elasticities are never significantly negative when using the higher cutoff, arguably a plausible outcome. For earned income, the estimated short-run and long-run elasticities remain close to identical.

Table 5. Estimation results for alternative cutoff rules, gender-pooled sample

	Mean income 1991-94 at least 125 000 SEK			Mean income 1991-94 at least 150 000 SEK		
	(1)	(2)	(3)	(4)	(5)	(6)
	Assessed income	Broad income	Earned income	Assessed income	Broad income	Earned income
$\Delta^2 n_{it}$	-0.106 (2.13)	-0.108 (2.06)	0.164 (1.67)	-0.025 (0.53)	-0.017 (0.34)	0.195 (2.11)
Δn_{it-1}	0.115 (4.75)	0.125 (5.05)	0.111 (2.23)	0.148 (6.04)	0.163 (6.47)	0.139 (2.90)
Δy_{it-1}	0.494 (28.06)	0.517 (27.32)	0.315 (30.30)	0.489 (23.53)	0.519 (22.91)	0.320 (28.81)
Long-run elasticity	0.227 (4.50)	0.258 (4.71)	0.162 (2.22)	0.289 (5.41)	0.339 (5.61)	0.205 (2.87)
AR(1)	-37.92	-35.42	-51.71	-33.13	-30.68	-39.59
AR(2)	-2.18	1.38	-1.81	2.10	1.25	0.12
Obs.	740,326	740,718	692,694	535,978	536,343	507,385

Note: The cutoff rules pertain to average taxable incomes over the period 1991-94. See also notes to Table 3.

We have undertaken a number of other sensitivity tests. As shown in Table 6, the results are reasonably robust to the inclusion or exclusion of various non-tax covariates. The estimated long-run elasticities are not much affected by exclusion of the trends that control for the widening of the income distribution. Nor are the estimates much affected by exclusion of other variables, such as education, marital status and local labor market conditions. The age limit makes a difference, however: the estimated long-run elasticities are consistently smaller when we restrict the sample to the prime-aged groups.

In summary, the estimates of the long-run elasticity of income with respect to the net-of-tax rate typically range from 0.2 to 0.3. The results for men are somewhat more robust than the results for women. It should be noted, however, that the tax changes we have studied have affected many more men than women since they have been targeted at high-income earners. It should therefore generally be easier to identify behavioral responses among men than among women.

Table 6. Further robustness checks, gender-pooled sample.

	Assessed income			Broad income			Earned income		
	Long-run elasticity	AR(1)	AR(2)	Long-run elasticity	AR(1)	AR(2)	Long-run elasticity	AR(1)	AR(2)
Benchmark specification	0.275 (5.18)	-34.73	1.67	0.316 (5.34)	-32.39	0.89	0.220 (2.98)	-44.37	-1.01
No trends	0.310 (4.00)	-58.35	-1.51	0.355 (4.28)	-55.55	-2.19	0.278 (3.19)	-61.41	-2.32
Few covariates	0.299 (5.57)	-33.60	1.71	0.339 (5.66)	-31.33	0.92	0.255 (3.52)	-43.95	-1.28
29<age<50	0.166 (3.56)	-33.39	1.88	0.196 (3.85)	-30.87	1.17	0.177 (2.48)	-40.47	-0.80
No entrepreneurial income	0.225 (4.58)	-30.64	-0.66	0.109 (2.69)	-30.10	0.24	0.213 (3.07)	-40.80	-2.43

Notes: Few covariates mean inclusion of the tax variables, the trends, age squared and the year dummies. See also notes to Table 3.

Comparisons with Conventional Specifications

We now turn to a comparison with results that are based on the traditional difference specification as given by eqs. (6) and (7) above. To implement this specification, we follow the common practice of instrumenting the net-of-tax rate in year *t* by means of income in year *t*-1 – inflated to year *t* – and the tax code as of year *t*, i.e., $n_{it}^{p} = n(y_{it-1}^{P,t}; z_t)$, where $y_{it-1}^{P,t}$ is predicted income for year *t*. The relevant instrument in the difference specification thus becomes $\Delta n_{it}^{P} = n(y_{it-1}^{P,t}; z_t) - n(y_{it-1}; z_{t-1})$. The use of y_{it-1} as an instrument is valid as long as there is no first-order autocorrelation in v_{it}.

The results are displayed in Table 7. The three first columns correspond to eq. (6), whereas the remaining columns include lagged income and thus correspond to model (7).[22] The estimated coefficients on the net-of-tax variables range between 0.08 and 0.11 in the first three columns. This is roughly one third of the (long-run) magnitudes estimated in the dynamic model and presented in Table 3. Note however that there is severe first-order autocorrelation in the residuals, a fact that casts doubts on the validity of this model.

Table 7. Estimation results, conventional difference specifications, gender-pooled sample.

	(1)	(2)	(3)	(4)	(5)	(6)
	Assessed income	Broad income	Earned income	Assessed income	Broad income	Earned income
Δn_{it}	0.076 (10.53)	0.078 (10.88)	0.113 (8.38)	0.022 (3.08)	0.026 (3.66)	0.010 (0.75)
y_{it-1}				-0.178 (50.59)	-0.169 (-47.87)	-0.251 (74.06)
AR(1)	-31.47	-29.92	-41.40	-18.31	-17.33	-21.77
AR(2)	-13.67	-13.54	-19.94	2.69	1.95	7.23
Obs.	624,300	624,497	592,079	624,300	624,497	592,079

Notes: Other variables are those included in the previous regressions (except Δn_{it-1} and Δy_{it-1}).

The estimates of the net-of-tax effects are markedly reduced when lagged income is included among the regressors. The coefficients on the lagged income variables are negative, which is

[22] We include the same controls for income trends as in the previous regressions. The estimated coefficients are only marginally affected by exclusion of these trend variables.

the common finding in these kinds of specifications. Again, there is evidence of severe first-order autocorrelation in the residuals.

As noted, the dynamic specification nests the conventional formulation (for one year differences) as a special case; the relevant restrictions on eq. (4) are $\beta_2 = \rho = 0$. These restrictions are almost always rejected: $\rho = 0$ is always rejected as is clear from the tables; $\beta_2 = 0$, which implies equal coefficients on $\Delta^2 n_{it}$ and Δn_{it-1}, is rejected for assessed and total income but not for earned income.[23]

5.3 Fiscal Consequences of a Tax Cut

A frequently advocated tax reform would entail abolishment of the top bracket in the state income tax system.[24] Such a reform, involving a 5 percentage cut in marginal income tax rates for top-income earners, would restore the Swedish tax system to the basic principles set out in the major tax reform of the early 1990s.

What are the fiscal consequences of such a reform? Consider a stylized representation of the tax system pertaining to high incomes, i.e., incomes above the threshold where the top rate kicks in. Let τ represent the statutory marginal income tax rate, YA_i assessed income for individual *i*, *D* deductions and Y^* the threshold above which the top rate applies. Taxable income is given as $YT_i = YA_i - D$, where deductions are constant for top-income earners. The income tax function for the top bracket can thus be written as follows:

(8) $$T_i = \tau\left(YA_i - D - Y^*\right)$$

Differentiation of the tax function with respect to the marginal tax rate yields:

(9) $$\frac{dT_i}{d\tau} = \left(YA_i - D - Y^*\right) + \tau\frac{dYA_i}{d\tau}$$

[23] For the gender-pooled sample, the *t*-values for the restriction are 5.44 and 5.53, respectively. For earned income we have *t*=0.75.

[24] Two of the three major Swedish union federations, organizing white collar workers, have repeatedly argued in favor of such a reform.

which can be written as

$$\frac{dT_i}{d\tau} = \left(YA_i - D - Y^*\right) - \eta\left(\frac{\tau}{1-\tau}\right)YA_i \tag{10}$$

where $\eta \equiv d\ln YA_i / d\ln(1-\tau)$ is the elasticity of assessed income with respect to the net-of-tax rate. The expression in the first parenthesis captures the direct (or mechanical) effect of a tax change, whereas the remaining term represents the indirect effect associated with the income response. Note that the direct effect is negligible for incomes close to the threshold so $dT_i / d\tau < 0$ holds for incomes in the neighborhood of the threshold.

Expression (10) captures only the impact on tax revenues that operates through the income tax system whereas revenue effects via payroll and value added taxes are ignored. By slightly modifying (8) so as to incorporate proportional payroll taxes levied on employers, τ^e, we obtain an expression that captures the total change in labor taxes associated with a change in the top marginal income tax rate:

$$\frac{dT_i}{d\tau} = \left(YA_i - D - Y^*\right) - \eta\left(\frac{\tau + \tau^e}{1-\tau}\right)YA_i \tag{11}$$

The total effect on tax revenues is thus obtained as:

$$\frac{dT}{d\tau} = \sum_i \left[\left(YA_i - D - Y^*\right) - \eta\left(\frac{\tau + \tau^e}{1-\tau}\right)YA_i\right] \tag{12}$$

Table 8 shows the results of experiments where the top tax bracket is abolished in 2002, the last year in our data. We set $\tau = 0.525$ and $\tau^e = 0.33$ (or $\tau^e = 0$) in these experiments.[25] Three alternatives for η are considered, viz. 0.10, 0.20 and 0.30. The exercises indicate that

[25] This experiment involves calculation of $\Delta T = \Sigma_i \left[YA_i - D - Y^* - \eta\left((\tau + \tau^e)/(1-\tau)\right)YA_i\right] \times (-0.05)$. The summation pertains to all income earners above the relevant income threshold. The numbers are scaled to the macro level by dividing by the sample probability in LINDA, i.e., 0.0335. The calculations ignore the fact that τ varies across individuals (because of variations in municipality tax rates), but this has negligible effects on the results. The average marginal income tax rate was 55 percent in 2002 in the relevant top income interval. The proportional statutory payroll tax rate was 32.82 percent. We place no age restrictions on age in the calculations.

an elimination of the top bracket is fiscally inexpensive. The mechanical fall in tax revenues is more than offset by the increase in tax revenues associated with the positive income response for $\eta = 0.20$ or higher and with account taken of revenues from the payroll tax. For the most "elasticity-optimistic" case, the income-driven increase in tax revenues is over 80 percent bigger than negative direct revenue effect. It should be noted that these calculations probably provide lower bound estimates since we have ignored increased revenues from value added taxes.

Table 8. Fiscal implications of elimination of the top tax bracket ($\Delta\tau = -0.05$) in 2002. Millions SEK.

	$\eta = 0.10$		$\eta = 0.20$		$\eta = 0.30$	
	(*i*)	(*ii*)	(*i*)	(*ii*)	(*i*)	(*ii*)
Mechanical effect	-2,910	-2,910	-2,910	-2,910	-2,910	-2,910
Indirekt effect (income response)	1,100	1,790	2,200	3,580	3,300	5,370
Net effect: ΔT	-1,810	-1,120	-710	670	390	2,460

Notes: (*i*) ignores the payroll tax effect whereas (*ii*) incorporates the payroll tax effect. No age restrictions are imposed. The SEK/USD exchange rate in 2007 is around 7 SEK per USD.

Finally, we note by inspection of (12) that the tax cut has no effect on tax revenues provided that the following equality holds:

$$\text{(13)} \qquad \frac{\sum_i \left(YA_i - D - Y^*\right)}{\sum_i YA_i} = \eta\left(\frac{\tau + \tau^e}{1-\tau}\right)$$

The numerator of the left-hand side is the sum of taxable incomes above the threshold for the top rate, whereas the denominator is the sum of (all) assessed incomes for individuals above the threshold. The left-hand side is equal to 0.29 in our data. For $\tau = 0.525$ and $\tau^e = 0$, it follows that $\eta > 0.262$ must hold if the tax reform should be revenue neutral. For $\tau^e = 0.33$, it is sufficient that $\eta > 0.161$ holds.

6. Concluding Remarks

We have proposed a new approach to the estimation of income responses to changes in marginal tax rates. The conventional approach, where changes in income are regressed on changes in tax rates, can only capture long-run responses under restrictive and implausible conditions. Our more general approach, which involves application of a standard lagged adjustment framework, nests the conventional specification as a special case and delivers estimates of both short-run and long-run effects.

Our estimates of long-run responses are much larger than the estimates we obtain by employing the conventional difference specifications. At the same time, these long-run estimates are considerably smaller than some of the previous estimates in the literature. However, our simulations of a tax reform that abolishes the top marginal tax rate suggest that even modest elasticities are sufficient to make such a reform fiscally inexpensive; in fact, the reform may well bring about a fiscal surplus when we account for induced increases in revenues from payroll taxes and value added taxes.

The results for men are more robust than those we have obtained for women. There is no evidence from our results that female incomes are more responsive than those of men, an implication that would follow from most studies of labor supply.[26] However, the tax changes we have studied have affected many more men than women since they have been targeted at high-income earners. It should therefore generally be easier to identify behavioral responses among men than among women.

There is a need for better understanding of how and why the estimates differ across alternative definitions of income. Much has been said in favor of the view that one should focus on taxable income since this is what matters for the effects on the government's tax revenues. But perhaps this focus misses the difficulty to satisfactory model income variables that are complex outcomes of individual work effort as well as rules pertaining to tax deductions and transfers. It may well be that separate structural approaches to the modeling of the components of taxable income will prove to be the route forward.

[26] However, Blomquist and Hansson Brusewitz (1990) caution that the conventional results – higher female labor supply elasticities – may be artifacts of restrictive functional forms.

The paper has focused on individual responses and ignored the household context. For married (or cohabiting) individuals, the economic fortunes of both partners are presumably relevant. It should be a prioritized research agenda to incorporate a family perspective in this area.

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APPENDIX A

Effective marginal tax rates

Taxable income is obtained after various deductions from gross income. A stylized description of the tax system runs as follows. Let T denote the amount of income taxes paid, τ the statutory marginal tax rate, Y broad (or gross) income, D the basic deduction, F the social security fee and R other deductions (such as work related deductions). The tax function can be written as:

$$\text{(A1)} \qquad T = \tau(Y - D - dF - R) + aF - \left[(1-d)F\right]_{00,02}$$

The first parenthesis represents taxable income, i.e., $YT = Y - D - dF - R$, where d is the fraction of the fee that is deductible and a the fraction of the fee that is equivalent to a tax, i.e., the non-actuarial element of the fee. The expression in square brackets capture some changes of tax policy during the period 2000-2002, where tax cuts were linked to the social security fees. Up to 1999, d=1 applied; in 2000, d was reduced to 0.75; in 2001 it was further reduced to 0.5 and in the following year d=0.25 applied. The social security fee includes a pension fee that is associated with future pension entitlements.

The basic deduction depends on the level of income in a hump-shaped fashion: $\partial D / \partial Y = 0.25$ applies up to an income limit; D is then constant over a range of (low) incomes; and there is a subsequent interval where $\partial D / \partial Y = -0.10$ applies. D is constant for relatively high incomes.[27] The marginal increase in the social security fee associated with an increase in income, $\partial F / \partial Y$, is constant up to an income threshold beyond which it is zero.[28] The caps on the fees have kicked in at the 85th to the 90th percentiles of broad income.

Derivation of the tax function yields the effective marginal tax rate as:

$$\text{(A2)} \qquad \frac{dT}{dY} = \tau\left(1 - \frac{\partial D}{\partial Y}\right) + \left[(a - \tau d) - (1-d)_{00,02}\right]\left(\frac{\partial F}{\partial Y}\right)$$

[27] The basic deduction is equal to the level of assessed income for very low levels of assessed income. In other words, there is an exemption level in the tax system, such that only incomes above that level are subject to taxation.

[28] D is determined by assessed income whereas F is determined by broad income. We assume that a given marginal increase in broad income translates into an increase in assessed income of the same magnitude.

The contribution of the social security fee to the effective marginal tax rate is small. We have $\partial F / \partial Y = 0$ for 1991 and 1992; $\partial F / \partial Y$ then increases gradually from 0.0095 in 1993 up to 0.07 in 2000. However, this increase is partly or wholly offset by deduction rules and the fact that the fee is associated with pension entitlements. The size of the non-actuarial component of the pension fee is debatable, but *a*=0.5 seems to be a reasonable estimate. All in all, the social security fee has a negligible impact on changes in the effective marginal tax rate.

Table A1 shows estimation results where the effective marginal tax rate includes the basic deduction, i.e., the effective marginal tax rate is defined as $\tau^e \equiv \tau(1+\partial D / \partial Y)$, where τ is the statutory tax rate. The effective net-of-tax rate is thus $n_{it} = \ln(1-\tau_{it}^e)$. As instruments, in addition to those applied in the main text, we use two variables capturing the rules for the basic deduction.[29] The estimates of the long-run elasticity range between 0.17 and 0.20, thus somewhat lower than those shown in the main text.

Table A1. Estimation results with effective tax rates, gender-pooled sample.

	(1)	(2)	(3)
	Assessed income	Broad income	Earned income
$\Delta^2 n_{it}$	-0.081 (1.67)	-0.099 (1.99)	0.193 (1.98)
Δn_{it-1}	0.098 (3.60)	0.081 (2.85)	0.149 (3.00)
Δy_{it-1}	0.519 (26.69)	0.531 (25.90)	0.325 (33.31)
Long-run elasticity	0.203 (3.42)	0.172 (2.73)	0.220 (2.98)
AR(1)	-34.48	-32.74	-44.37
AR(2)	2.14	1.38	-1.01
Obs.	620,784	621,144	585,234

Note: See explanations in the text and notes to Table 3.

[29] The two variables are $D_{it}^p = \ln\left[1 - D'(YA_{it-2}^{p,t}; d_t)\right]$ and $D_{it-1}^p = \ln\left[1 - D'(YA_{it-2}^{p,t-1}; d_{t-1})\right]$, where d_t captures the rules for the basic deduction pertaining to year *t*. In words, we use assessed income in year *t*-2, inflated to year *t* (and *t*-1), in conjunction with prevailing rules.

APPENDIX B

Descriptive statistics

Table B1. Income bracket thresholds for the Swedish state tax, 1991-2002.

	First bracket	Tax rate (%)	Fraction affected (%)	Second bracket	Tax rate (%)	Fraction affected (%)
1991	170,000	20	26.2			
1992	186,600	20	20.6			
1993	190,600	20	20.6			
1994	198,700	20	22.5			
1995	203,900	25	19.2			
1996	209,100	25	20.0			
1997	209,100	25	22.0			
1998	213,100	25	22.8			
1999	219,300	20	23.8	360,000	25	5.2
2000	232,600	20	24.3	374,000	25	5.7
2001	252,000	20	23.1	390,400	25	6.1
2002	273,800	20	21.1	414,200	25	5.8

Note: The thresholds refer to taxable income in nominal SEK beyond which the state tax kicks in. The fraction of affected tax payers refer to individuals aged 20-59 with positive taxable incomes.

Table B2. Sample characteristics (means).

	1991	**1996**	**2002**
Female	0.488	0.490	0.491
Age	38.51	39.20	39.95
Compulsory school	0.266	0.256	0.173
Upper secondary school	0.488	0.443	0.497
University	0.220	0.260	0.311
PhD	0.005	0.006	0.008
Married	0.497	0.454	0.412
Local labor market tightness	0.033	0.026	0.138
Obs.	154,183	160,236	161,848

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